Dance, Autism, and Communication: Exploring the Feasibility of a Dance-Based Exergame within the Home and School Environments to Enhance Autistic Children's Social Communication Skills

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Covid Impact Statement

I embarked on my PhD journey in January 2020. I moved from my home town in Staffordshire to live in Colchester to attend the University of Essex and immerse myself in the research. Little did I know, little did we all know, that one of the biggest events in world history was about to follow. In the initial weeks of my PhD, I discussed and consolidated the trajectory of my research with my supervisory team and knew that I ideally wanted to work with autistic children, preferably in a school-based setting, to increase the likelihood of collaborating with more children. Fast forward to the 23rd of March 2020, the United Kingdom's Government imposed a nation-wide lockdown due to the increasing risk and concerns relating to the coronavirus pandemic spreading across the country. Almost three months to the day that I moved down to Colchester, I was obligated to move back to my family home in Staffordshire and begin two long years of working and researching through various lockdowns, fire-breakers, and tiered systems.

Schools were forced to close and only remained open for vulnerable children; class sizes were restricted, and exposure and movement throughout schools was limited. Furthermore, ethical restrictions at the University prevented face-to-face research occurring until at least September 2021, while still placing a strong emphasis on remote-based research. As a result, I had to redesign the course of my research to ensure that it could be completed remotely and either in the home environment or potentially the school environment - if accessible when the time came. Although the pandemic caused a major disruption and delayed the progress of my research, it helped to ensure that the final intervention overcame many of the limitations associated with traditional therapies for autism. Due to the nature of the pandemic, the proposed intervention had to be deliverable remotely, meaning it could be completed in the home environment with parents acting as

the interventionalists, it did not require travel to various sites, and was low cost; thus, increasing its accessibility for many.

Due to the pandemic, I also sought to investigate the impact that COVID-19 had for many autistic children's social communication skills, as perceived by their parents. This research helped to shed light on the varying differences to social communication skills autistic children experienced during the pandemic. Furthermore, the study also highlighted that levels of physical activity dropped for many autistic children during the pandemic, providing an impetuous to increase and improve physical activity levels in future work. Work on this topic can be found here: https://doi.org/10.1080/20473869.2021.1936870.

Abstract

Autism spectrum disorder (ASD) is a common neurodevelopmental condition, typically characterised by challenges in social communication and restricted or repetitive patterns of behaviours and interests. Autistic individuals are observed to also display a variety of differences and strengths in cognitive functioning, motor skills, and sensory processing, uniquely impacting individuals. Despite its heterogeneity, enhancing social communication skills and supporting physical well-being are two of the autistic community's top research priorities. Therefore, the present thesis explores communication challenges observed within autism and the use of physical activity and dance movement therapy (DMT) to enhance autistic children's social communication skills.

Two systematic reviews were conducted. The first suggested the beneficial use of two fundamental DMT techniques, mirroring and rhythm, for enhancing autistic children's social communication skills. The second highlighted the beneficial effects of exergaming for the autistic population. A subsequent study then investigated common styles of rhythm and music used by dance movement therapists in their sessions with autistic children, suggesting music and rhythms with a 4/4 time signature, moderato tempo, and age-appropriate lyrics were most popular. A mixed-methods approach was later employed to examine the feasibility and potential effectiveness of a dance-based exergame in the home and school environments to enhance autistic children's social communication skills. Results suggest that the exergame can be implemented by parents and teachers in their respective environments, affords children ownership of their intervention, and is an enjoyable activity. Furthermore, limited-efficacy testing inferred the beneficial effects of the dance-based exergame, enhancing autistic children's social communication skills. This work advocates that the chosen exergame is an engaging physical activity, which addresses some of the current limitations of traditional interventions for supporting autistic children's social

communication skills. Overall, the findings presented are promising and suggest additional research within this area will prove worthwhile and meaningful for the autistic population.

Acknowledgements

I would first like to thank my family for their unwavering love and support throughout my academic journey so far. I would like to thank my mother, Sarah, for proof-reading countless pieces of work, teaching me to be fierce and independent, and instilling the belief that anything is possible. My father, Ashley, for showing me that hard work and determination will help you to achieve your goals and for always cooking the best chicken wings whenever I asked for them. My sister, Francesca, for always brightening the day, showing me how to be my authentic self, and for the many, many, *many* morning dog walks we shared together discussing my ongoing research. I would also like to thank my partner, Jake, for sticking by me through thick and thin. Your confidence in me, your encouragement, and your dedication to learn more about the research I have been conducting throughout my studies has not gone unnoticed.

Secondly, I would like to thank my team of supervisors, including Dr John Mills, Dr Edward Hope, and Dr Tom Foulsham. I am grateful for your help, technical advice, and support throughout this experience. Your guidance has been most appreciated and valued.

Finally, I would like to thank the members of the consultation panel and the parents, autistic children, teachers, project liaisons, and dance movement therapists who participated in the studies. Without you, the work presented within this thesis would not have been possible. I am eternally grateful for your participation and your enthusiasm to support autism research.

Author biography

Phoebe Morris is a third year Ph.D. candidate at the University of Essex, England. She received her undergraduate degree from the University of Nottingham, England, obtaining a First-class MSci in Neuroscience. Her research currently focuses on the use of physical activity to support autistic children's social communication skills.

Author statement and declaration

In all cases of material that has been published, presented, and submitted for publication, the work has been directly attributed to me as the Ph.D. candidate. All formulations, investigations, data collection, analyses, reporting, and writing have been independently completed by myself in alignment with the requirements of a Ph.D. candidature. However, those acknowledged as co-authors have advised, when appropriate, on methodology and have assisted by reviewing the submitted drafts of the published manuscripts.

The work in this thesis is based on research conducted during my time as a Ph.D. candidate at the University of Essex, England. No part of this thesis has been submitted elsewhere for any other degree or qualification and all is my own work unless referenced to the contrary in the text.

Publications and presentations

Throughout the ongoing programme of research presented within this thesis, it was important to ensure that I was disseminating and sharing the work with those who would benefit from it most. Whether this be academics or researchers working within the field of autism, physical activity, and dance movement therapy or autistic individuals, parents of autistic children, and teachers working within various education providers – I aspired to make my work accessible. Therefore, I sought to publish the ongoing work in peer-reviewed journals throughout my Ph.D. journey, whilst providing freely available pre-prints of all articles and lay summaries of our final studies. Furthermore, I attended and presented the ongoing work at several domestic and international conferences to impart findings and receive feedback from individuals actively participating in the field. These can be found below.

1. **Morris, P.,** Mills, J. P., Hope, E., & Foulsham, T. (2022). Dancing out for a voice; a narrative review of the literature exploring autism, physical activity, and dance. *Journal of Bodywork and Movement Therapies*. https://doi.org/10.1016/j.jbmt.2022.09.016
    a. Pre-print: **Morris, P**., Hope, E., Foulsham, T., & Mills, J. (2020). Dancing Out for a Voice; a Narrative Review of the Literature Exploring Autism, Physical activity and Dance. *SportRxiv*. https://doi.org/10.31236/osf.io/u2rvk
2. **Morris, P**., Hope, E., Foulsham, T., & Mills, J. P. (2021). The Effectiveness of Mirroring- and Rhythm-Based Interventions for Children with Autism Spectrum Disorder: A Systematic Review. *Review Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s40489-021-00236-z
    a. Pre-print A: **Morris, P.,** Hope, E., Foulsham, T., & Mills, J. P. (2020). *The* Effectiveness of Mirroring- and Rhythm-based interventions for children

diagnosed with Autism Spectrum Disorder: A Systematic Review (Pre-print). *PsyArXiv*. https://doi.org/10.31234/osf.io/xbvj2

3. **Morris, P. O**., Hope, E., & Mills, J. P. (2022). The non-fitness-related benefits of exergames for young individuals diagnosed with autism spectrum disorder: A systematic review. *Research in Autism Spectrum Disorders*, 94, 101953. https://doi.org/10.1016/j.rasd.2022.101953
    a. Pre-print B: **Morris, P**., Hope, E., & Mills, J. P. (2021). The Non-Fitness-Related Benefits of Exergames for Young Individuals Diagnosed with Autism Spectrum Disorder: A Systematic Review. *SportRxiv*. https://doi.org/10.31236/osf.io/czexa
4. **Morris, P. O.,** Hope, E., Foulsham, T., & Mills, J. P. (2021). Dance, rhythm, and autism spectrum disorder: An explorative study. *The Arts in Psychotherapy*, 73, 101755. https://doi.org/10.1016/j.aip.2020.101755
    a. Pre-print A: Morris, P., Hope, E., Foulsham, T., & Mills, J. P. (2020). Dance, Rhythm and Autism Spectrum Disorder: A Scoping Study. *PsyArXiv*. https://doi.org/10.31234/osf.io/2dj8g
5. **Morris, P. O.,** Hope, E., Foulsham, T., & Mills, J. P. (2023). Exploring the use of a dance-based exergame to enhance autistic children's social communication skills in the home and school environments: A feasibility study. *International Journal of Developmental Disabilities, 0(0), 1–18.* https://doi.org/10.1080/20473869.2023.2212985
    a. Pre-print B: **Morris, P.,** Hope, E., Foulsham, T., & Mills, J. P. (2022). Exploring the use of a dance-based exergame to enhance autistic children's social communication skills in the home and school environments: A feasibility study. *PsyArXiv*. https://doi.org/10.31234/osf.io/xz5w9
    b. Lay Summaries: Home; https://osf.io/as6fv. School; https://osf.io/jwpxn.

Conferences attended

1. **Morris, P.,** Hope, E., Foulsham, T., & Mills, J. P. (2021). Parent-reported social communication changes in Children diagnosed with autism spectrum disorder during the COVID-19 pandemic in the UK (presentation), British Psychological Society Annual West Midlands Conference, Celebrating Psychology in the Midlands, virtual.
2. **Morris, P.,** Hope, E., Foulsham, T., & Mills, J. P. (2022). Assessing the Feasibility and Initial Effectiveness of a Dance-Based Exergame for Enhancing Autistic Children's Social-Communication Skills in the home environment (presentation). British Psychological Society's Annual Division of Health Psychology Conference, Bristol.
3. **Morris, P.,** Hope, E., Foulsham, T., & Mills, J. P. (2022). Assessing the Feasibility and Initial Effectiveness of a Dance-Based Exergame for Enhancing Autistic Children's Social-Communication Skills (poster). 16th European congress of Sport and Exercise Psychology, Padova.
4. **Morris, P.,** Hope, E., Foulsham, T., & Mills, J. P. (2022). Assessing the Feasibility and Initial Effectiveness of a Dance-Based Exergame for Enhancing Autistic Children's Social-Communication Skills in the School Environment (presentation). British Psychological Society's Annual PsyPAG Conference 2022, Ulster.

Contents

List of figures

Chapter One Figures

Chapter Three Figures

Chapter Four Figures

List of tables

Chapter One Tables

Chapter Two Tables

Chapter Three Tables

Chapter Four Tables

1 Chapter One: General Introduction

1.1 Setting the scene

In the United Kingdom (UK), it is expected that one in every 100 people will have an autism spectrum disorder diagnosis (ASD; Brugha et al., 2011; National Autistic Society, 2019). The condition comprises an array of challenges to typical social communication, including limited joint attention, diffident social bids, reduced eye contact, and varying reciprocity during conversations. It also encompasses a variety of repetitive or restricted patterns of behaviour and interests (American Psychiatric Association; APA, 2013). Additionally, individuals on the autism spectrum display a variety of strengths and challenges in the realms of cognitive functioning, motor capabilities, and sensory processing. As a result, autism is an incredibly heterogenous condition.

It has previously been observed that such differences and challenges with social communication are often exacerbated in social exchanges that include an autistic/neurodivergent individual and a non-autistic/neurotypical individual (Crompton et al., 2020; Sheppard et al., 2016). This paradigm is known as the 'double empathy problem' and suggests that a breakdown in reciprocity and mutual understanding can happen between individuals with very differing ways of experiencing the world (Milton, 2012). Challenges to social communication can elicit a variety of barriers during social interactions and environments (Cresswell et al., 2019). Subsequently, autistic individuals are often vulnerable to social isolation, the feeling of loneliness, and peer-rejection; negatively impacting their quality of life (QoL; Chiang & Wineman, 2014; de Vries & Geurts, 2015). Furthermore, proficiencies in social communication have been associated with academic success and professional opportunities, both in neurodiverse and neurotypical populations (Grob et al., 2019; Lafavor, 2018; Tureck & Matson, 2012; Welsh et al., 2001). Therefore, learning to navigate the social world in which we all exist, is a vital skill, not only for autistic individuals, but for everyone.

Previous research has indicated that participation in physical activity and movement-based therapies, such as dance movement therapy (DMT), can have beneficial effects for autistic individual's social communication skills (Berlandy, 2019; Chan et al., 2020; DeJesus et al., 2020; Howells et al., 2019; Sam & Tong, 2015). Briefly, DMT offers embodied interventions and recognises the importance of bodily movements for communication and expression. It involves the psychotherapeutic use of movement to promote emotional, social, cognitive, and physical integration of the individual and aims to improve both physical and mental wellbeing (ADTA, 2014). The therapy tends to focus on non-verbal communication through the use of mirroring, rhythmic patterns, synchrony, and physical expression, whilst support is offered for the development of therapeutic relationships through movement and dance (Meekums et al., 2015). DMT or utilising the specific elements of DMT may be particularly beneficial for enhancing autistic children's social communication skills as it: 1) draws on the application of the embodiment theory (Eigsti, 2013), 2) may encourage understanding of non-verbal communication and empathy through the interpersonal synchrony of bodily movements (Berrol, 2006), and 3) could support the strengthening of the mirror neurone system (Rizzolatti & Craighero, 2004). These multi-modal theories support the notion that movement and body-based activities may improve social communication skills through concurrent influences, which are explored throughout the body of this thesis and may also lessen the double empathy problem (Figure 1.1).

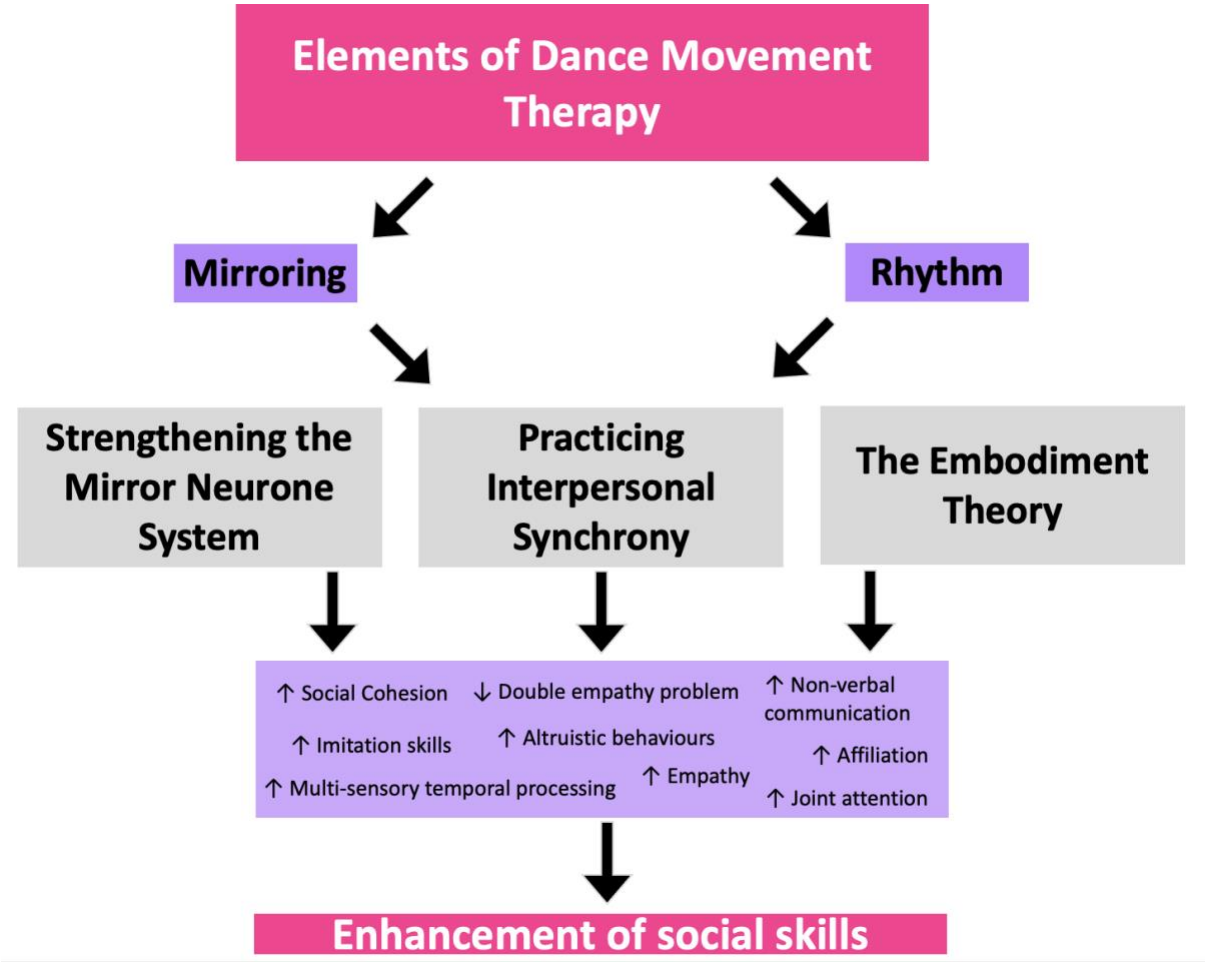


Figure 1. 1 Schematic diagram to illustrate the links between the key elements of dance movement therapy and possible rationales for how they enhance autistic children's social communication skills.

Briefly, the embodiment theory proposes that thoughts, feelings, and behaviours are grounded in sensory experiences and bodily states and, therefore, we can learn, acquire skills, and develop affordances from both movement and our lived experiences with the social world (Barsalou, 1999, 2008; Loveland, 1991). Similarly, the practicing of interpersonal synchrony during movement-based interventions such as DMT may have downstream effects on social skills as interpersonal synchrony has continuously been linked with positive social influences. For example, improving social cohesion, enhancing affiliation with others, and increasing the likelihood of altruistic behaviours towards other

(Behrends et al., 2012; Cirelli et al., 2014; Fitzpatrick et al., 2017; McNaughton & Redcay, 2020). Lastly, the mirror neurone system represents a specific class of neurons that fire both when an individual executes a motor act and when they observe another individual performing the same or a similar motor movement. These neurons were first discovered in monkey's brains. In humans, brain activity consistent with that of mirror neurons has been observed in the premotor cortex, the supplementary motor area, the primary somatosensory cortex, and the inferior parietal cortex (Acharya & Shukla, 2012). Activation of the mirror neurone system has been linked to the understanding or simulation of other people's action and may extend to understanding the emotions of others and showing empathy (Berrol, 2006; Iacoboni & Dapretto, 2006).

Despite the observed positive effects of physical activity for autistic individual's social skills, it is apparent that autistic individuals often partake in more sedentary activities, such as videogaming, than their typically developing (TD) peers (Engelhardt et al., 2017; Mazurek et al., 2012). Therefore, avenues have been explored to enhance autistic children's participation in physical activity and investigate activities that are intrinsically motivating for this population. For example, utilising videogames that incorporate exercise may be an ideal platform to increase physical activity levels while reducing some of the traits associated with autism that may reduce QoL. For example, reducing challenges to social communication skills or increasing motor skill proficiencies. These types of interventions may not only help to alleviate some of the potentially impairing traits of autism but may also help to address some of the various health inequalities, such as the rising rate of obesity within the autistic population (Curtin et al., 2010; McCoy et al., 2016). However, such interventions should be person-centred and focus on behaviours that are most impairing to each individual due to many autistic individuals viewing their diagnosis as a neurodiversity and something that should be rightfully celebrated, not dampened.

1.2 Rationale for this research

A detailed report, exclusively reviewing the cost of autism in the UK in 2001, estimated a figure of £1 billion for the total annual cost of autism (Järbrink & Knapp, 2001). However, a report later published in 2014 estimated the aggregate national costs each year of supporting autistic children in the UK were closer to £3.2 billion (Buescher et al., 2014; Knapp et al., 2009). This indicates a substantial increase in the cost of autism and could reflect the relative increase in the prevalence of autism (Jick & Kaye, 2003). For example, a trend analysis of boys born in the UK between the years of 1988 and 1993, suggested that the cumulative incidence of autism in the UK rose from approximately 7/10,000 boys to approximately 28/10,000 boys, thus documenting a marked and progressive increase in the incidence of diagnosed autism over just five years (Kaye et al., 2001). With more and more children being diagnosed with autism each year, most likely due to improved recognition and understanding of the condition (Russell et al., 2022), there is a desire to cultivate new and innovative interventions that support autistic children's development and alleviate some of the functionally impairing facets associated with the condition. This will not only help with the personal and familial implications of autism but will also help to minimise the condition's financial impact on society and households. There is a general agreement between professionals that early intervention is central to enable an individual to reach their full potential, and in some cases, early intervention may reduce the need for services later on in life (Jordan et al., 1998; Matson et al., 2011).

With the knowledge above, there is a clinical and social need to explore trait-specific interventions that aid personal development in ways that still celebrate neurodiversity and do not try to impose neurotypical standards onto neurodivergent individuals. A study conducted by the UK's leading autism research charity, 'Autistica', indicated that improving

interventions that target social communication skills was one of the autistic community's top research priorities (Autistica, 2016). Furthermore, work by Autistica has indicated that avenues to improve physical well-being should also be explored in upcoming research. Although several therapeutic interventions currently exist to aid social development for autistic individuals, they often feature an array of limitations that impact their use. For example, commonly employed social skills interventions including the Picture Exchanges Communication System (Bondy & Frost, 1994) and the Early Start Denver Model (Dawson et al., 2010) are often intensive and extensive in duration, require a trained professional to initially deliver them, often involve autistic individuals travelling to various sites, and can incur large financial costs if attended privately (Lee & Meadan, 2020). Furthermore, many social skill interventions include long durations of sedentary activity between the individual and the professional. Therefore, the present research attempts to address several key issues of current practice. It investigates the feasibility and potential effectiveness of an intervention to enhance social communication skills and ensures that it is a physical and engaging activity that is accessible to most, can be completed in a variety of environments, and is low cost.

1.3 Overall aim and objectives for this research

The overall aim of the current research is to explore interdisciplinary fields of neurodevelopmental psychology, social development, dance, movement, and physical activity. Therefore, the primary aim is to '*Investigate the use of a dance-based exergame in the home and school environments as a vehicle to enhance autistic children's social communication skills*.' In total, there were five objectives for this programme of work, which are described below.

The first objective aimed to collect, synthesise, and narratively review the existing literature to ascertain where research from the interdisciplinarity fields currently stood in relation to the overall aim of this research and to highlight directions for future studies. The second objective expanded into the realms of DMT and strived to confirm that core elements of the physical therapy, including mirroring and rhythm, were beneficial for autistic children's communication skills by systematically reviewing the literature. The third objective intended to explore the most commonly used and beneficial elements of rhythm and music for autistic children, responding to a gap in the scientific literature.

Due to the ongoing COVID-19 pandemic and becoming more engrained in autism research, it became apparent that additional work was needed to ensure that new interventions were accessible to a range of autistic children. Therefore, the fourth objective aimed to investigate the beneficial use of exergames (virtual exercise games) for autistic children by systematically reviewing the literature. To this end, the use of these games can be employed in the home or school environment on a variety of platforms, do not need a trained professional to deliver them, and incur low costs. The final objective strived to explore the feasibility and potential effectiveness of a dance-based exergame for enhancing autistic children's social communication skills in multiple environments, specifically the home and school settings.

1.4 Structure of this thesis

This thesis comprises a collection of papers that attempt to address the specific aforementioned objectives, which collectively endeavour to answer the overall aim of the current research. More specifically, I will investigate the use of a dance-based exergame in the home and school environments as a vehicle to enhance autistic children's social communication skills.

Chapter Two contains a narrative literature review that introduces autism and the topic of this current research. '*Dancing out for a voice; a narrative review of the literature exploring autism, physical activity, and dance'* investigates interdisciplinary fields of research to provide an overview of the literature surrounding communication and coordinated movement; outlining what is meant by communication challenges, exploring the benefits of coordinated movement for traits associated with ASD, and delineating how coordinated movement elicits positive outcomes for autistic children. This provides a sound introductory base to this programme of research.

Chapter Three includes two systematic reviews relating to the specific aims of the current research. Part A, '*The effectiveness of mirroring- and rhythm-based interventions for autistic children; a systematic review',* evaluates the effectiveness of both mirroring and rhythm as interventions in studies from 1975 – 2020 that targeted communication skills and social development in children diagnosed with ASD to better understand their beneficial use outside the practice of DMT. Part B, '*The non-fitness-related beneficial effects of exergames for young autistic individuals; a systematic review*', reviews the literature for articles published between 1990 – 2020, which concentrated on the effectiveness of exergames for improving various autism-specific traits, exclusive of physical fitness-related outcomes, to understand the functional benefits of participating in exergames for autistic children.

Chapter Four is an empirical chapter comprising of three studies, which strive to answer varying gaps in the literature relating to specific objectives and the overall aim of the current research. Part A, '*Dance, rhythm and autism spectrum disorder; an explorative study*' is the first experimental study of this programme of work and it investigates the most common features of music and rhythm used by registered dance movement therapists during their DMT sessions with autistic children. Part B, '*Assessing the feasibility of a dance-based exergame for enhancing social-communication skills in young autistic individuals in the*

home environment', is a small-scale mixed-methods study, which investigates the feasibility of a collaborative protocol for introducing a dance-based exergame into the home environment to enhance autistic children's social communication skills. Part C, '*Assessing the feasibility of a dance-based exergame for improving social-communication skills in young autistic individuals in the school environment*' follows on from the home-based study and is another small-scale mixed-methods study that examines the feasibility of introducing a dance-based exergame into two special educational schools. Further, both studies conducted limited-efficacy testing within participants to assess the potential effectiveness of the dance-based exergame for enhancing autistic children's social communication skills based on parent and teacher reports, respectively in the two environments.

Chapter Five attempts to discuss all the relevant parts and chapters of this thesis; initiating inferences that can be drawn, highlighting limitations of the current work, and providing directions for future research. This chapter discusses the implications of the findings in relation to current practice and emphasises the significance and originality of the studies and their contribution to the field. Finally, this chapter brings the thesis to a close and provides an in-depth conclusion to the programme of work.

1.5 Methodology employed

Qualitative and quantitative procedures ought not be viewed as rigid and distinct categories, nor should they be presented as opposites or dichotomies. Instead, qualitative and quantitative methods represent differing ends of a continuum; where mixed methodology research resides in the middle of this continuum, incorporating elements of both qualitative and quantitative approaches (Newman et al., 1998). Although the mixed-methods research approach is relatively new, it is fast growing in its popularity and use (Maxwell, 2015; Shorten & Smith, 2017; Wasti et al., 2022). Creswell (2007) defines

mixed-methods research as an approach that combines both quantitative and qualitative forms, involving philosophical assumptions and the mixing of qualitative and quantitative approaches in tandem so that the overall strength of a study is greater than either qualitative or quantitative methods alone.

When determining questions relating to the feasibility and effectiveness of a dance-based exergame for autistic children's social communication skills, the emphasis may seem to lie in generating quantitative data. However, the exclusive use of quantitative outcome measures may neglect subtle changes in an individual's presentation and does not afford the in-depth exploration regarding the feasibility and acceptability of the intervention by those implementing it (Meekums, 2010). Therefore, mixed-methods approaches can, in instances such as this, be superior to single-method designs as this type of research strategy can answer questions that the other single paradigms cannot. Although, the worldwide standards and acceptance of 'Evidence Based Practice' credits the requirement of rigorous quantitative approaches, with meta-analyses and randomised controlled trials (RCT) ranked top in the hierarchy of evidence (Murad, et al., 2016), these methodologies are unable to capture the nuanced experiences of participants and the perceived feasibility of interventions. Whereas a mixed-methods approach can provide stronger inferences as the data are drawn from multiple perspectives. One method can provide depth, whilst the other may afford greater breadth; confirming or complementing each other (Creswell, 2013). For example, quantitative data may be used to measure the effectiveness of an intervention on a specified outcome, whilst the qualitative data are used to explain the process of the intervention and its acceptance by participants. Therefore, the Medical Research Council (MRC) and National Institute for Health Research (NIHR) guidance for developing and evaluating interventions identifies the importance of a thorough feasibility evaluation and a measurement of effectiveness, requiring the use of both qualitative and quantitative

approaches (O'Cathain et al., 2019). This further strengthens the impetuous of using mixed-methods approaches within this body of research. As a result, a mixed-methods approach, aligned with a pragmatic view, was used to undertake and explore the aims of the current research - the feasibility and effectiveness of a dance-based exergame for enhancing autistic children's social communication skills.

Pragmatism, in its simplest sense, is a practical approach to address a research question and has strong associations with mixed-methods research (Johnson & Onwuegbuzie, 2004). It suggests that research should be designed and conducted in a way that best serves to answer a research question and that this can be achieved by employing qualitative or quantitative research methods or combining both approaches (Maarouf, 2019). Pragmatists often "recognise that there are many different ways of interpreting the world" and, therefore, undertaking research (p. 144, Saunders et al., 2019). This provides scope for embracing the complexity of human nature and the heterogeneity of autism, offering new insights and the appreciation of different realities for different individuals (Maarouf, 2019). Importantly, "pragmatism offers an immediate and useful middle position both philosophically and methodologically", providing a practical and outcome-orientated method of inquiry that is founded on action, leads, and reflection (p. 7, Johnson & Onwuegbuzie, 2004). Within the body of research presented in this thesis, dance movement therapists, teachers, parents, and autistic children were all used as sources of knowledge that can feed directly back into the growing knowledge base of how to develop a feasible, accessible, and engaging intervention for autistic children - seamlessly aligning with outcome- and action-orientated research (Dewey, 1989).

Creswell (2013) identified three basic models for conducting mixed-methods research: the convergent parallel design, the exploratory sequential design, and the explanatory sequential design. Throughout this thesis, the convergent parallel method of

data collection was adopted (Figure 1.2). This was due to the simultaneous collection of both qualitative and quantitative data, each having equal weighting and importance regarding the overarching research question (Bell et al., 2022). Overall, a mixed-methods approach enables researchers to combine empirical evidence with descriptive accuracy (Johnson et al., 2007; Johnson & Onwuegbuzie, 2004).

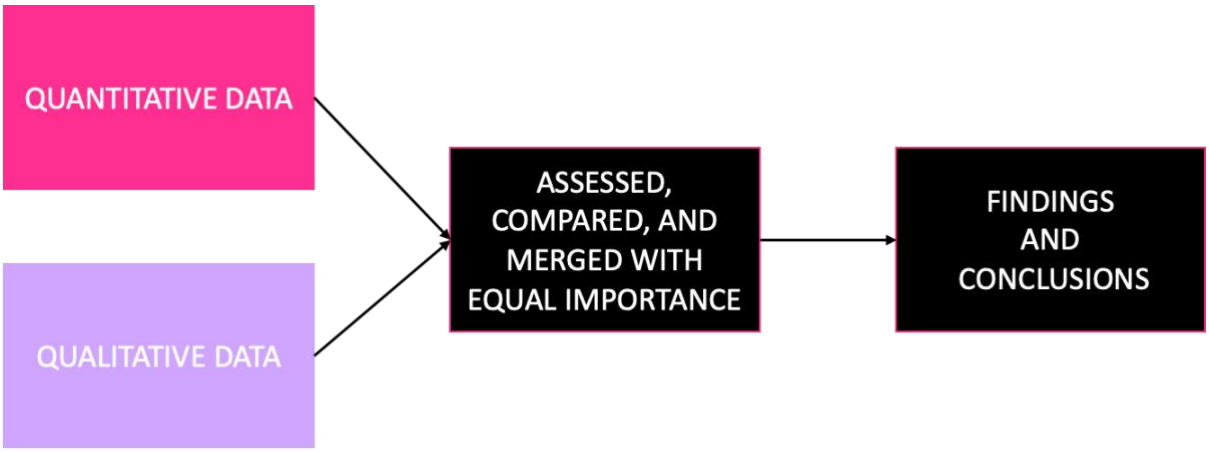


Figure 1. 2 Simplified diagram showing the convergent parallel design.

Several mixed-methods researchers who employ a pragmatic view ensure a purpose for mixing methods has been established - a rationale for why qualitative and quantitative data should be combined (Cherryholmes, 1992; Creswell, 2009; Morgan, 2007). After completing a content analysis of articles on studies using mixed-methods approaches between 1994 and 2003, Bryman (2006) identified 16 rationales for combining qualitative and quantitative methods. Aligning with the pragmatic approach of mixed-methods research, Table 1.1 includes the selected rationales identified by Bryman (2006) and how these were applied to the specific studies presented within this thesis.

Table 1. 1 Rationale for using mixed method research as defined by Bryman (2006) and application of rationale within this programme of work.

Rationale	Definition by Bryman (2006)	Application with this thesis
Triangulation or greater validity	"The traditional view that quantitative and qualitative research might be combined to triangulate findings in order that they may be mutually corroborated"	In this programme of research, combining text responses, behavioural observations, semi-structured, survey data, and standardised questionnaires will provide a greater insight into the feasibility and initial effectiveness of a dance-based exergame in two environments for autistic children's social communication skills
Offset	"Research methods associated with both quantitative and qualitative research have their own strengths and weaknesses so that combining them allows the researcher to offset their weaknesses to draw on the strengths of both"	Examining only quantitative measures (i.e., the standardised questionnaires or survey data) will neglect the nuanced experiences of the participants and their perceptions of acceptability, feasibility, and effect of the intervention
Completeness	"The researcher can bring together a more comprehensive account of the area of enquiry in which he or she is interested if both quantitative and qualitative research are employed"	The qualitative approach will illuminate the benefits of participating in *Just Dance* and afford a completer and more comprehensive overview of the feasibility of the intervention, complementing the quantitative outcome measures, such as the calendar-style grids
Explanation	"One is used to help explain findings generated by the other"	The qualitative measures, such as interviews or intervention-based observations should help to explain and give backing to the

		quantitative outcomes, such as the percentage of sessions completed and changes in children's social communication skills
Illustration	"The use of qualitative data to illustrate quantitative findings, often referred to as putting 'meat on the bones' of 'dry' quantitative findings"	The detailed behavioural coding and thematic analysis of the semi-structured interviews will shed light on how *Just Dance* may enhance social communication skills and why adherence may vary regarding feasibility
Process	"Quantitative research provides an account of structures in social life but qualitative research provides sense of process"	The quantitative measures will provide a numerical overview of feasibility and adherence to the intervention, whereas the qualitative measures will afford a sense of why adherence varied and participant's differing experiences
Credibility	"Employing both approaches enhances the integrity of findings"	Utilising a continuum of methods in data collection and analysis, will both complement and enrich the findings, whilst also strengthening the results and inferences that can be drawn
Utility or improving the usefulness of findings	"Combining the two approaches will be more useful to practitioners and others"	The findings will be more useful to dance movement therapist, parents, and school staff members when presented in a comprehensive and holistic manner – using real world examples

Hence, the qualitative data obtained within this programme of research attempts to shed light on the comprehensive, personal perspectives, and in-depth experiences of the

participants (dance movement therapist, parents, teachers, and children), whilst the quantitative data presents general trends and relationships in response to the research questions being asked. To address the overarching research aim of the thesis, the qualitative data consisted of text responses, behavioural observations, and semi-structured interviews. Meanwhile, the quantitative data consisted of survey data and standardised questionnaires (Figure 1.3).

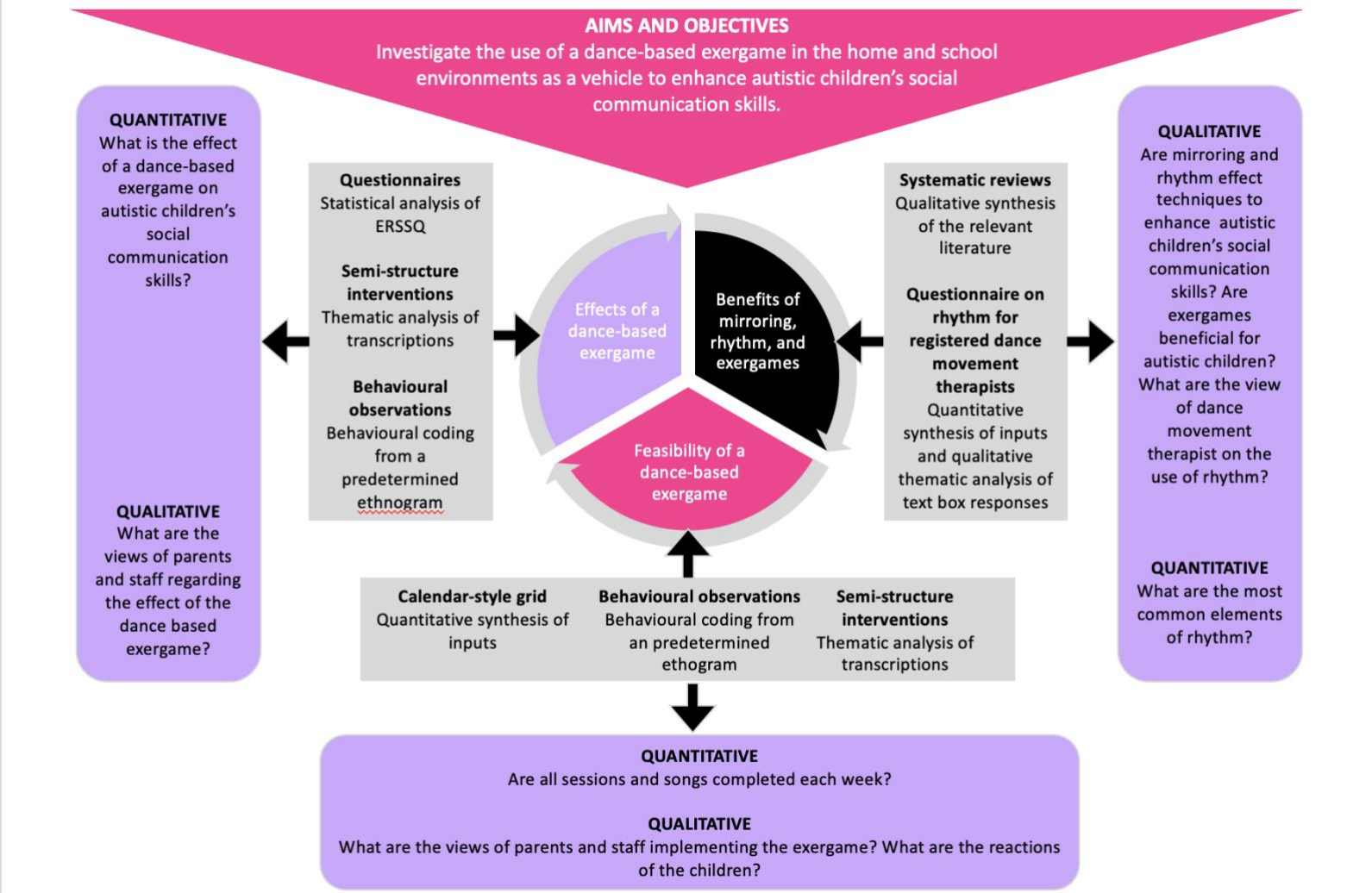


Figure 1. 3 Details the use of mixed methodology to explore qualitative and quantitative research questions relating to the overarching aim of this thesis.

1.6 Autism terminology and viewpoints upheld within this thesis

The use of terms to identify autism and people diagnosed with autism has long been a matter of contention. Currently, a range of terms are used to describe autism such as: 'autism', 'autism spectrum' (AS), 'autism spectrum disorder' (ASD), and 'autism spectrum condition' (ASC), being among the most widely cited. A distinction on the order of words, for example, person-first (person with autism) or identity-first (autistic person) language, is also evident. A study by Kenny et al. (2016) revealed that there is no consensus on one single term used to describe autism between autistic people, family members, and professionals working within the field of autism. This notion was reaffirmed by a more recent study suggesting that there is still no unified consensus on what term(s) should be used regarding the semantics of language and that the default option should be to actively seek out the preference of the autistic individual and/or their family (Lei et al., 2021). However, it is generally noted that autistic individuals often prefer the identity-first language (autistic person) and most commonly endorse the terms 'autism' and 'on the autism spectrum' to describe the condition (Botha et al., 2021; Bury et al., 2020). At present, the national health service (NHS) within the UK still commonly uses the term 'autism spectrum disorder' for its diagnoses. Therefore, the above terms (ASD/ASC) will be used inter-changeably throughout this thesis. Furthermore, throughout the thesis more of the identity-first language was used to reflect the preferences of autistic people. More recently, the use of terms such as 'high-functioning autism' and 'Asperger's Syndrome' have been scrutinised, especially due to the on-going debate regarding Hans Asperger's involvement in national socialism and its eugenic policies with Nazi Vienna (Czech, 2018). Therefore, terms such as those will not be used throughout the thesis.

The neurodiversity movement has been fast growing since the early 2000s and has been awakened largely due to the voices, advocacy, and protest of the autistic community,

facilitated through online communities and networks (Kras, 2010). The impact of the neurodiversity movement has progressively influenced academic, clinical, and lay understanding of autism. A central premise of the neurodiversity movement is that "variations in neurological development and functioning across humans are a natural and valuable part of human variation and therefore not necessarily pathological" (p. 2 Leadbitter et al., 2021). Furthermore, it advocates that challenges for autistic individuals arise from the interactions between the neurodiverse individual and an unaccommodating environment (Jaarsma & Welin, 2012).

According to Leadbitter et al. (2021), the implications of the neurodiversity movement on future interventions are three-fold. Firstly, neurodiversity-informed interventions oppose any attempts to 'cure' or 'normalise' autistic children or lead autistic individuals to mask their autism and attempt to 'pass' as neurotypical individuals. Secondly, interventions informed by neurodiversity should encourage and provide opportunities for physical activity and sensory or emotional regulation. Similarly, they should address a goodness-of-fit approach between the child and their physical or socio-emotional environment (Leadbitter et al., 2021). Finally, any neurodiversity-informed intervention should allow for a person-centred methodology that can help to address individual-specific challenges, avoid any possible causes of emotional harm, and respect and enhance those things that bring happiness and joy to the individual. Therefore, throughout the current programme of research, a conscious effort to uphold the influences of the neurodiversity movement was strived for and an attempt to move away from the pathological or medical model of autism was made (Pellicano & den Houting, 2022).

2 Chapter Two: Dancing out for a voice; a narrative review of the literature exploring autism, physical activity, and dance

2.1 Abstract

Autism spectrum disorder is characterised by profound challenges with social communication and social interaction. Currently, there are few therapeutic interventions that successfully target some of the functionally impairing traits associated with autism. Furthermore, many of these interventions comprise a variety of limitations, including limited accessibility, extensive durations, or the requirement of a trained professional to deliver the intervention. New research suggests that instead of targeting all traits associated with autism spectrum disorder with a single solution, scientific research should focus on providing therapeutic tools that alleviate functionally impairing facets specific to the individual. Owing to the nature of physical activity, sports and dance (coordinated movement) activities could provide opportunities to enhance communication skills and social development for autistic children. This chapter provides a narrative overview of the literature surrounding communication and coordinated movement; outlining what is meant by communication challenges, exploring the benefits of coordinated movement for traits associated with autism, and delineating how coordinated movement elicits positive outcomes for autistic children.

Keywords: Physical activity, Movement, Dance, Autism Spectrum Disorder, Communication

2.2 Introduction

2.2.1 Autism spectrum disorder

ASD includes a spectrum of neurodevelopmental conditions experienced by a large number of both children and adults across the world (National Autistic Society, 2019). At a symptomatic level, autism is most commonly described as persistent challenges to social communication and social interaction within multiple contexts and across restricted, repetitive patterns of behaviour, interests, or activities, which can result in significant disadvantages in social, occupational, or other main areas of functioning (American Psychiatric Association; APA, 2013). Although the direct cause of autism is unknown, the available evidence suggests that an interaction between genes and the environment results in changes from typical brain development (Chaste & Leboyer, 2012; Tordjman et al., 2014). Due to the complexity of the condition and its strong heterogeneity, new research proposes that instead of attempting to alleviate all facets associated with ASD with a single solution, scientific research should attempt to provide therapeutic tools that reduce individual traits, which may impair present functioning (Lombardo et al., 2019). These trait-specific interventions can then be used in combination with other practices aiming to minimise or reduce a variety of functionally impairing traits as defined by the individual; thus, leading to a better QoL for autistic individuals.

It should be recognised that some autistic individuals do not wish to be 'treated' or participate in interventions targeting facets associated with ASD as they see their diagnosis simply as a difference or neurodiversity and not something that requires intervention. However, due to the spectrum of autism, some autistic individuals or parents of autistic children may feel that they or their child could benefit from additional support whilst still celebrating their uniqueness. Increasing the development of trait-specific interventions will allow researchers and clinicians to target facets associated with ASD that may impact on QoL and enhance skills

already upheld by each autistic individual they work with (Hart, 2014; Kapp et al., 2013; National Autistic Society, 2019).

2.2.2 Communication is an autistic-prioritised outcome

The very earliest descriptions of ASD reported challenges to social interaction and limited communication skills (Kanner, 1943). At present, these difficulties and differences are central to the diagnostic definition of autism (APA, 2013), with social communication differences appearing to arise during early childhood and presenting in several different ways. For example, impairments in non-verbal communicative behaviours, challenges in social-emotional reciprocity, and difficulties in developing, maintaining, and understanding relationships. Such social communication differences can lead to a poor QoL, due to reduced interaction in recreational activities, the feeling of isolation, and increased loneliness (Chiang & Wineman, 2014; de Vries & Geurts, 2015; Wang et al., 2018). Owing to the impact of communication difficulties in everyday life, promoting social development and communication skills has been outlined as one of the autistic community's top priorities for research (Autistica, 2016). Researchers and practitioners should be working with autistic communities to address autistic-prioritised outcomes (Leadbitter et al., 2021). Therefore, developing new and innovative interventions that enhance autistic peoples' communication skills should currently be a top research priority. This will support neurodivergent individuals to successfully navigate the social world we all live in and ensure they can live as independently and as rewardingly as possible.

Although there have been advances in interventions and therapies that gently address the social communication differences experienced by autistic individuals in a supportive and caring way, more work is needed. For example, interventions that target communication skills, such as Social Skills Training, the Picture Exchanges Communication System (Bondy

& Frost, 1994), or the Early Start Denver Model (Dawson et al., 2010), are often intensive and extensive, require a trained professional to deliver the intervention, or require travelling to various sites to participate in the intervention (Lee & Meadan, 2020). Additionally, such social skill interventions often focus on teaching social skills and might rely on intellectual functions as it is reported that autistic children with higher IQs have been observed to respond better to interventions than those with lower IQs (Ben-Itzchak & Zachor, 2007; Herbrecht et al., 2009), or interventions can rely on explicit rule-based learning, for example learning how to respond in social situations such as greetings (Parsons & Mitchell, 2002). Similarly, many social skills interventions may rely on generating compensatory strategies. Ullman and Pullman (2015) suggest that in ASD, where socio-cognitive functioning typically differs, intact declarative memory ability may scaffold social behaviour taught in social skill interventions. For example, the ability to recall learned social rules may replace intuitive understanding of social cues, thereby contributing to an appropriate neurotypical social response and thus relying on a compensatory strategy. This demands explicit cognitive strategies, which may prove difficult or inaccessible for some autistic children (Koehne et al., 2016). As a result, several limitations exist when using the more 'traditional' styles of social skills interventions with autistic individuals.

In contrast, it is believed that physical activity, movement, and dance, also referred to as coordinated movement, can be used as exciting vehicles to enhance social communication skills in children on the autistic spectrum in a more naturalistic way, whilst also increasing QoL (Berlandy, 2019; Chan et al., 2020; Güeita-Rodríguez et al., 2021; Howells et al., 2019; Lee & Vargo, 2017). Such activities involving coordinated movement may address some of the barriers associated with the more 'traditional' styles of therapy. Exercise interventions can be much more cost-effective than traditional therapies as they often do not need a highly trained specialist or require intense individual support. Moreover, physical activity can be performed

in home-, community-, or school-based environments with minimal equipment or specialised supervision (Bremer et al., 2016).

Alongside enhancing communication and language skills, there is also a desire to improve the physical health of autistic individuals outlined by both Autistica and the National Health Service (Alderwick & Dixon, 2019; Autistica, 2018). Therefore, a better understanding of the available literature relating to coordinated movement for autistic children may benefit the design and implementation of evidence-based interventions, helping to not only support children's social development but also their physical well-being.

As a result, the aim of this review is to concentrate on the available literature exploring physical activity, movement, dance, and communication skills in autistic children; pooling the existing literature from interdisciplinary fields of research, such as psychology, sports psychology, neuroscience, and DMT into one coherent narrative review. A narrative review was deemed most appropriate, as the aim of this paper was to provide a broad overview of topic-related research fields. Furthermore, narrative reviews are often able to address multiple queries and synthesise a wealth of knowledge from several inter-disciplinary fields (Ferrari, 2015; Pae, 2015).

Firstly, the chapter defines communication challenges in autistic children and delineates what is meant by dance and physical movement, which is often referred to as coordinated movement. Secondly, the benefits of coordinated movement for an autistic individual are narratively explored, before focusing on common elements of dance movement therapy that may help to enhance communication skills. Finally, unlike many of the reviews available, this review explores the available evidence and theories that rationalise why these more naturalistic coordinated movement-based therapies are effective at enhancing social communication skills in autistic children. The review provides suggestions for how specific

components of coordinated movement interventions are underpinned by theory, allowing for real-world impact (Healy et al., 2018).

2.3 Methods

As previously mentioned above, a narrative approach was enlisted due to the primary aim of presenting a broad perspective on a range of diverse topics. A systematic approach was not enlisted as the strict process used in systematic reviews would restrict the breadth of information collected from the relevant literature bases and their interdisciplinary fields (Ferrari, 2015; Pae, 2015). Similar methods to those outlined by Green et al. (2006) were applied for this narrative review and the information used to write this chapter was collected from the sources listed in Table 2.1. The key terms were used to source and explore papers that focused on communication skills in autism and physical activity and dance as therapeutic interventions for autistic children's social communication skills.

Table 2. 1 Sources used for this narrative overview.

Sources	**Dates searched**	**Keywords used (relating to topics of narrative review)**
PubMed SPORTDiscus EBSCOhost MEDLINE Google Scholar	1970 - 2021	Autism, Autism Spectrum Disorder, Autistic Physical activity, Exercise, Sport*, Co-ordinated Movement, Dance, Dance Movement Therapy, Intervention Communication, Social Skills, Socia* Effect*, Benefic*,

Examination of the references included in retrieved and relevant articles	1970 - 2021

2.4 Communication challenges in autism

Social communication challenges may encompass an array of 'non-typical' or limited social skills. For example, impairments in social-emotion linguistic reciprocity may involve atypical social approach or failure of back-and-forth conversation, limited sharing of emotion, affect or interests, and failure to initiate or respond to social interactions. Challenges in paralinguistic or pragmatic communicative behaviours used for social interaction can involve a monotonous voice, inconsistent eye contact, atypical body language, limited understanding of context, and minimal use of gestures or facial expressions. Many of these social communication idiosyncrasies are observed in ASD. As communication skills are key to developing and maintaining personal and professional relationships, struggles with communication and social interaction can lead to both personal and professional difficulties, subsequently impacting QoL (Palmer et al., 2016; Wang et al., 2018).

As previously outlined, social communication challenges represent a core feature of ASD that are extensively relied on for its diagnosis. Generally, deviations in typical social development in an infant later diagnosed with autism are recognised by reduced frequency and diversity of communicative forms. This includes complex babbling, gestures, consonants in syllables, words and word combinations (Landa, 2007; Ronconi et al., 2016; Vivanti et al., 2017). Furthermore, opening social-communicative interactions with others that require integrated attention to social and non-social aspects of the context is also often reduced in autistic children (Hess, 2006). As a result, autistic children may have a reduced repertoire by which to initiate conversation and indicate their needs or requests to others. Consequently, their

effectiveness as communicators (initiating social bids and requests) is perceived as restricted in comparison to TD age-matched peers.

Autistic children are often observed to show reduced joint attention during infancy; reflecting difficulty in coordinating attention between objects and people, or between multiple people, a key skill required during social interactions (Frith et al., 2003; Mundy & Crowson, 1997). Due to difficulties in joint attention, children may struggle to use others' gaze as cues in word learning tasks (Franchini et al., 2019) or use eye contact and eye gaze appropriately during exchanges. It is also reported that early joint attention abilities are predictive of later language functioning and communication abilities in autism (Adamson et al., 2019; Poon et al., 2012). Therefore, if early joint attention can be enhanced for autistic children at an early age, it may reduce later language impairments and improve communication for social interactions.

Akin to joint attention, imitation is a social skill that allows for social connectedness and emotional sharing between humans. It is described as a 'core human skill, which is critical for the development of both social interaction and practical knowledge' (p. 279; Vivanti & Hamilton, 2014). For example, infant imitation allows a child to learn and explore other's actions and intentions, providing a vehicle for early communicative reciprocity (Landa, 2007). However, it is observed that autistic children typically demonstrate diminished imitation abilities, displaying less frequent spontaneous imitation and relating to their social interactions (Hobson & Lee, 1999; Rogers et al., 2003). Additionally, a previous systematic review including 21 well-controlled studies involving 281 cases of ASD found that, overall, autistic children performed significantly worse on imitative tasks than non-autistic individuals (Williams et al., 2004), consequently affecting their sensory and motor capabilities. Therefore, it may be inferred that limited imitation skills somewhat hinder communication skills and limit social interaction (Dadgar et al., 2017; Pusponegoro et al., 2016). Nonetheless, it is anticipated

that autistic children often have reduced and not absent imitation skills. Their ability to imitate objects and goal-directed imitation often remains relatively intact (Edwards, 2014; Sowden et al., 2016; Vivanti & Hamilton, 2014). Therefore, highlighting a potential target for therapeutic intervention to enhance and improve pre-existing skills.

Although autistic children may not possess 'typical' communication skills, they can still utilise and develop their own means of communication. Subsequently, routes should be explored to enhance autistic children's own form of communication and not just characteristic or neurotypical forms of communication. For example, children on the autistic spectrum may use various behaviours, such as stereotypy, aggression, or even self-injury in an attempt to communicate. Research suggests that up to 80% of 'challenging' behaviours may have a communicative function, demonstrating these behaviours are not meaningless (Goldstein, 2002; Watkins et al., 2017). Instead, they have a vital function for a significant number of autistic children. Resultantly, interventions focused on reducing challenging behaviours should also aim to provide an alternative means of communication to ensure autistic children still feel they have a voice.

2.5 Physical activity as a therapeutic intervention in autism

Coordinated movement and physical activity, whereby movement of the limbs is coordinated via motor control and energy is required, may offer an exciting vehicle to enhance joint attention abilities, imitation capabilities, and social communication development, whilst reducing behaviour that challenges. Thus, offering autistic children the opportunity to develop their own voice and enhance how they would like to communicate.

Research has increasingly investigated how coordinated movement and physical activity can be used as effective interventions to reduce functionally impairing traits typically associated with ASD. Several systematic reviews have been published highlighting the

potential strength of interventions involving coordinated movement and physical activity for improving outcomes in autistic individuals, including Chan et al. (2020), Howells et al. (2019), and Sam and Tong (2015). Overall, involvement in physical activity and coordinated movement appears to positively influence the primary areas associated with ASD, including social skills and repetitive movements. As enhancing communication skills and social development is an important research priority for the autistic community (Autistica, 2016), studies investigating physical activity and coordinated movement as interventions targeting social-communicative outcomes for autistic children are now explored and narratively reviewed (Table 2.2).

Table 2. 2 Brief overview of primary studies included in the narrative review, relating to physical activity for autistic individuals, including studies' authors, title, characteristics, and conclusions drawn from research.

Authors	**Title**	**Study Design**	**Participants**	**Intervention**	**Conclusion**
Bass et al. (2009)	The effect of therapeutic horseback riding on social functioning in children with autism	Randomised controlled trial	34 autistic children, aged between 4- and 10-years-old	Experimental group (n=19) were assigned 12-weeks of therapeutic horseback riding. Control group (n=15) were placed on a 12-week waitlist	Autistic children participating in therapeutic horseback riding showed greater sensory seeking and sensitivity, improved social motivation, and less inattention and distractibility than the control group
Best and Jones (1974)	Movement Therapy in the Treatment of Autistic Children	Within-participant repeated-measures study	4 autistic children, aged between 2- and 4-years-old	Children participated in 30-minutes of swimming and water aerobics activities for 10-weeks	Improvements in gross motor behaviours whilst in the water were reported. Furthermore, improvements in social functioning and vocabulary were also noted
Borgi et al. (2016)	Effectiveness of a Standardized Equine-Assisted Therapy Program for Children	Randomised controlled trial	28 autistic children, aged between 6- and 12-years-old	Experimental group (n=15) completed 6-months of once-weekly equine-therapeutic sessions; consisting of structured	Autistic children in the experimental group showed an improvement in social skills and a mild effect on motor abilities compared to the control group. Improved executive functioning was also observed at the end of the equine-therapeutic sessions

	with Autism Spectrum Disorder			activities including work on the ground and horse riding. Control group (n=13) were placed on a waitlist	
Chu & Pan (2012)	The effect of peer- and sibling-assisted aquatic program on interaction behaviors and aquatic skills of children with autism spectrum disorders and their peers/siblings	Controlled trial	21 autistic children and 21 typically developing children. All children aged between 7- and 12-years-old	Participants were assigned to three groups: peer-assisted group, sibling-assisted group, and control group. In each group there were 7 autistic children and 7 typically developing children. All children completed the twice-weekly after-school aquatic program for 16-weeks	Autistic children in the peer-assisted group and sibling-assisted group showed significantly more improvements on physical and social interactions compared to children in the control group. All groups improved their aquatic skills
Güeita-Rodríguez et al., 2021	Effects of Aquatic Therapy for Children with Autism Spectrum Disorder on Social Competence and	Mixed methods intervention study	6 autistic children, aged between 6- and 12-years-old.	Children completed Water Specific Therapy Halliwick sessions twice a week for over 7-months	Results showed statistically significant increases in perceived physical competence and aquatic skills, alongside improvements in social acceptance and advances in school functioning

	Quality of Life: A Mixed Methods Study				
Pan (2010)	Effects of water exercise swimming program on aquatic skills and social behaviours in children with autism spectrum disorders	Within-participant repeated-measures study (A-B design)	16 autistic children, aged between 6- and 9-years-old	Children completed a 10-week water exercise swimming program intervention consisting of 20 sessions; twice per week. The A-group (n=8) completed 10 sessions first, then the B-group (n=8) completed 10 sessions	Results indicated that water exercise and swimming sessions improved aquatic skills in the participants, holding potential for social improvements as children also showed a decrease in antisocial behaviours following the aquatic program
Toscano et al. (2018)	Exercise Effects for Children With Autism Spectrum Disorder: Metabolic Health, Autistic Traits, and Quality of Life	Randomised controlled trial	64 autistic children, aged between 6- and 12-years-old	Experimental group (n=46) were exposed to a 48-week exercise-based intervention; involving coordination and strength exercises. Control group (n=18) continued with treatment as usual and maintained their usual levels of daily activity,	Children participating in the exercise-based intervention showed greater positive effects in their improved metabolic health and reduced autistic traits relative to the control group. Parent's perceptions of their children's quality of life also significantly increased more so for those in the intervention group, in comparison to those in the control group

				without additional exercise components	
Van den Hout and Bragonje (2010)	The effect of equine assisted therapy in children with autism spectrum	Within-participant repeated-measures study	60 autistic children, aged between 2- and 14-years-old	Children participated in once-weekly equine assisted therapy sessions for 10-weeks	A significant improvement in autism presentation was observed for children following 10-weeks of equine-assisted therapy. Effects on specific areas of functioning measured were all significant, with the most positive effects on sociability and sensory/cognitive awareness
Vonder Hulls et al. (2006)	Clinicians' perceptions of the benefits of aquatic therapy for young children with autism: A preliminary study	Qualitative survey study	18 aquatic occupational therapists treating young autistic children (aged between 4- and 10-years-old)	Participants responded to a survey requesting their opinions on changes observed in skill performance as a consequence of aquatic therapy	All of the therapists surveyed indicated an increase in skill performance for tolerating touch, initiating and maintaining eye contact, and concentrating or paying attention. The most frequently reported benefits ranged from improving physical skills (e.g., improved strength, balance) at the body's functional level to increasing social participation
Watters and Watters (1980)	Decreasing self-stimulatory behaviour with physical exercise in a group of autistic boys	Within-participant repeated-measures study	Five autistic children aged between 9 and 11-years-old	Children participated in 27 language training sessions. After each session, one of three conditions followed: (1) Physical exercise (8-10	It was found that the lowest levels of self-stimulation followed the physical exercise condition. However, no differences were found between conditions for accurate question answering

				minutes of jogging), (2) TV watching, or (3) regular academic work.	
Yilmaz et al. (2004)	Effects of swimming training on physical fitness and water orientation in autism	Case study	1 autistic child, aged 9-years-old	The child completed a water based programme based on the Halliwick method. Completing three sessions per week for 10-weeks	The results showed that swimming training and water exercises were effective for the development of physical fitness and water orientation capabilities for the autistic participant. Stereotypical movements (spinning, swinging and delayed echolalia) also decreased
Zachor et al. (2017)	The effectiveness of an outdoor adventure programme for young children with autism spectrum disorder: A controlled study	Controlled trial	51 autistic children, aged between 3- and 7-years-old	Experimental group (n=30) participated in a 13-week outdoor adventure programme, completing weekly challenging physical activities. Control group did not participate and continued as normal	Children in the experimental group showed a significant improvement in social communication skills; social cognition, social motivation, and autistic mannerisms, in comparison to the control group

Zhao and Chen (2018)	The Effects of Structured Physical activity Program on Social Interaction and Communication for Children with Autism	Randomised controlled trial	50 autistic children, aged between 5- and 8-years-old	The experimental group (n=25) completed a 12-week structured physical activity program consisting of 24 exercise sessions, which targeted social interaction and communication	Results showed an overall improvement in social skills and social interaction for the experimental group and improvements were also observed in communication, cooperation, social interaction, and self-control. However, no changes were observed for the control group

1.1.1. Aerobic exercises and activities

Some of the earliest research, demonstrating that physical activity may improve functional outcomes in autistic children, was completed by Watters and Watters in the 1980s. They reported that performing regular aerobic exercise for 8-minutes reduced self-stimulating behaviour, such as rocking, pacing and hand flapping in five-to-six year old children diagnosed with ASD (Watters & Watters, 1980). Although the authors did not investigate the effect of aerobic activity on communication skills, this study highlights the early potential of coordinated movement for addressing some of the traits associated with ASD.

Zachor et al. (2017) conducted a controlled trial with 51 autistic children. 30 participants completed an outdoor adventure programme for 13-weeks involving challenging physical activities. The activities, such as a climbing a two-way rope ladder and conquering a rope bridge, all required the children to communicate with their programme instructors and peers. Another 21 participants acted as a control group and did not partake in the adventure programme. The results revealed significant improvements in social communication and opposing directions of change in the two groups for social cognition, social motivation, and autistic mannerisms subdomains of the Social Responsiveness Scale (Constantino et al., 2003). The intervention group receiving the outdoor adventure programme showed a significant propensity towards decreased ASD-symptomology, whilst the control group showed an increase (Zachor et al., 2017). Thus, highlighting the positive benefits of physical activity for social skills.

Similarly, Toscano et al. (2018) examined the effects of a 48-week exercise-based intervention on the psychosocial health of autistic children in a randomised controlled trial (RCT). The authors reported a substantial improvement in children's psychosocial health score as measured by the Child Health Questionnaire (Raat et al., 2002) following the exercise-based intervention. Despite the robustness of a RCT protocol, the study relied on parental perception

of their child's profile changes. Therefore, future research may attempt to include complementary data from direct observations in their methods, alongside parent-reported measures.

Zhao and Chen (2018) implemented a 12-week structured physical activity program, which included 24 exercise sessions focusing on social interaction and communication with 41 autistic children. Both the Assessment of Basic Language and Learning Skills-Revised (Partington, 2008), and the Social Skills Improvement System Rating Scales (Gresham & Stephen, 2007) revealed statistically significant improvements in social interaction and social skills across the experimental group between pre- and post-programme results. Significant advances were also reported in communication, cooperation, social interaction, and self-control subdomains. This study demonstrated the benefits of coordinated movement in enhancing communication and social-communicative skills of autistic children. However, in the absence of a retention test, it is not clear whether the observed results were temporary or permanent. It would be interesting to conduct a similar study and include a follow-up study after the structured physical activity program to assess if improvements were transient. Nonetheless, the previous studies all provide support for coordinated movement as an important therapeutic intervention for autistic children targeting social development.

1.1.2. Swimming and aquatic physical activity

Alongside more linear forms of physical activity such as running and aerobic activity, the implementation of physical activity programmes concerning water aerobics has shown several beneficial effects in children who had a diagnosis of autism (Best & Jones, 1974; Pan, 2010; Yilmaz et al., 2004). For example, in a sample of autistic children (n = 4), the therapeutic use of water activities was found to support language development and facilitate self-concept, which are vital skills for effective communication (Best & Jones, 1974). However, this early

study was conducted within a small sample size, thus limiting its clinical significance. Since, a 10-week water exercise swimming program including 16 autistic boys was observed to produce significant improvements in aquatic skills and social-communicative behaviours as rated by the children's teacher using the School Social Behaviour Scales (Pan, 2010). Therefore, supporting the benefit of swimming for autistic children in a larger sample size.

Similarly, Chu and Pan (2012) reported that peer- or sibling-assisted swimming twice a week for 16-weeks improved social behaviours and social functioning in 21 autistic children. Subsequently, emphasising the successful use of swimming as a promising vehicle to enhance communication skills in autistic individuals. More recently, a multi-method study was conducted to evaluate the effects of swimming and aquatic therapy on autistic children's social competence and QoL (Güeita-Rodríguez et al., 2021). The study involved six children completing two 60-minute aquatic therapy sessions per week, for 7-months. The results revealed statistically significant improvements in social and physical competence; further promoting the important implications of aquatic programs and interventions for improving social outcomes in autistic children. However, this study had a relatively small sample size, and would therefore benefit from increasing the sample size to improve reliability and likelihood of clinical significance.

Nonetheless, a pilot study was conducted amongst occupational therapists, who often used water aerobics when working with autistic children and their families, to gain a greater understanding of the benefits of aquatic therapy from a clinician's perspective and the use of aquatic-based interventions for autistic children (Vonder Hulls et al., 2006). The most frequently reported benefits were improved performance in underlying skills at the body's functional level and increased social participation. The majority of therapists noted an improvement in eye contact, conversation skills, play skills, and turn-taking skills following aquatic therapy. The study demonstrated the successful integration of swimming and aquatic-

based therapy into practice, highlighting positive social-communicative outcomes for autistic children outside of the scientific literature.

1.1.3. Horse riding and equine-assisted physical activity

In addition to water-related physical activity, equine-related coordinated movement has been observed to have positive impacts for autistic children. Van den Hout and Bragonje (2010) employed a large study examining the effect of horse riding in 60 autistic children on the overall autism presentation and specific areas of functions (sociability, communication, sensory/cognitive awareness and physical behaviour). Results indicated that equine-assisted therapy significantly decreased areas of ASD, correlating with the quantity of horse-riding lessons. Moreover, significant improvements in all areas of functioning were observed, with particularly large effects noted in sociability and sensory/cognitive awareness (Van den Hout & Bragonje, 2010). However, the authors did not employ a control group. Therefore, the effects observed in the study cannot definitively be attributed to treatment effects. Bass et al. (2009), also explored the benefits of therapeutic horse-riding on social functioning in autistic children. However, they did employ a between-group comparison of the experimental group (n = 19) and control group (waiting-list, n = 15). Bass et al. (2009) reported that horse-riding for autistic children was associated with greater sensory seeking and social motivation, less inattention, distractibility and sedentary behaviours. As a result, equine-related coordinated movement may be a potentially efficacious intervention for autistic children.

Borgi et al. (2016) further supported the notion of therapeutic riding as a complementary intervention strategy for autistic children by conducting a RCT. Children who participated in the 6-month equine-assisted therapy showed a time-dependent improvement in social functioning compared to the waitlist control group. However, Borgi et al. (2016) noted a limitation of their study were the differing baseline scores in some of the domains assessed

between groups, which subsequently could have impacted the post-intervention scores. Therefore, the study may have benefited from matching participants before randomly assigning them to their groups. Nonetheless, the results observed fall in line with previous research demonstrating that the most frequently reported outcome of equine-assisted programs for autistic children was an improvement in social motivation and capabilities (Harris & Williams, 2017; Keino et al., 2009; Lanning et al., 2014; Srinivasan et al., 2018).

2.6 Dance as a therapeutic intervention for autism

Dance is a type of physical activity or coordinated movement that exists in the form of art, usually consisting of purposefully selected sequences of human movement requiring the coordination of different muscles. Dance teaches the importance of movement and fitness in a variety of ways, yet also allows one to express feeling and emotion through the use of rhythm and body positions (Camurri et al., 2003). It has also been used as a therapy to help several physical and psychological conditions, including depression – decreasing depression scores in individuals (Karkou et al., 2019), Parkinson's disease – promoting a significant improvement in Parkinson's disease symptoms as measured by standardised outcome measures (de Natale et al., 2017; dos Santos Delabary et al., 2018) and cancer – buffering perceived stress and pain in those receiving radiotherapy (Ho et al., 2016). As defined by the American Dance Therapy Association (ADTA), dance movement therapy (DMT) is the psychotherapeutic use of movement to promote emotional, social, cognitive and physical integration of the individual, for the purpose of improving health and well-being (ADTA, 2014).

Increasingly, dance has been shown to improve communication skills in various populations. In a group of high school females, attending weekly dance classes improved communication skills and allowed participants to communicate in their own style (Corteville, 2009). Further, Von Rossberg-Gempton et al. (1999) found that creative dance improved children's communication skills, cooperation skills, and awareness of others. The authors

suggest that creative dance and coordinated movement encouraged a bond between children through the sharing of ideas and physical space, and the acceptance of individual differences, leading to increased communication skills (Von Rossberg-Gempton et al., 1999). Similarly, a study conducted by Lobo and Winsler (2006) provided strong scientific evidence to support the use of dance and creative movement programs in early childhood for the improvement of social skills. Therefore, dance seems an excellent form of coordinated movement to enhance social development and improve communication skills for autistic children.

Outside of the scientific literature, dance movement therapists have consistently worked with autistic individuals and reported promising results through the successful use of mirroring, synchronous movement interaction, and rhythm to encourage connection and communication (Martin, 2014; Cozolino, 2014; Tortora, 2005). Before verbal language develops, infants and young children usually communicate through their bodies, using gestures and movements. For that reason, DMT is well suited to working with autistic children as it provides a holistic approach that incorporates the body and mind, thriving in the non-verbal realm of communication (Martin, 2014). Consequently, DMT focuses on a child's functioning in terms of body awareness, timing and rhythm, motor coordination, and social/communicative development. It is unsurprising, therefore, that DMT interventions may provide a potential pathway to integrate and enhance motor and social/communicative skills, which are often atypical in autistic children. The literature associated with DMT as an intervention for autistic individuals is now explored and narratively reviewed (Table 2.3).

Table 2. 3 Brief overview of primary studies included in the narrative review, relating to dance and dance movement therapy elements for autistic individuals, including studies' authors, title, characteristics, and conclusions drawn from research.

Authors	**Title**	**Study Design**	**Participants**	**Intervention**	**Conclusion**
Field et al. (2001)	Children with Autism Display more Social Behaviours after Repeated Imitation Sessions	Randomised parallel group trial	20 autistic children, aged between 4- and 6-years-old	Children were either repeatedly exposed to an imitation condition (n=10), where unfamiliar adults imitated their behaviour or they were exposed to a contingently responsive condition (n=10), where adults responded to their behaviour but did not imitate them	Distal and proximal social behaviours were observed to increase in children who were repeatedly exposed to adult imitation, in comparison to children in the contingently responsive group. Furthermore, solitary behaviours of children in the imitation group, including inactivity and playing alone, decreased as the sessions progressed
Hartshorn et al. (2001)	Creative Movement Therapy Benefits Children with Autism	Controlled trial	76 autistic children, aged between 3- and 7-years-old	Children in the intervention group (n=38) completed twice-weekly movement sessions for 2-	Following a 2-month period, children in the intervention group spent less time wandering and more time showing on-task behaviour than the control group. Furthermore, children who

				months, whereas the control group (n=38) continued with treatment as usual	participated in the movement sessions also spent less time showing negative responses to being touched and resisting the teacher
Hildebrandt et al. (2016)	We Dance and Find Each Other'1: Effects of Dance/Movement Therapy on Negative Symptoms in Autism Spectrum Disorder	Randomised controlled trial	78 autistic individuals, aged between 14- and 65-years-old	The study was subdivided into three consecutive rounds of the intervention within a two-year timeframe. Participants were randomly assigned to one of the three groups, one of which formed the waiting control group. The intervention group (n=55) participated in ten weekly sessions of manualised dance movement therapy, whilst the control group (n=23) continued with treatment as usual	A significant reduction in the overall negative symptoms experienced by autistic individuals was greater in the treatment group than for the control group

Koch et al. (2015)	Fixing the mirrors: A feasibility study of the effects of dance movement therapy on young adults with autism spectrum disorder	Controlled trial	31 autistic individuals aged, between 16- and 47-years-old.	Individuals in the intervention group (n=16) completed 7-weeks of a manualized dance movement therapy program once a week. The control group (n=15) did not participate in the intervention	Participants in the intervention group reported improved well-being, improved body awareness, improved self–other distinction, and increased social skills relative to the control group
Koehne et al. (2016)	Fostering Social Cognition through an Imitation- and Synchronization-Based Dance/Movement Intervention in Adults with Autism Spectrum Disorder: A Controlled Proof-of-Concept Study	Controlled trial	55 autistic individuals, aged between 18- and 55-years-old	Individuals in the intervention group (n=27) received a dance/movement intervention focusing on interpersonal movement imitation and synchronisation. Individuals in the control group (n=24) received a controlled movement intervention focusing on	Participants in the intervention group showed a significantly larger improvement in emotion inference than those in the control group, but this was not apparent for empathic feelings. Generally, the intervention group showed increased synchronisation skills and imitation tendencies, relative to the control group

				individual motor coordination. Both occurred for 10-weeks	
Mastrominico et al. (2018)	Effects of Dance Movement Therapy on Adult Patients with Autism Spectrum Disorder: A Randomized Controlled Trial.	Randomised controlled trial	57 autistic individuals, aged between 14- and 52-years-old.	Participants in the intervention group (n=35) participated in a 10-week manualised dance movement therapy intervention, whereas the control group (n=22) only received the intervention after a waiting period.	Although participants in the intervention group showed improvements in empathy, cognitive empathy, and mirroring abilities, these were not statistically greater than that of the control group.
Morris et al. (2021)	Dance, rhythm, and autism spectrum disorder: An explorative study.	Mixed-methods survey study	113 registered dance and movement therapists, aged not reported	Participants responded to a survey requesting their opinions on rhythm and music used within dance movement therapy sessions with autistic children	The most common features of music and rhythm therapists used within their sessions with autistic children included a 4/4 time signature, moderato tempo, and the inclusion of age-appropriate pop lyrics. Furthermore, dance movement therapists highlighted that rhythm and attending to rhythm were integral parts of their sessions with autistic clients for enhancing social skills

Samaritter and Payne (2017)	Through the Kinesthetic Lens: Observation of Social Attunement in Autism Spectrum Disorders	Mixed-methods, multiple case study	4 autistic children, with a mean age of 12.2-years-old	Children participated in dance movement therapy sessions in an outpatient clinical setting and sessions were recorded. Sessions were retrospectively analysed using four videos from each child reflecting four time points throughout the therapy process	Findings were summarised into an observation scale for interpersonal movement behaviours. Results showed a positive increase in interpersonal and social attunement behaviours between the first and fourth (final) time-points
Sharda et al. (2018)	Music improves social communication and auditory-motor connectivity in children with autism	Randomised controlled trial	51 autistic children, aged between 6- and 12-years-old	The intervention group (n=26) received 8–12 weeks of music sessions involving use of improvisational approaches through song and rhythm. The control group (n=25) were exposed to a structurally matched behavioural	Communication scores were higher in the intervention group post-intervention compared to control group. Furthermore, post-intervention brain connectivity was lower between auditory and visual regions in the intervention group compared to the control groups, often over-connected in autism. This lower brain connectivity was associated with improved communication for the intervention group

				intervention with no music	
Souza-Santos et al. (2018)	Dance and equine-assisted therapy in autism spectrum disorder: Crossover randomized clinical trial	Randomised controlled trial	45 autistic participants, aged between 5- and 12-years-old	Children were allocated to one of three groups and received 24 bi-weekly sessions in each group across 12-weeks. Children in the dance group (n=15) completed the 'TALT' dance programme. Children in the equine-assisted therapy group (n=15) completed tasks including horse approach, touch stimulation, and horse riding with various courses. Children in the dance and equine-assisted group completed both dance classes and equine-	Only the dance group showed a significant improvement in functional independence and more specifically, communication and psychosocial adjustments. Significantly greater improvements in classification of functioning was observed in the dance and equine-assisted therapy group

				assisted therapy sessions once a week	
Yoo and Kim (2018)	Dyadic Drum Playing and Social Skills: Implications for Rhythm-Mediated Intervention for Children with Autism Spectrum Disorder	Within-participant repeated-measures study	8 autistic children with a mean age of 10.8-years-old.	Each participant received a total of 8 individual dyadic drumming sessions. The intervention consisted of three stages: engagement, interpersonal coordination, and modulation	Children participating in the rhythm-mediated music therapy intervention improved their social skills, more specifically their cooperation and self-control skills. Furthermore, participants showed decreased asynchrony when tapping with a partner and greater engagement in joint action following the intervention

A recent systematic review highlighted seven studies, which were published between 1970 and 2018, focusing on the use of DMT for autistic individuals (DeJesus et al., 2020). Whilst many positive outcomes were observed for social development and communication skills, the authors concluded that future research should strive for greater scientific rigour in documenting the efficacy of DMT interventions for autistic individuals; attempting to improve the reliability and reproducibility of findings. Furthermore, only two of the seven studies were comprised of only autistic children. Nonetheless, DeJesus et al. (2020) reiterated the importance of both mirroring and rhythm during DMT for enhancing social skills in autistic individuals.

Siegel (1973) described working with four autistic children between the ages of 4- and 6-years-old in a nursery. Each child completed a nine-month intervention of DMT, which aimed to promote positive body-image building and an improved sense of 'self'. Siegel (1973) reported positive responses from the children and highlighted the use of verbal and non-verbal communication to encourage mirroring and reduce aggressive behaviours. Similarly, Boettinger (1978) explored mirroring in autistic children aged between 3- and 9-years-old during DMT. The author reported an increase in synchronous movement and communicative gestures, alongside a decrease in touch-aversion. Importantly, this study only included autistic girls, who are often underrepresented in the scientific literature, subsequently emphasising that coordinated movement can be beneficial for both boys and girls diagnosed with ASD.

Hartshorn et al. (2001) implemented two, 30-minute DMT-inspired sessions per week for 2-months for 38 autistic children. Results from the study demonstrated significant increases in attentive and on-task behaviours and a decrease in stress behaviours via behavioural observation. Further highlighting the utility of DMT for autistic children. Samaritter and Payne (2017) also investigated the use of DMT to elicit changes in

interpersonal movement behaviours in four young autistic children. Results were summarised into a movement observation scale termed the 'Social Engagement and Attunement Movement' (SEAM) scale. The authors reported positive increases in SEAM behaviours, attributing these improvements to social attunement. However, the small sample size and use of a novel observation measure somewhat limits the generalisability and validity of the findings. Nonetheless, the aforementioned studies suggest dance and coordinated movement are effective vehicles for enhancing social-communicative behaviours in autistic children.

Studies employing larger sample sizes and grounded in the 'gold-standard' of research methods - RCTs, have all demonstrated that dance can have positive effects for autistic individuals (Hildebrandt et al., 2016; Mastrominico et al., 2018; Souza-Santos et al., 2018). For example, Hildebrandt et al. (2016) demonstrated that participation in twice-weekly dance sessions helped to reduce negative traits associated with ASD in comparison to not participating in any dance sessions. Furthermore, Koehne et al. (2016) demonstrated in an active-control trial, that participation in a dance-based programme significantly improved emotion inference and synchronisation for autistic individuals in comparison to participation in an individual motor coordination programme. However, more work is needed to provide a scientific evidence base for the efficacy of using DMT as an early intervention for ASD, especially for autistic children as most available DMT studies appeared to include only adolescents and adults.

2.6.1 Element of mirroring within dance movement therapy

Throughout the literature, mirroring is regularly considered as a key element used during DMT. Tortora (2006) describes mirroring as the process of one individual, such as a dance movement therapist, imitating the shape, form, movement qualities, and feelings of

another individual's actions - whereby the dance movement therapist embodies an "emotional and physical mirror image" of their client (P.g. 504; Tortora, 2006). During DMT, mirroring is reported to help form a connection between the therapist and autistic child, enhancing meaningful imitation skills and social engagement (Berrol, 2006; Tortora, 2005). Several studies have demonstrated mirroring as an effective feature for enhancing communication skills in autistic individuals (Field et al., 2001, Hartshorn et al., 2001; Koch et al., 2015). Additionally, studies focusing on mirroring interventions in autistic individuals describe effects on the sensory-motor regulation of the subject, as well as social interaction with the environment and/or teacher/dance movement therapist (Hartshorn et al., 2001; Koch et al., 2015). As result, it appears that mirroring and imitation activities within DMT can be used to promote meaningful social skills and social interaction in autistic children.

2.6.2 Element of timing and rhythm within dance movement therapy

Referring to the use of a strong, regular repeated pattern of movement or sound, rhythm is incorporated in several aspects of DMT. The element of rhythm involves attending to not only external rhythms but also internal rhythms and can serve as a non-verbal unifier between individuals. Therefore, within DMT, the therapist may address the individual's ability to synchronise with external rhythms of their environments or internal rhythms such as their heartbeat. Attending to rhythm and the ability to synchronise with others has been associated with improved social outcomes, where interpersonal motor synchrony to musical rhythms serves as a vehicle to increase social bonds between social partners (Hove & Risen, 2009; Morris et al., 2021; Tordjman et al., 2015; Valdesolo & Desteno, 2011). During such interventions, the leader or dance movement therapist often utilise rhythm to attune to the autistic individual; helping to organise their feelings and facilitate interaction and communication (Amos, 2013; Levy et al., 2005; Martin, 2014). Whilst there is limited evidence focusing specifically on rhythmicity in DMT with autistic children, many dance

movement therapists report rhythm as a fundamental element of DMT (Amos, 2013; Behrends et al., 2012; Berlandy, 2019; Morris et al., 2021). Further, the use of rhythm has been extended to music-based interventions (Sharda et al., 2018) and rhythm-based interventions including dyadic drumming (Yoo & Kim, 2018), which have demonstrated successful positive changes in social skills in autistic children.

2.7 How coordinated movement alleviates symptomology in autistic children

The exact mechanism for how coordinated movement improves communication and other facets associated with autism are not yet clear. However, a possible explanation for the benefits of physical activity on social interaction and communication in children diagnosed with ASD is that physical activities often encompass a natural setting to promote positive social interactions, such as during sport or DMT (Lee & Vargo, 2017). It provides a vehicle to build successful relationships between the instructor and participants and also between the participants themselves in a group setting. Additionally, physical activity, movement, and dance provide several opportunities for interpersonal interaction, offering an ideal medium to engage in cooperative play, partnering for teamwork, and communication, which all benefit social skills and development (Lee & Vargo, 2017).

Possible explanations for reducing stereotypical and repetitive behaviours and subsequently allowing time for communication skills to develop, involve the idea of fatigue and automatic reinforcement. It is believed that fatigue, resulting from increased exercise, leads to decreased stereotyped behaviours (Lang et al., 2010). Alternatively, in some children, physical stimulation obtained through coordinated movement may be similar to that gained through stereotypy. It is hypothesised that repetitive and stereotypical behaviours, such as rocking and arm flapping, are performed as it produces a pleasant internal outcome for the individual (automatic reinforcement; Rapp et al., 2004). As

coordinated movements can include similar body movements that are observed in stereotypy or stimming, it may produce similar internal states in the individual and fulfil their need for automatic reinforcement (Lang et al., 2010). For example, repeating the same dance movements rhythmically to a piece of music may reduce the desire to produce stereotypic movements in the near future for that child. Similarly, higher levels of stereotypy have previously been associated with more significant impairments in social functioning in autistic children (Matson et al., 1997, 1998). A previous systematic review suggested that this relationship may be causal and not simply correlational (Lanovaz et al., 2013). Therefore, a reduction in functionally impairing stereotypy may help to improve social outcomes by providing greater opportunities for social development.

Swimming and aquatic-based physical activity programmes were observed to cause a reduction in antisocial behaviours and an increase in social behaviours (Pan, 2010; Chu & Pan, 2012; Yilmaz et al., 2004). All children, not only those diagnosed with ASD, can benefit from watching positive social interactions of others. During the swimming programmes, training and instructions were repeatedly given in very small groups (Pan, 2010; Chu & Pan, 2012). Furthermore, social interaction between the instructor and the children's peers were reinforced; for example, facilitating sharing exchanges, encouraging children to seek assistance from each other, and waiting in line for a turn. Additionally, the importance of instructors should be highlighted. During the study conducted by Pan (2010), the instructor to child ratio was 1:2. Each instructor had to physically guide their children through movement, explaining and demonstrating actions when the children did not understand, all whilst providing positive feedback (Pan, 2010). A favourable response to the individualised instruction could have increased motivation and enhanced competence, leading to increased social skills in the children and the development of positive relationships.

Zhao and Chen (2018) noted improved communication following their physical activity program, which incorporated the TEACCH model (Panerai et al., 2002). The TEACCH model is a validated intervention used when working with autistic individuals and incorporates physical structure, visual schedule cards and cues, and work systems. Zhao and Chen (2018) incorporated the structured instruction of the TEACCH model as a beneficial treatment strategy for facilitating language development; subsequently creating an environment that positively influenced the children's communication skills. Furthermore, Zhao and Chen (2018) ensured the integration of elements that created more opportunities for communication into their physical activity programme. For example, both teachers and volunteers were required to ask simple questions, encouraging the participants to answer and become active communicators. Additionally, the programme had a reward scheme to motivate the participants to engage in the activities program. Without realising, the children began to respond, with "thank you" or "bye-bye" and initiating eye contact to receive the reward (Zhao & Chen, 2018). Akin to Pan (2010), Zhao and Chen (2018) attributed the success of their programme in increasing communication and social competence to the instructor to child ratio (1:5). Therefore, highlighting the need for small groups and effective instructor to child ratios to ensure the success of physical activity interventions for autistic children.

2.7.1 Mirroring

When looking at the specific elements of DMT, mirroring appears to show a strong relationship between activity and social-communicative development (Fitzpatrick, 2018; Koch et al., 2015; McGarry & Russo, 2011; Morris et al., 2021). Further, a significant association exists between mirroring ability and early social communication in young autistic children (Hanika & Boyer, 2019). Therefore, social motor synchronisation and

mirroring may be important pathways to explore for understanding the social characteristics of autistic individuals.

Through utilising the body and effective coordinated movement, DMT attends to difficulties in emotional understanding and cognition (Shuper Engelhard & Vulcan, 2021). By mirroring the autistic child's movements and applying empathic reflection, DMT helps to create an understanding relationship between the child and dance movement therapist; enhancing emotional awareness of oneself and others (Devereaux, 2012; Fuchs & Koch, 2014). It is believed that these simple, non-verbal interactions in an enriching, trusting, and protected environment aids in the development of successful communicative relationships both during the DMT session and continuing to usual social interactions (Baron-Cohen & Wheelwright, 2004; Shuper Engelhard & Vulcan, 2021). This is further supported by the notion that shared understanding between individuals is generated ahead of speech, through body movements, physical responses, and non-verbal vocalisation (Delafield-Butt et al., 2020). As such, the paralinguistic and pragmatic features of an interaction establish the foundation of later, linguistic communication. Therefore, social communication is improved through the basic therapeutic modality of reciprocal and creative mirroring and motor synchrony.

Previous research suggests that pathways involved in the beneficial effects of social synchronisation and mirroring may include the role and function of the Mirror Neurone System (MNS; di Pellegrino et al. 1992; Rizzolatti & Arbib, 1998). Essentially, the MNS describes neurones that are believed to become activated when an individual is watching a movement/performance and when they are performing the movement themselves (Rizzolatti & Craighero, 2004). Therefore, the activation of the neurones in each individual somewhat mirrors each other – owing to the name mirror neurones. It is proposed that this system underlies our understanding, or simulation, of other people's actions, which may even

extend to understanding the emotions of others and showing empathy (Berrol, 2006; Iacoboni & Dapretto, 2006).

Since the discovery of the MNS, it is recognised that there is a network of areas involved in its functioning, including the *pars opercularis* of the *inferior frontal gyrus* and its neighbouring ventral area, which are activated during the observation and imitation of an action (Fitzpatrick, 2018). However, in autistic children it has been proposed that the MNS is somewhat impaired and reduced activations of the MNS have been observed – this is known as the 'Broken Mirror Theory' of autism (Becchio & Castiello, 2012; Dapretto et al., 2006; Iacoboni & Dapretto, 2006; Oberman & Ramachandran, 2007). The Broken Mirror Theory may provide some answers as to why reduced imitation skills are observed in autistic children. For example, reduced activity of the MNS is hypothesised to arise from limited social engagement; inferring that increased social engagement may lead to repaired functioning of the MNS (Becchio & Castiello, 2012). DMT utilises mirroring and engages the MNS, which may subsequently increase empathy, reciprocal behaviours, and social interactions between the teacher/dance movement therapy therapist and autistic individual (McGarry & Russo, 2011; Berrol, 2006). Furthermore, if mirroring is performed at an early age in ASD it may result in better communication skills and social interactions as the child develops (Martin, 2014). However, the Broken Mirror Theory of autism is not without its critics. Some researchers have since demonstrated that regions of the brain believed to contain mirror neurones show the same pattern of brain activity in both autistic children and TD children (Dinstein et al., 2010; Fan et al., 2010; Hamilton et al., 2007). Furthermore, a recent review of the role of mirror neurones concluded that there was no compelling evidence to suggest that autism is associated with a global dysfunction of the MNS (Heyes & Catmur, 2021). Overall, some researchers describe the evidence for a direct, causal relationship between the MNS regions of the human brain and the social difficulties

observed in autism as weak (Southgate & Hamilton, 2008). However, the degree to which activity in the MNS is preserved in autistic individuals may be associated with their autistic presentation; as such autistic individuals may not have a global deficit within the MNS, instead, they may have deficits within specific nodes of the MNS, somewhat relating to their presentation (Fan et al., 2010; Kana et al., 2011). This may also give rise as to why some imitation skills are preserved in autistic individuals and others are not. Despite the Broken Mirror Theory of autism gaining much criticism over the years and seemingly not offering a direct, causal relationship between neurobiology and the social challenges autistic individuals face, it presents a neurocognitive model of social behaviour that can be further explored and improved in order to understand the direct and indirect causes of social communication challenges observed in ASD.

Mirroring and the process of imitating, synchronising, and aligning movements in time between social partners may help to improve interpersonal motor synchronisation in autistic individuals, which has previously been associated with improved social outcomes (Behrends et al., 2012; Cirelli et al., 2014; Fitzpatrick et al., 2017; McNaughton & Redcay, 2020). It is observed that interpersonal synchronisation recruits brain areas that have previously been associated with social cognition and cognitive and emotional empathy, including the *ventromedial prefrontal cortex* and *inferior parietal lobule* (Koehne et al., 2016). As such, synchrony during social interactions is related to cognitive empathy in non-autistic individuals, with research demonstrating that this mechanism might be attenuated, but not absent, in autistic individuals (Koehne et al., 2016). Interestingly, increased synchrony with a social partner has been associated with symptom severity in terms of improved social functioning (McNaughton & Redcay, 2020). Further, dynamical measures of social motor synchronisation ability have been related to various measures of social competence that index ASD traits, providing initial support for a social motor synchrony

model of autism (Fitzpatrick et al., 2017). Therefore, attending to an individual's ability to mirror and synchronise to another's actions provides a promising avenue to enhance social skills and communicative outcomes for autistic individuals (McNaughton & Redcay, 2020).

2.7.2 Rhythm

ASD may include challenges to neurological connectivity between and within various areas of the brain (Kana et al., 2014; Lidstone et al., 2021). For example, in comparison to TD age-matched controls, autistic children are observed to have significantly weaker connectivity between the *amygdala* and several brain regions, including the *bilateral medial prefrontal cortex*, *temporal lobes*, and *striatum*, which are involved in social communication and repetitive behaviours (Shen et al., 2016). Similarly, disruptions in the connectivity of the *salience network* and *frontal cortex* of children with an autism diagnosis have also been reported (Hoffmann et al., 2016; Margolis et al., 2019). Such disruptions could affect the typical rhythms of sensory and social connectivity, resulting in a cascade of confusing perceptual experiences that affect the finely-tuned 'choreography' of social interaction (Amos, 2013).

Condon (1975) investigated the role of self-synchrony and interactional synchrony in communication and social interaction, suggesting these processes may be atypical in autistic children due to delayed sound processing. For example, an autistic infant may appear distracted from their caregiver as their sensory world lacks pattern and focus due to mistiming; subsequently compromising crucial sharing of experiences and vital rhythmic interactions between infant and caregiver (Condon, 1975, 1979; Trevarthen, 2011).

Researchers, investigating audio-visual processing, have demonstrated that the binding window (the window of time in which inputs from various sensory stimuli occur in quick enough succession to ascribe them to a single event) was twice as long for autistic

participants in comparison to a control group (600ms vs. 300ms; Foss-Feig et al., 2010). At a neurological level, this small difference in time can be sufficient to prevent or even inhibit multisensory experiences from blending into one single and coherent perception. Consequently, incoming sensory stimuli, such as sight, sound and smell, may not couple as smoothly. Unrelated events may be perceived as connected, whilst related events may be acknowledged without the precise timing that informs meaning (Amos, 2013). As a result, this large binding window may burden social interactions with irrelevant and confusing associations in autistic individuals. Attending to the feeling of rhythmicity and increasing knowledge of timing during DMT or physical activity could, therefore, have implications at a neurological level, helping to reduce the binding window and increase the likelihood of coherent social perception. As a result, the use of rhythm may be extremely beneficial in enhancing the social communication skills of autistic children (Morris et al., 2021).

2.8 Limitations and future directions

A multitude of studies show the great benefits of coordinated movement in TD individuals and research has highlighted the potential of coordinated movement and physical activity as a therapeutic intervention for autistic individuals. Specifically, physical activity-based interventions tailored to increase opportunities for communication demonstrate enhanced social interactions and communication skills in autistic children; thus, minimising a core and often functionally impairing trait of autism. Additionally, DMT (involving mirroring and rhythm) highlights the powerfulness of physical activity in the form of dance to positively influence social-communicative skills in the autistic population.

Despite the advantageous outcomes observed from many of the studies involving coordinated movement, conclusions must be drawn whilst recognising some of the studies' limitations. For example, many of the studies discussed are limited by their small sample

sizes, consequently restricting their generalisability. Therefore, research should aim to test hypotheses that explore beneficial elements of physical activity and dance in clinically relevant sample sizes, whilst using reliable and tested outcome measures. Additionally, some of the studies discussed utilised a case-study design or pre- and post-intervention testing within samples. Whilst these studies are useful and allow for detailed and in-depth analysis of the participant and subsequent outcomes, they are difficult to draw definite conclusions from when only examining the effect of an intervention. It is not possible to successfully attribute the observed positive (or negative) outcomes solely to the intervention without the presence of a control or comparison group (Gerstein et al., 2019). Subsequently, more studies, especially those exploring the effectiveness of an intervention, should strive to implement a control or comparison group into their design; aiming to randomise matched participants to specific groups, subsequently limiting potential bias and improving the validity of the results observed.

Additionally, determining the most advantageous duration and frequency of coordinated movement interventions for autistic children is necessary. For example, are smaller, more frequent physical activity sessions more effective than longer, less frequent physical activity sessions? The studies discussed within this narrative review used coordinated movement-based interventions that spanned from less than 10-weeks to 48-weeks. Therefore, determining the most advantageous duration of physical activity interventions may be beneficial and improve their integration into practice. Similarly, whilst DMT has already shown several positive effects utilising techniques such as mirroring and rhythm for autistic children, it is unknown if these techniques could be further enhanced. What is the optimum duration of DMT sessions for autistic children? What is the most beneficial group size - dyads or triads, during mirroring for autistic children? What is the most beneficial rhythm to use when working with autistic participants? Answering these

research questions could substantially improve the benefits of DMT observed in this population. Furthermore, many of the mirroring and DMT studies included mirroring between neurodivergent individuals and a trained neurotypical individual (Escalona et al., 2002; Field, 2017; Field et al., 2001; Morris et al., 2021). Future studies may wish to explore the effectiveness of child-to-child-based mirroring or child-to-parent-based mirroring, instead of child and therapist mirroring to further enhance and improve imitation skills and social interaction between autistic children or with their families. Similarly, new technologies could be explored to enhance or improve imitation abilities in autistic children, without the presence of trained professional; for example, mirroring a virtual avatar. Future research may also wish to investigate the most beneficial rhythm to use when working with autistic individuals to improve its acceptance.

Investigating the effects of combining these elements of DMT (mirroring and rhythm) into new sports/physical activity-based interventions could reveal impressive therapeutic benefits for autistic children's communication skills and social development. Therefore, it would appear beneficial to confirm the use of these elements in isolation and outside the practice of DMT. From this, improved interventions could readily be implemented into practice at a relatively low cost or used in special education schools during Physical Education (PE) classes. In addition, any schools or clubs that support autistic children could use such interventions during their PE lessons or warm-ups as the intervention would exist in a physical activity capacity, whilst simultaneously helping to develop communications skills and enhance social development.

From a clinical perspective, there is a requirement to explore methods used for increasing physical activity engagement in autistic children. Whilst the scientific literature suggests engaging in physical activity and coordinated movement elicits positive social outcomes, it is well recognised that there is a low rate of physical activity participation in

autistic individuals (Healy & Garcia, 2019; Srinivasan et al., 2014). A previous study found that in a sample of 83 autistic children, only 12% were physically active (Memari et al., 2015). Most children were found to engage in solitary play rather than physical social activities. Furthermore, the rate of physical activity participation was closely associated with sociodemographic variables, such as gender and family income. A more recent study, which analysed the weekly physical activity, sedentary behaviour, and body mass index classification of 33,865 individuals (autism spectrum disorder, n = 1036) from the 2016–2017 National Survey of Children's Health (United States), revealed that autistic children and adolescents engaged in less physical activity and were more likely to be overweight and obese compared to their TD peers (McCoy & Morgan, 2020). Such studies highlight the need to improve the accessibility of physical activities for autistic children; removing barriers and developing targeted programmes to increase participation rates of autistic children in physical activity.

Although an attempt to delineate how coordinated movement may lead to improvements in social skills was made, more work is needed to understand the mechanisms that may produce such improvements (Lang et al., 2010). Investigating the mechanistic processes that result in positive outcomes could further assist practitioners in the development of more efficient and effective programs targeting communication skills in children diagnosed with ASD. Further, understanding the key elements of physical activity and the biological or physical mechanisms that elicit positive and sustained outcomes could help integrate these approaches into practice. Therapists, teachers, sports leaders, and coaches might then draw on these elements to further support the social skills of autistic children during therapy sessions, PE classes, sports groups, or team games, subsequently aiding autistic individuals to integrate with their peers more effectively.

2.9 Conclusion

In conclusion, coordinated movement appears to offer substantial therapeutic benefits for autistic children. Physical activity and coordinated movement have been shown to enhance communication skills and social development, which may potentially improve QoL in autistic children. Mirroring and rhythm stand out as two key factors of coordinated movement in DMT that may elicit positive changes in social skills. The benefits of mirroring and rhythm should be confirmed in isolation and outside the practice of DMT to provide an impetuous for their use in novel interventions. Future research should also endeavour to improve sample sizes in which studies are conducted and explore mechanistically how physical activity leads to improvements in communication skills and social development. As a result, coordinated movement interventions and interventions employing mirroring and rhythm could be more readily recommended and implemented into social and clinical practice.

3 Chapter Three: Systematic reviews

Part A - The effectiveness of mirroring- and rhythm-based interventions for autistic children; a systematic review

3.1 Abstract

Autism spectrum disorder is characterised as a neurodevelopmental disorder that has continuing challenges in communication skills and social development. Utilising techniques known as mirroring and rhythm; dance movement therapy has shown positive effects in the autistic population helping to alleviate such challenges. However, no review to date has investigated these individual techniques outside the practice of dance movement therapy. This systematic review of studies published between 1975 - 2020 aims to evaluate the effectiveness of both mirroring and rhythm as interventions that target communication skills and social development in autistic children. Out of 1369 articles, 11 met the inclusion criteria. All studies suggested beneficial effects of mirroring and rhythm for communication skills and social development in autistic children. Therefore, incorporating these techniques into new interventions and practice may offer substantial therapeutic benefits for autistic children.

Keywords: Autism Spectrum Disorders, Mirroring, Rhythm, Communication, Social Development

3.2 Introduction

3.2.1 A gap in the literature

As previously discussed in Chapters One and Two, ASD is most commonly associated with differences in communication skills and social development. Continuing challenges with social communication skills and social development can be difficult for many individuals as these are often crucial for everyday functioning in the social world we live in. Such differences observed in autism, such as atypical eye gaze, reduced joint attention and imitation skills, and limited reciprocal conversation can negatively impact social interactions between communicative partners (Bourdon, 1999; Charman & Stone, 2008; Dereu et al., 2012; Eigsti et al., 2011; Franchini et al., 2019; Koegel & Rincover, 1977; Swanson & Siller, 2013; Tiegerman & Primavera, 1984). Often, this impact is exacerbated in social dyads involving an autistic individual and a non-autistic individual; known as the 'double empathy problem'(Crompton et al., 2020; Milton, 2012; Morrison et al., 2020).

Several studies have highlighted the use of DMT in alleviating some of the functionally impairing traits associated with ASD and enhancing communication skills and social development for autistic children (Martin, 2014; Cozolino, 2014; Tortora, 2005; Koch et al., 2015). Following on from the previous narrative review of the literature in Chapter Two, it is apparent that mirroring (i.e., emotional imitation/interpersonal motor synchrony) and rhythm (i.e., following beats, melodies, and keeping in time to the music) are key components of DMT that are extensively and consistently used. Chapter Two also highlighted an avenue for future exploration - investigating the use of mirroring and rhythm in isolation and outside the realms of DMT to suggest their application in novel interventions. Although, some studies and reviews have already highlighted the positive effects of DMT on communication skills and social development for autistic children

(Berlandy, 2019; Scharoun et al., 2014; Takahashi et al., 2019), no review to date has yet sought to investigate these specific techniques of DMT (mirroring and rhythm) in isolation and outside the practice of DMT to understand their individual effects on communication skills and social development. Therefore, it is necessary to investigate these techniques outside the realm of DMT to confirm their beneficial use. Examining the use of mirroring and rhythm outside the practice of DMT may help to further rationalise why dance movement therapists often use these techniques to support the development of communication skills in autistic children and provide an evidence-base for their use outside of DMT due to being low-cost and inclusive techniques.

3.2.2 Aims and objectives

This current study aims to review the literature that focuses on either mirroring or rhythm as interventions and investigate studies that have outcome measures assessing communication and social skills in autistic children. Outside the realms of DMT and within the scientific literature 'mirroring' and the process of 'imitation' are terms often used interchangeably. Therefore, in the current review, imitation is classified as mirroring if an experimenter/individual copies the movement of the child's actions in synchrony (i.e., completing the action as the child completes the action). To this end, imitation will henceforth be referred to as mirroring.

The potential therapeutic benefits of mirroring and rhythm will expectantly be highlighted, providing evidence that the techniques can be used effectively outside the practice of DMT for the development of prosocial behaviours for autistic children. As a result, dance movement therapists can more confidently use these techniques when working with autistic children. Furthermore, these techniques could be more readily integrated into interventions and programs, for example PE lessons or physical activities, which do not

have to be conducted by a dance movement therapists, thus increasing accessibility of the intervention.

3.3 Methods

3.3.1 Research question

A combination of the PICO and SPIDER strategies was used to help formulate a relevant research question and enhance the search for evidence in the chosen databases (Methley et al., 2014). PICO, where: P: population, patient or problem, I: intervention, C: control or comparative intervention, and O: outcome, is a useful tool commonly used for quantitative research. However, due to the nature of the studies expected to be assessed, the SPIDER strategy was also utilised, where: S: sample, P: phenomena of interest, D: design, E: evaluation of outcomes, and R: research type (Cooke et al., 2012). Using the criteria above, the following research question was formulated; "*What are the influences of the specific Dance Movement Therapy techniques, mirroring and rhythm, on the communication skills and social development of autistic children?",* where: P/S: autistic children (under the age of 12-years-old), I/P: mirroring/imitation, rhythm and dance movement therapy, O/E: communication, social interaction, social attention, and social behaviour, and R: quantitative, qualitative and/or mix-method. The search focused on studies that included participants under the age of 12-years-old in order to confirm that mirroring and rhythm can be beneficial for enhancing the communication skills of autistic children. It is believed that addressing communication challenges during early development be central to improving social skills and QoL in adolescence and adulthood (Jordan et al., 1998; Matson et al., 2011).

3.3.2 Inclusion and exclusion criteria

This review includes both blinded and non-blinded randomised control trials, parallel-group study designs, and pre- and post-intervention study designs published in English between January 1975 and March 2020. The interventions reported in the studies had to primarily focus on either mirroring or rhythm in order to be included. Additionally, the primary outcome measures had to clearly relate to either social development or communication skills, such as measuring eye gaze, joint attention, or standardised outcome measures. Studies that did not investigate mirroring or rhythm in samples of autistic children, reviews, letters, conference abstracts, or studies that had no relevant outcome measures were excluded from the review. Table 3A. 1 provides a summary of the criteria used for inclusion and exclusion.

Table 3A. 1 The requirements for inclusion and exclusion.

Inclusion	Exclusion
Paper in English	Paper not in English
Paper published between 1975 and 2020	Paper published before 1975
Participants younger than 12-years-old	Participants older than 12-years-old
Diagnosis of ASD	Participants do not have a diagnosis of ASD
Main intervention must use either mirroring or rhythm If a paper refers to mirroring as imitation, then imitation must be of the child, i.e., not teaching imitation	Single case studies, reviews, letters, and conference abstracts
Outcome measures must assess communication, social interaction, social attention and/or social behaviour	
Peer reviewed journals, articles and dissertations	

3.3.3 Literature search

Six databases were searched for the most appropriate and relevant documents that corresponded with the objectives of this review. EBSCOhost; which included PsycArticles (American Psychological Association – APA), PsycINFO (APA), SPORTDiscus and MEDLINE; Scopus and Web of Science were searched using combinations of the following descriptors: “autism”, “asd”, “autism spectrum disorder”, “autism spectrum disorders”, “mirroring”, “imitat*”, “rhythm”, “dance”, “dance and movement therapy”, “communication”, “social*, “early childhood” and “child*”, alongside the Boolean operators “or” and “and”.

For example, the search on Web of Science:

(“autism” OR “asd” OR “autism spectrum disorder”)

AND (“mirroring” OR “imitat” OR “rhythm” OR “dance” OR “dance and movement therapy”)*

AND (“communication” OR “social”)*

AND (“early childhood” OR “child”)*

3.3.4 Selection of studies and data extraction

The current review complies with the PRISMA guidelines for systematic reviews (Moher et al., 2009). Electronic searches were performed to obtain numerous articles concerning mirroring and rhythm as interventions for autistic children. A specific procedure was developed to extract relevant papers and articles and retrieve the necessary information. To this end, a search was carried out in the aforementioned databases using the search terms and Boolean operators previously provided. A six-phase selection procedure was then performed: Phase 1) combining all extracted articles into a single folder, Phase 2) removing

duplicates, Phase 3) analysing the article titles and selecting appropriate papers, Phase 4) reading abstracts of articles selected in phase 3 and identifying suitable paper abstracts, Phase 5) reading the full text of articles identified in phase 4 and assessing them against an inclusion and exclusion checklist (see Table 3A. 1), and finally, Phase 6) analysing the reference lists from articles that had been fully read for missed and relevant studies (Figure 3A.1).

Studies that matched the inclusion and exclusion checklist were fully read again and further analysed. A database was generated to retrieve particular information from the articles. This included:

- Author and year of publication
- Number and age of participants
- How participants were diagnosed or assessed for ASD
- The study's design
- Whether the study had a control or comparison group and if the study was randomised and blinded
- Specific intervention and DMT technique of interest
- Outcome measures utilised
- General results and conclusion

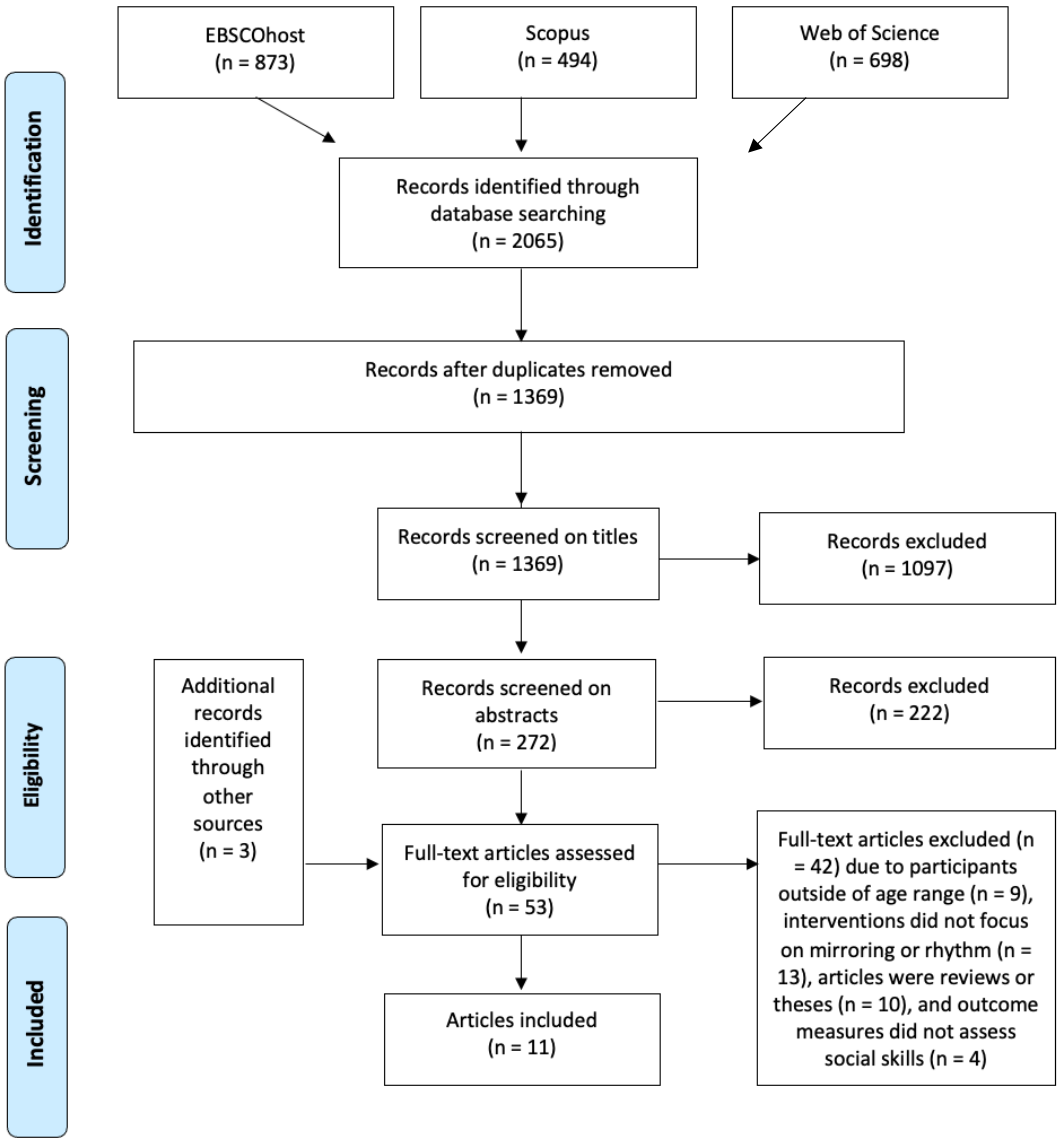


Figure 3A. 1 PRISMA flow diagram of the systematic literature review search (Adapted from Moher et al. (2009)).

3.3.5 Inter-rater reliability

Using the 'Dual Independent Review Approach' of the search results, the first author and an independent reviewer screened the titles and abstracts (EH; Stoll et al., 2019). The level of agreement between the reviewers was calculated using Cohen's Kappa, which is a statistical coefficient that represents the degree of accuracy and reliability in a statistical

classification (McHugh, 2012). Cohen's Kappa is routinely used to assess inter-rater reliability as it corrects for "chance" agreement between multiple researchers and allows for different types of disagreement to carry different weights (Jeyaraman et al., 2020). The degree of agreement is quantified by Cohen's K. One way to interpret Cohen's K is within a scale, where agreement is: poor (0), slight (0.1-0.2), fair (0.21-0.4), moderate (0.41-0.6), substantial (0.61-0.8), or near perfect (0.81-0.99) (Landis & Koch, 1977).

3.3.6 Risk of bias in included studies

The Cochrane risk of bias assessment guidelines was employed in this review; however, adaptations were made as not all studies were RCTs. As reported by the Cochrane handbook, bias can be defined as "a systematic error, or deviation from the truth, in results" (Boutron et al., 2019). It is somewhat unattainable to know the full extent of which biases affect the result of any particular study or analysis; therefore, it is apposite to deem the result at risk of bias rather than stating with certitude that it is biased (Savović et al., 2012). Using the "*the criteria for judging risk of bias*" in the Cochrane Handbook, it was established whether risk was low, high, unclear or not applicable for selection, performance, detection, attrition and reporting bias (Higgins et al., 2019; Sterne et al., 2019).

3.4 Results

3.4.1 Search results and description of studies

The initial search identified 2065 studies (EBSCO host = 873, Scopus = 494, and Web of Science = 698). After excluding duplicates and screening titles, 272 articles were selected. Abstracts were then screened to select specific studies for full-text reading. A total of 53 articles were fully read and eleven of these fulfilled the inclusion criteria. The

weighted kappa score for agreement between the two reviewers was 0.900, 95% Cl: 0.839 to 0.962, indicating near-perfect agreement.

Out of the eleven studies extracted, a total of eight were randomised, controlled, or parallel-group trials (Escalona et al., 2002; Field et al., 2001; Heimann et al., 2006; Katagiri et al., 2010; Sandiford, 2013; Sharda et al., 2018; Srinivasan et al., 2016; Warreyn & Roeyers, 2014). One study performed an alternating procedure design within-subjects (Tiegerman & Primavera, 1984), another was a simple pre-test, post-test intervention study design (Yoo & Kim, 2018), and the final study performed a multiple baseline study within-subjects (Reese, 2018). Only one study was fully blinded (Sharda et al., 2018) and 6 studies were fully randomised (Escalona et al., 2002; Field et al., 2001; Heimann et al., 2006; Sandiford, 2013; Sharda et al., 2018; Srinivasan et al., 2016). Warreyn and Roeyers (2014) attempted randomisation; however, took into consideration the location of rehabilitation centres participants attended and so participants were only partially randomised.

3.4.2 Characteristics of participants

This review focuses on specific DMT techniques used to enhance communication skills and social development in autistic children. Therefore, all participants in the selected studies were under the age of 12-years-old. The youngest age reported in all eleven studies was 2-years-old and the oldest was 12-years-old. Excluding Yoo and Kim (2018) as they did not report the mean age of participants in their study, the mean age of participants included in this review was 5-years and 7-months-old.

All participants had a diagnosis of ASD, most commonly assessed using the DSM-IV (American Psychiatric Association, 1994). Additionally, the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000), Autism Diagnostic Interview – Revised (ADI-R; Mazefsky & Oswald, 2006) and Childhood Autism Rating Scale (CARS;

Chlebowski et al., 2010) were used to measure ASD. The level of ASD varied throughout the selected studies; for example, in one study children's CARS scores ranged from 28–51.5 (Katagiri et al., 2010) whereas Escalona et al. (2002) implemented a cut-off CARS score of 38 for participants to be included in their study. This variability of ASD presentation not only between studies but also within studies is reflective of the heterogeneity of the disorder. Table 3A. 2 summarises the participants and study design used for each study.

Table 3A. 2 Characteristics of each study summarising the participants and study design used, including whether controls, randomisation and blinding was employed.

Authors	Title	Participants	ASD Diagnosis	Study Design	Control or comparison group	Randomised and blind	Follow up data collection
Tiegerman and Primavera, 1984	Imitating the Autistic Child: Facilitating Communicative Gaze Behaviour	6 children of pre-school age	Diagnosed with autism by psychiatrist	Alternating procedure design	No	No, No	No
Field et al., 2001	Children with autism display more social behaviours after repeated imitation sessions	20 children, aged between 4- and 6-years-old	Diagnosed according to DSM-IV criteria	Randomised parallel group trial	Yes, compared to contingently responsive play group	Yes, No	No
Escalona et al., 2002	Brief Report: Imitation Effects on Children with Autism	20 children, aged between 3- and 7-years-old	Diagnosed using DSM-IV by clinical psychologist	Randomised parallel group trial	Yes, compared to contingently responsive condition	Yes, No	No
Heimann et al., 2006	Imitative interaction increases social interest and	20 children, aged between	Diagnosed according to ICD-10 criteria	Randomised parallel group trial	Yes, compared to contingent interaction group	Yes, No	No

	elicited imitation in non-verbal children with autism	4- and 12-years-old					
Katagiri et al., 2010	Mirroring effect in 2- and 3-year-olds with autism spectrum disorder	6 children aged between 2- and 3-years-old	Diagnosed according to DSM-IV by a clinical psychologist and assessed using CARS	Parallel group-baseline study	No	No, No	No
Sandiford et al., 2013	A pilot study on the efficacy of Melodic Based Communication Therapy for eliciting speech in nonverbal children with autism	12 children, aged between 5- and 7-years-old	Assessed using the ADOS	Randomised controlled trial	Yes, compared to traditional therapy group	Yes, No	No
Warreyn and Roeyers, 2014	See what I see, do as I do: Promoting joint attention and imitation in preschoolers with autism spectrum disorder	48 children, aged between 3- and 7-years-old	Diagnosed according to DSM-IV criteria	Controlled trial	Yes, compared to control group who received their normal treatment	Partially randomised (controlled for rehabilitation centres participants attended), No	No

Srinivasan et al., 2016	The effects of embodied rhythm and robotic interventions on the spontaneous and responsive verbal communication skills of children with Autism Spectrum Disorder (ASD): A further outcome of a pilot randomized controlled trial	36 children, aged between 5- and 12-years-old	Clinically evaluated and assessed using the ADOS	Randomised controlled trial (pilot study)	Yes, compared to control group who received standard of care and also a robotic intervention group	Yes, No	No
Yoo and Kim, 2018	Dyadic Drum Playing and Social Skills: Implications for Rhythm-Mediated Intervention for Children with Autism Spectrum Disorder (Study 2)	9 children of primary school age (mean age of 10.8 years)	Clinically diagnosed with ASD and assessed using CARS	Pre-test, Post-test intervention study design	No	No, No	No
Sharda et al., 2018	Music improves social communication and auditory-motor connectivity in children with autism	51 children, aged between 6- and 12-years-old	Diagnosed according to DSM-IV criteria and assessed using either ADOS, ADI-R or CARS	Randomised control trial	Yes, compared to structurally matched intervention	Yes, Yes	No

					group, which focused on play		
Reese, 2018	The effect of mirroring on the social engagement of young children with autism spectrum disorder	4 children between the ages of 3- and 5-years-old	Diagnosed by a paediatric neuropsychologist with ASD and assessed using ADOS	A multiple baseline design across participants with replication	No	No, No	No

(DSM-IV; Diagnostic and Statistical Manual of Mental Disorders Fourth Edition, ICD-10; International Classification of Diseases Tenth Revision; ADOS; Autism Diagnostic Observation Scale, ASD; Autism Spectrum Disorder, ADI-R; Autism Diagnostic Interview Revised, CARS; Childhood Autism Rating Scale)

3.4.3 Characteristics of interventions

Interventions were either delivered on a single day of testing or delivered on a weekly basis. Four of the selected studies carried out their interventions over one day, with two of these repeating their procedure within the same day. The remaining seven studies delivered their interventions via weekly sessions. Three studies provided an intervention for 8-weeks or less, two studies provided an intervention for 16-weeks or less, one study provided an intervention for 5-months and one study omits the length their study ran for. Most weekly sessions appeared to last between 30-45 minutes; however, one study provided a weekly session for only 10-minutes.

All the eleven studies either used mirroring or rhythm as the main component of their intervention to enhance communication skills and social development. Seven studies utilised mirroring in their intervention and the remaining four studies utilised the technique of rhythm. The most common mirroring interventions used were variations of the still-face paradigm (Nadel et al. 2000; Figure 3A. 2).

Figure 3A. 2 Graphical representation of Nadal et al. (2000) still-face paradigm

Rhythm interventions differed across studies substantially. For example, one study focused on variations of rhythmic drum tapping, whilst another study used rhythmic clapping over a recorded melody to learn new words. Despite using different techniques, most studies employed dyadic groups (i.e. autistic child and experimenter) within the intervention; however, Srinivasan et al. (2016) employed triadic groups (i.e. child, model adult, and trainer). Srinivasan et al.'s (2016) study also investigated the use of a robot during their rhythm-based intervention. Therefore, there were 3 groups: 1) Rhythm group, 2) Robot group, and 3) Comparison/Control group. The rhythm and robot conditions were very similar, using rhythm and movement in a comparable way. However, during the rhythm condition, the trainer was an adult, and in the robot condition, the trainer was a robot (controlled by the adult experimenter). Table 3A. 3 provides an overview of the interventions and procedures carried out in each individual study.

Table 3A. 3 Interventions and procedures carried out in each individual study, noting the Dance Movement Therapy technique of interest.

Authors	Title	DMT technique of interest	Intervention/Procedure	Duration of intervention
Tiegerman and Primavera, 1984	Imitating the Autistic Child: Facilitating Communicative Gaze Behaviour	Mirroring	Three phases: 1) Experimenter sat opposite the child and mirrored every object-only action performed by the child 2) Experimenter used the same object as the child but performed different actions to the child 3) Experimenter performed different actions with a different object	17 sessions, which were scheduled on Monday, Tuesday, Wednesday and Friday for 6-weeks.
Field et al., 2001	Children with autism display more social behaviours after repeated imitation sessions	Mirroring	Four phases: 1) Experimenter sat on sofa like a statue ignoring the child 2) Experimenter mirrored all of the child's behaviours 3) Experimenter returned to sofa 4) Spontaneous play interaction between child and experimenter. Alternatively, during phase 2, the experimenter was contingently responsive to the child, but did not mirror them	The intervention repeated across three sessions. Authors did not specify the time scale for the three sessions

Escalona et al., 2002	Brief Report: Imitation Effects on Children with Autism	Mirroring	Four-phase procedure, same as above	One, single session
Heimann et al., 2006	Imitative interaction increases social interest and elicited imitation in non-verbal children with autism	Mirroring	Four- phase procedure, same as above	The procedure was repeated across two sessions with a 30 - 60 minute pause in between session A and session B on a single day
Katagiri et al., 2010	Mirroring effect in 2- and 3-year-olds with autism spectrum disorder	Mirroring	Three sequential phases: 1) 2-minute baseline phase, experimenter manipulated toys different from those the child manipulated 2) 3-minute mirroring phase, experimenter reproduced everything that the child did 3) 2-minute baseline phase, same as the first baseline phase	One, single session
Sandiford et al., 2013	A pilot study on the efficacy of Melodic Based Communication Therapy (MBCT) for eliciting speech in nonverbal children with autism	Rhythm	The children listened to a CD recording of 25 words set to rhythmic melodies while the therapist simultaneously presented the stimulus item to the child. Therapy progressed from listening to a recording of the word set to melody, to various clapping and singing formations over the rhythmic melody	5-weeks of intervention, with four 45-minute individual sessions a week.

Warreyn and Roeyers, 2014	See what I see, do as I do: Promoting joint attention and imitation in pre-schoolers with autism spectrum disorder	Mirroring	Involved a variety of games including mirroring and joint attention exercises. For example, one exercise was called a game of "goose"	24 sessions including two 30-minute sessions per week for approximately 5-months
Srinivasan et al., 2016	The effects of embodied rhythm and robotic interventions on the spontaneous and responsive verbal communication skills of children with Autism Spectrum Disorder (ASD): A further outcome of a pilot randomized controlled trial	Rhythm	Intervention consisted of several different aspects: 1) Hello song. 2) Action song where fingerplay was engaged. 3) Beat copying involving copying the trainer during rhythmic actions, 4) Music making. 5) Moving game, where the child was asked to copy trainer during gross actions. 6) Farewell song	32 sessions including four sessions per week (two expert trainer sessions and two parent sessions) for 8-weeks
Yoo and Kim, 2018	Dyadic Drum Playing and Social Skills: Implications for Rhythm-Mediated Intervention for Children	Rhythm	Three-phase intervention: 1) Engagement - tapping to the tempo of beats 2) Interpersonal coordination - tapping to the beat of an experimenter and mirroring the rhythm. 3)	Eight sessions that were 30-minutes in duration

	with Autism Spectrum Disorder (Study 2)		Adaptive adjustment - tapping to the drumming of an experimenter, paired with rhythmic cueing	
Sharda et al., 2018	Music improves social communication and auditory-motor connectivity in children with autism	Rhythm	Intervention delivered by an experienced therapist who made use of music, instruments, songs and rhythmic, whilst targeting communication, turn-taking, sensorimotor integration and social appropriateness	45-minute individual weekly sessions conducted over 8-to-12-weeks
Reese, 2018	The effect of mirroring on the social engagement of young children with autism spectrum disorder	Mirroring	The therapist entered the room in which the child had been for 10-minutes and music began playing. The experimenter began to mirror the participant. The experimenter mirrored the children's behaviours for the entire 10-minute session	Up to 15 sessions repeated once a week.

3.4.4 Outcome measures utilised

Although all studies from the systematic search had a primary objective of improving communication skills and social development, the studies extracted used different combinations of various outcome measures to assess change in communicative and social behaviour (Table 3A. 4). Many of the studies videotaped interactions between the child and experimenter for later observational assessment and behavioural coding. During behavioural analysis eye gaze was continuously assessed throughout most of the chosen studies. Similarly, joint attention was also commonly assessed. Behaviours towards the experimenter, such as smiling, touching the experimenter, offering the experimenter toys and vocalisations/verbalisations were coded in most of the studies that replicated Nadel et al.'s (2000) still-face paradigm. Very few studies used standardised outcome measures to assess changes in communication skills and social development. However, Reese (2018) utilised the Social Skills Improvement Scale, Yoo and Kim (2018) used the Korean-Social Skills Rating System, and Sharda et al. (2018) employed a battery of standardised outcome measures, including the Children's Communication Checklist-2 (CCC-2), the Social Responsiveness Scale-2 (SRS-2), and the Peabody Picture Vocabulary Test-4 (PVT-4).

3.4.5 Results reported

All eleven studies noted changes and improvements, either within-subjects or compared to control groups, in communication skills and social development of autistic children following or during a mirror- or rhythmic-based intervention (Table 3A. 4).

Table 3A. 4 Outcome measures used in each study and the results obtained, noting the authors conclusion for each study.

Authors and Date	Title	Outcome measures specific to communication and social behaviours	Results	Conclusion
Tiegerman and Primavera, 1984	Imitating the Autistic Child: Facilitating Communicative Gaze Behaviour	Measured eye gaze including frequency of eye gaze and duration of eye gaze	Frequency of eye gaze was greatest during the mirroring phase. This increased with number of sessions, then decreased. Duration of eye gaze was highest during mirroring phase, also increasing with number of sessions	Autistic children initially interacted with various objects without gazing at the experiment. Most likely due to mirroring, the children became more socially aware of the experimenter and increased their gaze towards the examiner. It is now important to understand how gaze behaviours interface with other developmental behaviours
Field et al., 2001	Children with autism display more social behaviours after repeated imitation sessions	Coded behaviours including: 1) Stereotypy, inactivity, playing alone, 2) Object play and mirror	Mirrored children spent less time showing typical behaviours, being inactive and playing alone compared to contingently responded	Results suggest both distal and proximal social behaviours displayed by autistic children increase following repeated

		play, 3) Smiling, laughing and vocalising towards the adult, 4) Being proximal to the adult, sitting next to or touching the adult, 5) Showing recognition of being imitated and engaging in reciprocal play	to children. Children who were mirrored spent more time showing object behaviours, distal social behaviours and more time showing imitation recognition and engaging in reciprocal play. Effect increased with multiple sessions	sessions of mirroring, highlighting the potential usefulness of mirroring
Escalona et al., 2002	Brief Report: Imitation Effects on Children with Autism	Coded behaviours including: 1) Looking at adult's face or body, 2) Silence (no discernible sound or vocal stereotypy), 3) Distance from adult (more than 5 feet away), 4) Touching adult in a socially positive way (smooth, light touch vs. abrupt, rough touch)	Children in both groups showed an increase in proximal behaviours towards the adult. Only the mirroring group showed significantly less motor activity. Children in the mirroring group significantly increased social touch behaviours towards the adults, greater than the contingent response group	The contingency condition appeared to be a more effective way to facilitate distal social behaviours, whereas the mirroring condition was a more effective way to facilitate a proximal social behaviour. The data from this study suggest that mirroring by adults may be an effective intervention in young non-verbal autistic children
Heimann et al., 2006	Imitative interaction increases social interest and elicited	Coded behaviours including: 1) Touch as a	The mirroring group looked more at the experimenter and also displayed	Overall, the study suggests that autistic children are sensitive to

	imitation in non-verbal children with autism	proximal category, 2) Look at a person as distal category, 3) Request as proximal or distant depending on the context. Also used the imitation subscale of the Pyscho-Educative Profile for imitation rating	an increase in socially touching and requesting behaviours compared to the contingently responsive group. More children in the mirroring group increased their scores than in the contingently responsive group, although this did not reach statistical significance	being mirrored, highlighting usefulness of mirroring as a clinical or educational tool. The results from this study indicate intense mirroring can facilitate both distal and proximal positive social behaviours
Katagiri et al., 2010	Mirroring effect in 2- and 3-year-olds with autism spectrum disorder	Coded behaviours including: gazing at the experimenter's face, giving positive socio- emotional signals smiling, verbalizing, vocalizing, approaching, touching to the experimenter; offering toys to the experimenter, and requesting the experimenter to imitate his/her own action)	Social attention increased during and after the mirroring phase in all participants and socio-emotional behaviour appeared in four of the six participants. IQ was negatively correlated with the mirroring effect for social attention and was positively correlated with the mirroring effect for socio-emotional behaviours	The findings suggest that the mirroring effect exists in autistic children regardless of their developmental stage or severity of autistic traits. Additionally, dyadic interaction via mirroring appears to be promising as an early intervention for a wide range of autistic children

Sandiford et al., 2013	A pilot study on the efficacy of Melodic Based Communication Therapy (MBCT) for eliciting speech in nonverbal children with autism	Measured the number of verbal attempts, correct words, number of words reported by parent in home environment and number of imitative attempts	Both treatment groups showed an increase in number of verbal attempts, number of correct words and number of imitative attempts following treatment. The MBCT group displayed more verbal attempts overall. Only parents of children who were in the MBCT group reported a significant improvement in new words heard at home. For number of imitative attempts, the participants in the MBCT group showed significantly greater overall gains than the traditional group	While both therapies were found to be effective at the completion of the study, results suggest a possible faster rate of improvement for the MBCT group as well as greater overall gains in verbal attempts and imitative attempts
Warreyn and Roeyers, 2014	See what I see, do as I do: Promoting joint attention and imitation in pre-schoolers with autism spectrum disorder	Measured: 1) Reaction to ambiguous behaviours, 2) Gaze following, 3) Initiating requests, 4) Following requests, 5) Initiating joint attention, 6)	Both experimental groups made significant gains in joint attention ability, with the experimental group showing more progress than the control group. Both groups made advancements in imitation skills	The findings show that it is possible to promote joint attention in a limited number of sessions, over a short period of time. The results concerning imitation were less pronounced

		Spontaneous joint attention, 7) Gestural imitation, 8) Verbal imitation, 9) Object imitation, 10) Symbolic imitation, 11) Spontaneous imitation	and the experimental group had higher total imitation scores compared to the control group	and although the experimental group showed a significant improvement on this domain, this improvement was not significantly larger than that in the control group
Srinivasan et al., 2016	The effects of embodied rhythm and robotic interventions on the spontaneous and responsive verbal communication skills of children with Autism Spectrum Disorder (ASD): A further outcome of a pilot randomized controlled trial	Used a standardised test of joint attention, training-specific measures of response to social bids and training-specific measures of vocalisation/verbalisation patterns	No between-group differences in joint attention performance, however both the rhythm and control group improved their scores. The rhythm group showed an increase in total word counts and verbalised more with the trainer compared to the model across all three sessions	Children in the rhythm and robot groups increased levels of social verbalisation over training sessions. The rhythm group also generalised learned skills to a standardised test conducted outside the training context with a novel examiner
Yoo and Kim, 2018	Dyadic Drum Playing and Social Skills: Implications for Rhythm-Mediated Intervention for Children with	Used the: 1) Korean-Social Skills Rating System (K-SSRS), 2) Scoring a selection 20 gestures, 3) Scoring of target social	The group significantly improved in cooperation and self-control and showed an increase in eye gaze, engagement in joint action and synchronous movements. Guardians	The social skills of autistic children improved after receiving the rhythm-mediated music therapy intervention. This study presents the structured

	Autism Spectrum Disorder (Study 2)	behaviours including eye gaze, joint action, synchronous movement	of participants with more severe autistic traits and lower levels of social skills reported more immediate positive effects on their children's motor coordination–related skills and social relationships	framework with regard to the use of rhythmic cueing for the social domain of autistic children
Sharda et al., 2018	Music improves social communication and auditory-motor connectivity in children with autism	Used the: 1) Children's Communication Checklist-2, 2) Social Responsiveness Scale-II, 3) Peabody Picture Vocabulary Test-4	The music intervention group made significant improvements in social communication skills based only on the Children Communication checklist compared to the no-music intervention group	The findings demonstrate that 8-to-12-weeks of a rhythm and music intervention (relative to non-music behavioural intervention) can improve parent-reported social communication, family quality of life in school-age children, thus supporting the use of rhythm as a therapeutic tool for autistic individuals
Reese, 2018	The effect of mirroring on the social engagement of young	Measured children's Social skills score and problem behaviour scores.	Individually most of the children showed a reduction in challenging behaviour and showed an increase	The findings contribute to the autism literature by demonstrating that an

	children with autism spectrum disorder	Additionally, initiations (verbal or non-verbal acts towards the adult) and gaze (child directed eye contact or visual gaze towards the adult) were measured	in social skills. All children showed an increase in initiations, gaze behaviour and engaging in positive affect towards the adult	intervention solely implementing mirroring techniques results in positive change in quantifiable, objectively-measured social engagement behaviours when implemented with fidelity

Each study completed differing statistical analyses to establish the significance of their observed effect. Tiegerman and Primavera (1984) indicated that both gaze frequency directed toward the experimenter ($P < 0.001$) and gaze duration ($P < 0.001$) differed significantly across sessions. With gaze duration continuing to increase following the mirror-based intervention and gaze frequency initially increasing before decreasing across sessions. Field et al. (2001) highlighted that children who were mirrored spent more time engaging in mirror play ($P < 0.05$), more time being proximal to the adult ($P < 0.05$), sitting next to the adult ($P < 0.01$) and touching the adult ($P < 0.001$), than children who were contingently responded to. Similarly, Escalona et al. (2002) reported that children who were mirrored were more likely to socially interact with and touch the experimenter compared to children who were contingently responded to ($P < 0.05$). Heimann et al. (2006) reported that social interest (sum of touch, looking at the experimenter and initiating requests) was significantly greater in the post-intervention phase compared to the pre-intervention phase, but only in the mirroring condition ($P < 0.05$) and not in the contingently responsive condition. Katagiri et al. (2010) highlighted that social attention and social-emotional behaviours increased in autistic children during and/or after the mirroring phase of their procedure ($P < 0.001$). Warreyn and Roeyers (2014) stated that children who were in the mirror- and joint attention-based intervention group made significantly more gains in overall joint attention ($P < 0.01$), specifically gaze following ($P < 0.05$) and initiating requests ($P < 0.05$) than the control group. Reese (2018) adopted a case-by-case approach when investigating the effect of mirroring; however, it appears no statistical analysis was carried out. Nonetheless, they reported an increase in social skills based on the SSIS and also highlighted an increase in initiations and eye gaze towards the adult. To this end, these

studies suggest the beneficial effect of mirroring for autistic children's social communication skills.

Sandiford (2013) suggested that their rhythmic-based melody intervention caused autistic children to perform more verbal attempts than children in the traditional therapy group. This did not reach statistical significance, although it showed a positive trend ($P > 0.05$). Additionally, parents reported a significant improvement in the number of new words heard in the home and other environments for participants in the Melodic Based Communication Therapy (MBCT) group ($P < 0.05$). Srinivasan et al. (2016) revealed that both their rhythmic intervention group and robotic intervention group demonstrated significant improvements in joint attention and that this did not differ between groups. However, the rhythmic group showed a greater increase in total word count compared to the robotic and control group ($P < 0.05$). Yoo and Kim (2018) noted significant improvements on the K-SSRS following the rhythm-based drum tapping intervention, specifically in areas of cooperation ($P < 0.05$) and self-control ($P < 0.05$). Additionally, comparison of the occurrence of the target behaviours (eye gaze, joint attention and synchronous movement) between the second and eighth sessions showed that autistic children demonstrated increases in all behaviours. Sharda et al. (2018) reported a significant improvement in communication skills based on the CCC-2 ($P < 0.05$) following their rhythmical-based intervention. However, no other significant effects were observed using either the SSRS-2 or the PBVT-4. Overall, these studies suggest the potential of rhythmical-intervention for enhancing autistic children's social communication skills.

3.4.6 Risk of bias in included studies

Risk of bias (low, unclear and high risk) was reported for all studies according to selection, performance, detection, attrition and reporting bias. However, risk level was not

applicable for all categories in each study. For example, Tiegerman and Primavera (1984) did not have a control or parallel-group, therefore the category of randomisation was not applicable due to randomisation not being needed.

It is evident that all studies had difficulty blinding participants and personnel due to the nature of the practical interventions with children, as it would be difficult for the child or the experimenter to not to know what intervention they were receiving or delivering. However, it was believed that this would not lead to increased risk of bias as children were unaware of the reasons why they were participating in the intervention. Additionally, behavioural coders were often not blind. However, most authors accounted for this by having multiple coders and assessing inter-rater reliability or training coders, before behavioural assessment began to alleviate detection bias. For example, most studies, which included multiple coders, trained coders to an inter-rater reliability of at least K = 0.80 or higher, using kappa co-efficient to correct chance disagreement. However, it was observed in Field et al. (2001) and Escalona et al. (2002) that the kappa scores for inter-rater reliability averaged 0.71 and 0.72 for one-third of the observations, respectively. Most studies had low reporting bias, reporting all outcome measures listed in the methods in the results and had a low risk of attrition bias, explaining and accounting for all missing data (Figure 3A. 3).

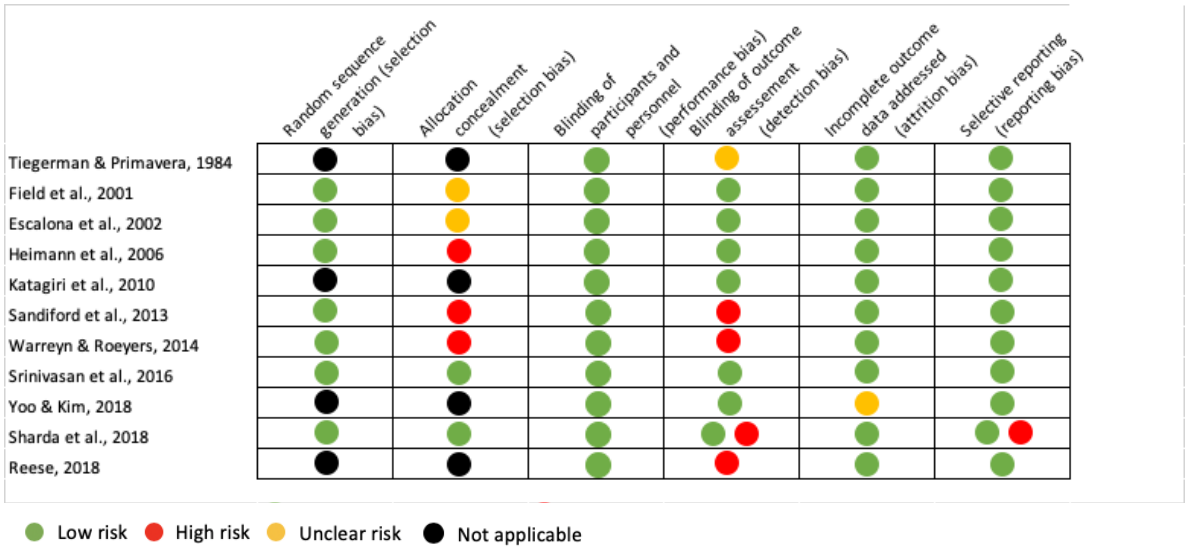


Figure 3A. 3 Risk of bias assessment of selected studies (Adapted from Cochrane Handbook; Higgins et al., 2019; Sterne et al., 2019) with key to the bottom.

3.5 Discussion

To our knowledge, this is the first systematic review that focused on the specific DMT techniques, mirroring and rhythm, as the primary component of interventions targeting communication skills and social development in autistic children. After successfully reviewing the literature, which concentrated on either mirror- or rhythm-based interventions and investigating studies that had outcome measures assessing communication and social skills in autistic children, it is clear that the studies included in this review infer the positive effects of mirroring and rhythm. As previously mentioned, ASD is characterised by communicative and social differences that may affect an individual's QoL. The results of this study suggest the therapeutic potential of mirroring and rhythm for enhancing autistic children's communication skills and social development.

3.5.1 The element of mirroring and its effect on communication skills

Studies evaluating the effect of mirroring on communication skills and social development utilised a variety of outcome measures, including eye gaze, joint attention and the scoring of proximal (touching, sitting next to or on and being close to the adult) and distal (looking, vocalising, smiling and engaging in reciprocal play) social behaviours towards the adult. The eyes and their gaze are important social signals as they have the ability to enhance social connections, indicate that you are paying attention to someone, and show a range of social meanings such as intimacy and aggression (Cañigueral & Hamilton, 2019). Additionally, the eyes are used to observe and retrieve social information from others around you, making the eyes an effective tool with a dual function and an active element in

social interactions (Cañigueral & Hamilton, 2019; Risko et al., 2016). Subsequently, monitoring eye gaze during communicative interactions can give an indication of social competence. This is demonstrated by its consistent use as an outcome measure in five out of the six studies investigating mirroring in this review (Escalona et al., 2002; Heimann et al., 2006; Katagiri et al., 2010; Reese, 2018; Tiegerman & Primavera, 1984; Warreyn & Roeyers, 2014). Likewise, joint attention is a valuable social skill that was also measured to reflect social competence (Warreyn & Roeyers, 2014). Joint attention is defined in early communicative development as the capability to coordinate social attention between an adult, an infant, and an object or an event (Beuker et al., 2013). Consequently, effective joint attention is a relative measure of social communication competence (Charman & Stone, 2008). All studies revealed an increase in socially relevant eye gaze behaviour and joint attention abilities following mirroring interventions, inferring supported social communication competence and development.

Studies that employed variations of Nadel et al.'s (2000) still-face paradigm all noted an increase in communicative social behaviours following the mirroring phase. They suggested that the experience of being acutely mirrored creates a social expectancy for the autistic child, making social situations more interesting (Escalona et al., 2002; Field et al., 2001; Heimann et al., 2006). Therefore, the saliency of the social world is elevated and the probability that the child will offer social responses following the mirroring phase is increased. This was observed in all studies that employed a variation of the still-face paradigm. Autistic children may be markedly susceptible to the positive effects of mirroring because it challenges a potential struggle reported in and by some autistic individuals – reduced social interest (Heimann et al., 2006).

Additionally, mirroring may offer a form of social reward and increase social attention due to sharing the same body movement or emotional state (Contaldo et al., 2016).

It is believed that TD children find social situations salient, whereas some autistic children, dependent on their level of functioning, may find social situations difficult, uncomfortable, or uninteresting (Hilton et al., 2007). The diminished social behaviours observed toward the adults during the first still-face phase in all studies employing Nadel's paradigm perhaps reflects this. In this framework, reduced social attention is believed to lead to impaired social development. Known as the "social motivation theory", differences in the social reward system of autistic children are observed at the neurological level, which may change the way autistic children engage with and adapt to social stimuli (Dawson, 2008). For example, uncharacteristic activations in the orbito frontal-striatum-amygdala circuit in response to social stimuli have been reported (Dichter et al., 2012; Scott-Van Zeeland et al., 2010). The neural circuitry related to social reward, such as the orbitofrontal circuit, is also activated when individuals are being mirrored (Kühn et al., 2011; Mainieri et al., 2013). Therefore, the mirror-based interventions may enhance communication skills and social development by improving the neural circuits that might be affected in autism. However, it is important to note that the social motivation theory has experienced some criticism in the recent years. Several researchers suggest that social motivation is not universally reduced in autism and demonstrate that many autistic individual 'compensate' or 'mask' their autistic traits to appear neurotypical suggestive of heightened social motivation to 'fit in' (Jaswal & Akhtar, 2019; Livingston et al., 2019). Recent studies have indicated that autistic girls, as young as 7-years-old employ masking and compensatory strategies on the playground during break times at school (Dean et al., 2017).

Again at the neurobiological level, the beneficial effects of the mirror-based interventions explored in this systematic review may be explained by 'Broken Mirror Theory' of autism (Becchio & Castiello, 2012; Dapretto et al., 2006; Iacoboni & Dapretto, 2006; Oberman & Ramachandran, 2007). As touched upon in the Chapter Two, the theory

refers to the MNS of the brain, where the same neurons that are activated in an individual watching a movement/performance are activated in an individual performing the movement (Rizzolatti & Craighero, 2004). It is proposed that autistic individuals may have atypical anatomical connectivity or impaired functional synchronisation within specific nodes of the MNS (Becchio & Castiello, 2012; Iacoboni & Dapretto, 2006; Kana et al., 2011). Continued use of specific mirror-based interventions may improve differences within these certain nodes and promote connections with alternative neural networks involved in social cognition, resulting in the observed positive effect of increased eye gaze, joint attention, and proximal and distal social behaviours towards the experimenters in the given studies (Contaldo et al., 2016; McGarry & Russo, 2011). However, Katagiri et al. (2010) challenge the view of the broken mirror theory of autism and suggest the primal MNS function somewhat remains in toddlers with ASD. Additionally, it is unclear if the child being mirrored needs to *know* that they are being mirrored to observe positive results, and to what extent recognition of mirroring behaviour correlates to improvements in communication and social development. Overall, it appears that the technique of mirroring is successful at enhancing and supporting the communication skills and social development of autistic children (Escalona et al., 2002; Field et al., 2001; Heimann et al., 2006; Katagiri et al., 2010; Reese, 2018; Tiegerman & Primavera, 1984; Warreyn & Roeyers, 2014). This may be through improving atypical networks, increasing social expectancies, or another mechanism.

3.5.2 The element of rhythm and its effect on communication skills

Studies that looked at the ability of rhythm to enhance communication skills and social development used a range of outcome measures to assess its efficacy. Studies reported either an increase in verbal attempts at home, total word counts, levels of co-operation and

self-control, or improved CCC-2 scores; inferring improvements in communication skills and social development following their rhythmic-based interventions.

These rhythmically-based interventions may be successful at enhancing the social skills of autistic children as they harness children's musical strengths while alleviating their challenges (Simpson & Keen, 2011). Autistic children often have a predisposition for musical stimuli, demonstrating intact musical perception despite their struggles with social communication (Heaton, 2003; Simpson & Keen, 2011; Srinivasan et al., 2015). Therefore, the rhythmic interventions, such as dyadic drumming or MBCT, utilised a non-threatening and acquiescent medium that is often well-received by autistic individuals (Sandiford, 2013; Yoo & Kim, 2018). Moreover, the rhythmic and musical interventions provided several opportunities for developing social skills such as imitation, joint attention, social reciprocity, shared affect, and empathy (Overy & Molnar-Szakacs, 2009; Sandiford, 2013; Sharda et al., 2018; Srinivasan et al., 2016; Yoo & Kim, 2018). The observed increase in communication skills measured in Srinivasan et al. (2016) and Yoo and Kim (2018) may indicate the child attuning to the actions of their social partner (the experimenter) through rhythmic exercises, gradually developing an appreciation and awareness of their partner's emotions and intentions (Srinivasan & Bhat, 2013).

Within ASD differences in neurological connectivity are observed. This may disrupt the typical rhythms of sensory and social connectivity, resulting in a sequence of disorientated perceptual experiences that affect the delicate 'choreography' of social interactions (Amos, 2013). As reflected on in the narrative review of this thesis, research on audio-visual processing in ASD has revealed that the "binding window" can be twice as long for autistic subjects compared to typically-developing controls (Foss-Feig et al., 2010; Wallace & Stevenson, 2014; Zhou et al., 2018). Therefore, atypical temporal processing of multisensory information and individual differences might affect multisensory integration

for autistic individuals (Kawakami et al., 2020). Consequently, social interactions for autistic individuals may be encumbered with unrelated and confusing associations between audio and visual stimuli. As the rhythmic interventions included in this review targeted the child's ability to synchronise with the external rhythms in their environments, this may have reduced the uncharacteristic binding window; thus, making social situations more salient and resulting in the improved communication skills observed in the chosen studies.

3.5.3 Limitations within studies

All studies had a relatively small sample size, ranging from the smallest group of four participants to the largest group of 51, where 25 individuals were in the intervention group and 26 individuals were in the control group. Consequently, the statistical power of all studies was limited. Additionally, the clinical relevance of findings is somewhat reduced due to the small sample sizes and whether the sample of participants reflects the general ASD population. A simple sample size calculation suggests that to detect a medium-sized effect between two groups (intervention and control), with a power of 95% and a significance-level alpha of 0.05, at least 176 participants, with 88 participants in each group, would be needed. An even larger sample size would be required to explore time and group interactions. Besides the small sample sizes, participant groups were often recruited from a singular school, charity or catchment area, introducing a geographical bias which again, reduces the notion that the samples of participants used are reflective of the general ASD population.

Although most studies attempted to measure and report the perceived severity of autism in their samples, either by using the CARS, ADOS, or ADI-R, there was substantial variability in scores across studies. Controlling for autism presentation can be useful during scientific research as it limits potential variability, enables matching across groups, and

could allow for establishing what intervention is most effective for different presentations of autism. However, Warreyn and Roeyers (2014) did not confirm the child's ASD diagnosis with either the CARS, ADOS or ADI-R; therefore, the level of autism for each participant was unknown and was not matched between the control and intervention groups. Similarly, Yoo and Kim (2018) did not consider the developmental level or autistic presentation across participants. Analysis of feedback in terms of the effectiveness and acceptability of the intervention from the guardians of participants highlighted this limitation. It could be argued that by not controlling for autism presentation a more generalisable scientific study is established– in that, the intervention is successful (or not) across various levels of autism. Furthermore, clinical assessments and diagnoses are attempting to move away from defining the 'type' or 'severity' of autism an individual has. For example, in the UK, America, and other countries aligning themselves with the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-V), specific diagnoses of autism no longer include Asperger's Syndrome or Pervasive Developmental Disorder-Not Otherwise Specified (American Psychiatric Association, 2013). Instead, the DSM-V, which was revised in 2013, merged all 'types' of autism into a single diagnosis of autism spectrum disorder. Likewise, the severity of autism was revised to align with 'levels of support required' rather than categorising the individual's traits (Lobar, 2016; Volkmar & McPartland, 2014).

None of the studies included in this systematic review examined if their intervention produced effects that were long term. Therefore, it is unknown whether the positive effects of mirroring or rhythm in the given studies are transient. Many of the authors expressed concerns regarding follow-up examinations due to time constraints, the nature of the population they were working with, and that they often had to rely on parents, who already had busy family lives, to bring their children to the pre-assessment, intervention, and post-

assessment sessions. Consequently, adding a follow-up assessment seemed unmerited with logistical difficulties but this information would still be useful ensure longevity and sustained positive responses of the interventions.

Very few studies successfully examined if the positive effects observed were generalised to a more naturalistic environment; for example, at school or at home (Ingersoll, 2008). Only Sandiford (2013) reported findings observed in the home environment, noting a significant improvement in the number of new words heard at home by parents of children in the rhythmic group. Therefore, studies may wish to further explore effect of interventions in different environments. Additionally, the risk of bias for outcome measures was reportedly high as most parents were not blind to which intervention their child was receiving (Figure 3A. 3).

3.5.4 Review limitations

The lack of standardised outcome measures, variability in ASD population, and inconsistency in the duration and frequency of interventions of studies covered in this review made a comparison between studies and analysis of the results extremely difficult. To this end, a meta-analysis or meta-synthesis was not performed due to the substantial variability across studies. Furthermore, there were limited papers published within this area that demonstrated sound methodological quality, as some studies lacked control or comparison groups or were not blinded or fully randomised as demonstrated by the risk of bias check.

As the main aims of this review were to focus on mirroring and rhythm as the central components of interventions targeting communication skills and social development in children, many articles were excluded from the review due to mirroring or rhythm being used in combination with other techniques or as an element of a multi-step procedure.

However, these articles may still offer valuable information regarding the power of mirroring or rhythm within an intervention even though they were not the main component. Tortora's (2006) definition of mirroring was primarily followed to guide the inclusion criteria, however there are several studies available investigating the effect of reciprocal imitation training to teach imitation to autistic children, indicating positive results (Cardon & Wilcox, 2011; Ingersoll, 2010; Ingersoll et al., 2013; Malik, 2016). Although this form of mirroring, i.e., child learning skills to imitate the experimenter, was not explored within this review, it may be worthwhile evaluating the different types of mirroring to note any differential outcomes with regards to the development of social skills. Additionally, articles were excluded if participants were over the age of 12-years-old, therefore it is unclear if the positive effects of mirror-based and rhythmic-based interventions would be replicated in adolescents and adults on the autistic spectrum. Future research may wish to explore this.

3.5.5 Implication of findings for practice

All the studies selected for the systematic review suggested some benefits of mirroring and rhythm for autistic children regarding communication skills and social development. A key factor to consider is the attendance of participants for interventions that lasted over eight weeks. Often dropout rates in the autistic population for scientific studies is relatively high (Magán-Maganto et al., 2017; Parracho et al., 2010). However, in this review, three studies had no drop-out rates, two studies had only one participant fail to complete the full duration of the intervention, and one study had three participants drop out. Perhaps this highlights the desire of children to attend multiple sessions, enjoyment felt by each participant, and the willingness of parents to take their children to the intervention to support their child's skill development. As a result, it seems plausible that mirroring and

rhythmic interventions are useful and well-received strategies that hold therapeutic potential and could therefore be integrated into practice.

Despite the heterogeneity of the studies included in this review, it is evident that mirroring and rhythm are effective interventions and suggest a positive impact on autistic children's social communication skills. However, it is not clear what the optimum duration and frequency of mirroring or rhythmic sessions are needed to obtain the best outcomes following the intervention. For example, Warreyn and Roeyers' (2014) intervention lasted five months, whereas Sandiford's (2013) intervention only lasted five weeks. To this end, the time period and frequency of such interventions may influence their success (DeJesus et al., 2020). Therefore, in order to improve the uptake of mirroring and rhythm interventions in practice the most beneficial duration and frequencies should be explored.

As discussed in the Chapter Two, mirroring and rhythm are consistently used within DMT for the development of communication skills in autistic children, whereby DMT is the holistic use of dance to build relationships and communicative channels through movement. During DMT, mirroring and rhythm can usually be used in synchrony or in various arrangements, alongside other techniques; for example, the use of body awareness or more structured processes such as a Chace Circle (Karampoula & Panhofer, 2018). Whilst it was observed that mirroring and rhythm are effective techniques used by dance movement therapists when working with autistic children, within this review it is suggested that mirroring and rhythm are capable of enhancing communication skills when used in isolation and outside the realms of DMT. The healthcare system asserts demand for more evidence-based and cost-effective interventions. This review highlights valuable studies that suggest the effectiveness of mirroring and rhythm to enhance communication skills and social development in autistic children when not used during DMT sessions (Warreyn & Roeyers, 2014). Further, these techniques, especially mirroring, are relatively inexpensive and cost

effective. Therefore, mirroring- and rhythm-based tasks could be more readily implemented into school routines, where teachers or assistants could utilise mirroring or rhythm in order to support communication skills and social development of pupils on the autistic spectrum. For example, elements of mirroring or rhythm could be integrated into PE sessions where children mirror each other or focus on the rhythm of music either within special education facilities or main-stream schools.

3.5.6 Future research

From this review, it is suggested that both mirroring- and rhythm-based interventions have beneficial effects on the communication skills and social development of autistic children. However, the lack of homogeneity between study designs, classification of participants, and outcome measures used means it is difficult to conclusively state their therapeutic potential. Consequently, more research is needed to verify the optimum duration and frequency of mirroring or rhythm-based interventions and the effects of these interventions in different populations of autistic children. Moreover, reliable, informative, and standardised outcomes measures are needed in order to compare and contrast the effectiveness of interventions, highlighting the most beneficial interventions for clinical and social practice. Similarly, future research may strive to capture the 'voice of the child' through various pragmatic outcome measures to understand and ensure children are enjoying and engaging with the intervention put forward. For example, in addition to coding social behaviours during observational recordings, researchers may also code for indicators of enjoyment, including verbal affect or positive changes in facial expressions. Alternatively, authentic indicators of enjoyment could also be gained through questionnaires and semi-structured interviews with participating children.

On the other hand, DMT has already shown the usefulness of rhythm and mirroring in combination to increase communication skills and social development in autistic children in a clinical/therapy-based environment (Scharoun et al., 2014). It would now be worth exploring the combination of rhythm and mirroring techniques in a more practical and naturalistic setting; for example, in a school environment or in groups of children (rather than 1:1). All the studies utilised either a dyad or triad; however, group-based interventions with more than one child have shown significant positive effects for autistic individuals (Eren, 2015; Hildebrandt et al., 2016; Koch et al., 2015). Therefore, future research might investigate the use or practice of mirroring and rhythmic techniques in groups of autistic children rather than individually.

In addition, all of the studies in this review focused on the experimenter mirroring the child or a rhythmic procedure between the experimenter and the child. None investigated child-to-child based mirroring or rhythmic procedures between children. In common social contexts, children typically interact and play with each other. Therefore, creating a common social context within an intervention may further enhance its positive effects on communication skills and social development (Garfinkle & Schwartz, 2002). Similarly, the application of virtual reality or the use of modern technologies for therapeutic purposes in the autistic population has escalated rapidly in the recent years (Karami et al., 2021; Rafiei Milajerdi et al., 2022). Therefore, future work may also wish to explore how to incorporate mirroring and rhythm into modern technologies or draw upon existing virtual programs that already include these elements for young autistic individuals. Such programs may include the use of virtual exercise games, often referred to as exergames (Bogost, 2007).

3.6 Conclusion

In conclusion, the findings from this review suggest the positive effects of the DMT techniques, mirroring and rhythm, on the communication skills and social development of autistic children. The studies included in this review used mirroring and rhythm independently and outside the realm of DMT, therefore providing evidence that the techniques can be used effectively to support communication skills and social development. Although each study used a range of outcome measures, eye gaze and joint attention were most commonly used as an index for improved communicative social behaviours, suggesting reliable measures of social competence. Whilst acknowledging several limitations, this review suggests the use of mirroring and rhythm to enhance communication skills and social development, hopefully inferring therapeutic potential for autistic children. Future directions include the exploration of mirroring and rhythm techniques in the school environment or through the use of modern technologies such as exergames.

Part B - The non-fitness-related benefits of exergames for young autistic individuals; a systematic review

3.7 Abstract

Although autism spectrum disorder is most commonly characterised by social communication challenges, it is also often accompanied by an array of cognitive and motor differences. Research has begun to investigate the utility of exergames (virtual exercise games) for combating some of the functionally impairing traits associated with autism spectrum disorder. However, no review to date has investigated the positive effects of exergaming for young autistic individuals, exclusive of their effects on fitness-related/health-related outcomes. The literature was systematically reviewed for articles published between 1990 – 2020, which aimed to examine the effectiveness of exergames for targeting some of the facets observed in autistic children, exclusive of physical fitness-related outcomes. Out of 193 relevant articles, 10 met the inclusion criteria. Some studies showed initial beneficial effects of exergaming for executive functioning and motor skills, however more work is needed to examine the beneficial effects of exergaming for social development in young autistic individuals. The present review suggests the potential use of exergaming for enhancing some functions in autism spectrum disorder and future research is needed to expand the use of exergames for supporting social communication skills. Furthermore, additional studies using rigorous research designs are needed to draw stronger conclusions about the effects of exergames for the young autistic population.

Keywords: Autism Spectrum Disorder, Young, Communication, Social Development, Physical activity, Exergames

3.8 Introduction

3.8.1 Motor and executive difficulties

It is increasingly recognised that autistic individuals demonstrate reduced motor proficiencies and executive dysfunction. The available literature suggests that between 60 - 80% of autistic children exhibit some kind of motor challenge (Dziuk et al., 2007; Fournier et al., 2010; Gargot et al., 2022; Ming et al., 2007). A recent study, including data from 11,814 autistic children reported that the proportion of autistic children at risk of motor challenges was very high at 86.9% (Bhat, 2020). However, only 31.6% of these children were receiving physical therapy services. In comparison to their TD peers, those on the autistic spectrum are more likely to express difficulties with balance, gait, postural stability, movement speed and joint flexibility (Ghaziuddin & Butler, 1998; Jansiewicz et al., 2006; Minshew et al., 2004, and see Hudry et al., 2020 and Lim et al., 2017 for reviews). For example, using the Henderson Test of Motor Impairment (Lam & Henderson, 1987), Manjiviona and Prior (1995) reported impaired movement in 67% of autistic children. Additionally, Green et al. (2009) assessed 101 autistic children using the Movement Assessment Battery for Children (Henderson, 1992; Henderson et al., 2007) and reported that 79% of children had a movement difficulty and another 10% were rated as borderline "impaired".

In addition to motor difficulties, it is frequently observed that cognitive skills, such as executive function (EF), are altered in autistic individuals (Demetriou et al., 2018). It is believed that EF difficulties may play a central role in manifestation of ASD. Arising from reduced regional coordination and integration of *prefrontal* executive processes that combine emotion and social circuits, executive dysfunction may relate to some of the core autism-specific traits associated with the condition, such as social cognition and social challenges (Leung et al., 2016; Maximo et al., 2014).

Due to the complex symptomology, including social, cognitive, and motor differences and the vast heterogeneity of the condition, there are no pharmacological or behavioural interventions that successfully target all traits that may functionally impair an autistic individual or that alleviate facets associated with ASD, which may negatively impact their QoL. For example, Early Intensive Behavioural Intervention (EIBI) for young autistic children is a well-established intervention for ASD, yet a recent systematic review has indicated that EIBI does not improve autism presentation or alleviate 'behaviour that challenges' (such as self-harming behaviours or destruction of property), warranting caution as an effective, all-encompassing, behavioural intervention (Reichow et al., 2018). Additionally, some autistic individuals do not want to participate in behavioural interventions as they see their diagnosis as an inherent part of their being – autistic is *who* they are (Vivanti, 2020). However, some individuals on the autistic spectrum may need help and support for certain activities or require therapeutic intervention to improve their QoL. Therefore, current research suggests that interventions should aim to target and alleviate specific traits that may functionally impair an autistic individual or reduce their QoL in a person-centred approach (Galpin et al., 2018; Nicholas et al., 2020; Therrien & Light, 2018).

3.8.2 Physical activity and exergames

As first explored in the Chapter Two, physical activity and exercise have been shown to have beneficial effects for young autistic individuals, supporting development and alleviating some traits that may negatively impact wellbeing and QoL. Several reviews are available that highlight the potential of physical activity for improving or enhancing different facets of ASD including physical and mental health, self-regulation, cognitive development, and social-emotional functioning for children (Sam & Tong, 2015), adolescents (Sorensen & Zarrett, 2014), and adults (Colombo-Dougovito & Lee, 2020; Elliott et al., 1994). Despite the somewhat promising relationship between ASD

symptomology and physical activity, autistic individuals are less likely to engage in physical activity and exercise than their typically-developing peers (Bandini et al., 2013; Fitzgerald & Yip, 2017), contending with several barriers to accessible physical activity. Further, engagement in physical activity is likely to decrease as autistic children transition into adolescence, often due to bullying, barriers in community programs, and the prioritisation of traditional therapeutic interventions (Jachyra et al., 2021; McCoy & Morgan, 2020).

Correspondingly, individuals on the autistic spectrum are more likely to engage with video or computer games than other populations, with online gaming increasing from childhood to adolescence in autistic individuals (Engelhardt et al., 2017; Mazurek et al., 2012; Mazurek & Wenstrup, 2013). It is thought that videogames are particularly attractive to autistic individuals as they offer low social demand, are consistent and predictable, and allow the user/player to determine the pace of the activity - taking control of the activity (Durkin, 2010; Engelhardt et al., 2017). The use of modern technologies is becoming increasingly common in the autistic population.

An innovative solution to increase physical activity in sedentary populations and draw up on the interests of videogaming platforms in many, can be found in the application of ‘exergaming’. The term ‘exergame’ has many definitions associated with it. For example, Bogost (2007) defines exergames as “the combination of exercise and video games” (p. 294), whereas as Oh and Yang (2010) redefined exergames as “an experiential activity in which playing exergames or any videogames requires physical exertion or movements that are more than sedentary activities and also include strength, balance, and flexibility activities” (p. 10). More recently, Kappen et al. (2019) defined exergames as “the combination of gaming technologies and exercise routines to motivate physical activity among individuals or groups” (p. 142). For the purpose of this systematic review, I will be drawing upon Kappen et al.'s (2019) definition, where exergames are the combination of

gaming technologies and exercise routines that encourage physical activity in autistic children. Exergames; combining videogaming technology with exercise, could offer the perfect platform to increase physical activity in young autistic individuals. Furthermore, the application of exergames may harness the potential therapeutic benefits of physical activity for alleviating some of the traits associated with ASD that impact QoL or limit the difficulties that have been noted as autism-prioritised outcomes for research studies to focus on, whilst being engaging and enjoyable for many autistic individuals (Autistica, 2016).

Due to the vast array of available exergames, previous research has indicated that they could be effective interventions for supporting an array of developmental skills, including social, cognitive, and motor development, and also rehabilitation in many different populations and clinical samples. For example, exergames have been observed to have some positive effects on self-concept, situational interest and motivation, enjoyment, psychological and social well-being, and different learning experiences for TD children and adolescents (see Joronen et al., 2017 for review). In addition, children and adults with cerebral palsy have shown positive responses to participating in Wii Sports, which involves performing the actions associated with tennis, baseball, bowling, golf and boxing, and Wii Fitness (Deutsch et al., 2008; Jelsma et al., 2013). Similarly, individuals diagnosed with Down Syndrome have also shown significant improvements in physical fitness and functional outcomes (Perrot et al., 2020) and motor proficiencies after participating in Wii-based exergames (Silva et al., 2017). Furthermore, exergaming was an effective intervention for temporarily enhancing balance and reducing fatigue in individuals diagnosed with Parkinson's disease after 12-weeks of Wii Fit games (Ribas et al., 2017). Kappen et al., (2019) also provide a good overview of the diversity and use of exergames for older adults. Therefore, due to the rapid development of computer technology, promising results in various clinical populations, and young autistic individuals' interest in electronic media (i.e.,

videogames), more research is needed to better understand and establish the benefits of exergames for ASD.

Many studies have focused on the impact of exergames for increasing physical activity levels in autistic individuals, in an attempt to decrease sedentary behaviours and improve fitness-related outcomes such as heart rate and calories burned (Fang et al., 2018; Finkelstein et al., 2013; Finkelstein et al., 2010; Hilton et al., 2015; Jozkowski et al., 2016). Whilst these studies have shown promising results for fitness-related outcomes, they do not account for how exergames could influence any of the well-recognised facets associated with ASD. Therefore, some studies have since focused their efforts on examining the effect of exergames for some of the specific domains that are commonly affected in ASD, such as motor skills, cognitive function or social capabilities. However, no review to date has acknowledged and highlighted the potential beneficial effects of exergames for alleviating symptomology associated with the ASD, which may be functionally impairing to the individual, exclusive of physical activity levels/fitness-related outcomes.

Therefore, the purpose of this review is to systematically search and synthesise all available and suitable studies relating to the non-fitness/non-physical-health-related effects of exergames, such as cognitive, social, or motor functions, for young autistic individuals and to understand whether exergames are a viable vehicle for therapeutic intervention. In addition, directions for future research are provided. For example, advising the development of tailored exergame-based interventions for young autistic individuals, which can support communication skills in a person-centred manner as this is an autism-prioritised research outcome.

3.9 Methods

3.9.1 Research question

To provide a summary of the current evidence relevant to the non-fitness-related impacts of exergames for young autistic individuals and to investigate whether exergames and active videogames can elicit positive effects for autistic individuals, the PICO and SPIDER strategies were utilised to devise a central research question. Using these frameworks (which were previously outlined in Part A of the current chapter), the following research question was generated: *"To what extent can exergames have non-fitness-specific beneficial effects for young autistic individuals?";* where: P/S: individuals (under the age of 18-years-old) diagnosed with autism spectrum disorder, I/P: exergames, O/E: non-fitness related outcomes; for example, social communication skills, motor skills, and executive and/or cognitive functioning, and R: quantitative, qualitative and/or mix-methods. It is appreciated that some studies may use varying study designs, including within-subject study designs, comparing the effects of an exergame with pre- and post-intervention tests and an initial review of the literature suggested that there were limited studies available for review that included a comparison group. Therefore, the inclusion of a control group or comparative intervention was not specified in the research question and the limitations this begets is considered in the discussion.

3.9.2 Inclusion and exclusion criteria

Studies were included in the review if they met the inclusion criteria. For example, studies were included if they were in English, published between 1990 and 2020, included participants younger than 18-years-old, where most participants had a diagnosis of ASD, used an exergame as an intervention, and measured the effect of the intervention with reported outcome measures that focused on skills such as social, cognitive or motor proficiencies. Studies were excluded if the papers were not in English, participants were

older than 18-years-old, and/or if the outcome measures focused only on physical activity levels or fitness-related outcomes; for example, heart rate, calories burned or moderate-to-vigorous physical activity levels, as this was not the main focus of the systematic review. Additionally, conference papers and review articles were excluded (Table 3B. 1). In contrast to Part A of Chapter Three, the age range was increased to 18-years-old due to the limited number of studies that only included children younger than 18-years-old.

Table 3B. 1 Criteria for inclusion or exclusion of study in the review.

Inclusion Criteria	Exclusion Criteria
In English	Not in English
Included children or young autistic individuals	Included no individuals with a diagnosis of ASD
Published between 1990 and 2020	Published before 1990 or after 2020
Participants younger than 18-years-old	Participants older than 18-years-old
Intervention must be an exergame or active video game	Intervention is not an exergame or active video game
Outcome measures focus on non-fitness specific measures; for example, cognitive measures, social measures or motor measures	Outcome measures only focus on fitness-specific outcomes; for example, heart rate or calories expended
Research Articles	Conference abstracts, conference papers or reviews

3.9.3 Literature search

A total of six databases were searched for the most appropriate and relevant studies that corresponded to the specific objectives of this review. Databases included Scopus, Web of Science, and EBSCOhost; together with PsycArticles (American Psychological Association – APA), PsycINFO (APA), SPORTDiscus and MEDLINE. The key search

terms consisted of the descriptives; “autism”, “ASD”, “autism spectrum disorders” “child*” “young”, “exergames”, “virtual physical activity*”, “exercise games”, “exergaming”, “positive”, “benefi*”, “social”, “communi*”, “impact”, “behaviour”, “effect*”, alongside the Boolean operators; “and” and “or”.

3.9.4 Selection of studies and extraction of data

Following the PRISMA guidelines for systematic reviews, an orderly procedure was carried out to select the most relevant articles to include in the review from the literature search (Moher et al., 2009). During the first phase of the procedure, all extracted articles from the literature search were combined into a single folder, removing any duplicates. Adhering to the inclusion and exclusion criteria, articles were first excluded based on their titles and then based on their abstracts.

Using the ‘Dual Independent Review Approach’ of the search results, the first author and an independent reviewer (TM) both screened the titles and abstracts to ensure reproducibility in the inclusion and exclusion criteria (Stoll et al., 2019). The remaining articles were all read fully and brief notes were made on each of the study’s characteristics, including title and author, study design, participants used, intervention utilised, and outcome measures, whilst still assessing them against the inclusion and exclusion checklists (Table 3B. 1). Additionally, the reference lists of relevant articles were read, seeking studies that were appropriate for inclusion but had been missed by the search parameters. Papers that met all the inclusion criteria and were relevant to the central research question were all comprehensively read again in order to finalise articles to include for evidence synthesis (Figure 3B.1). Once the final studies to include in the review had been selected, data was extracted to retrieve particular information regarding each study. This included:

- Author and years of publication

- Number and age of participants
- The study's design
- Exergame platform used
- Outcome measures utilised
- General results and conclusions.

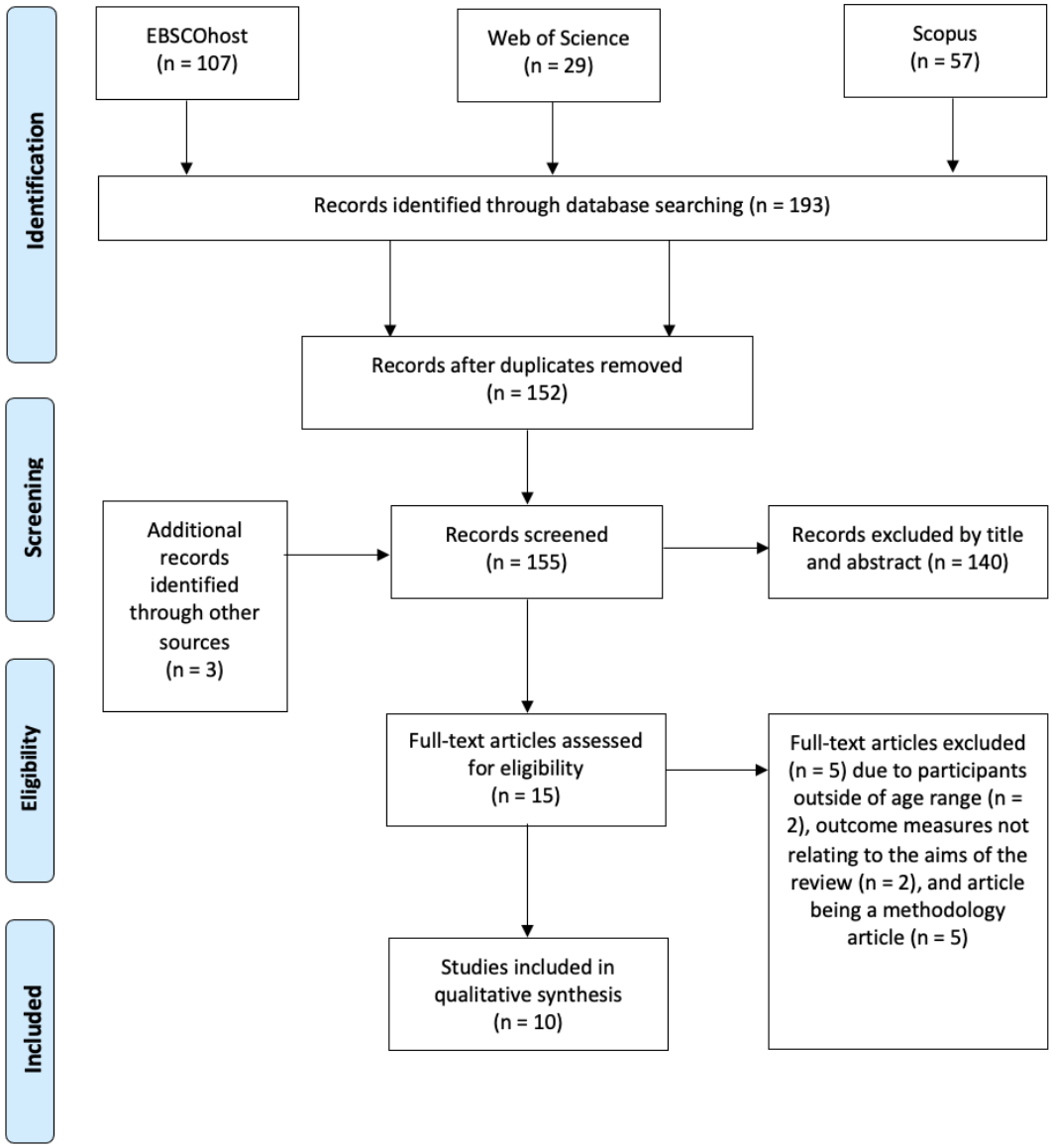


Figure 3B. 1 PRISMA diagram for the flow of information through the different phases of the systematic review (Moher et al., 2009).

3.9.5 Assessment of risk of bias for included studies

As reported in the Cochrane handbook, bias "is a systematic error, or deviation from the truth, in results or inferences" (Boutron et al., 2019), where different biases can lead to an over or underestimation of the true effect of an intervention. It is important to assess bias in all studies included in the review to ensure accurate conclusions can confidently be made from the synthesis of the available literature. As discussed in the previous Part A of this chapter, it is often impossible to know the extent that biases have affected the results of a particular study. Therefore, it is more appropriate to reflect on the 'risk' of bias of a particular study. The Cochrane risk assessment guidelines was employed to determine whether the risk of bias was low, high, unclear or not applicable (if non-randomised study) for selection bias (random sequence generation and allocation concealment), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective reporting), and any other potential bias.

3.10 Results

3.10.1 Study selection

The initial literature search identified 193 studies that met some of the key terms relating to the research question (Scopus, n = 57; Web of Science, n = 29; and EBSCOhost, n = 107). An additional three studies were identified by examining the reference list of relevant papers. After removing duplicates, screening papers based on titles, and then screening based on abstracts, 15 potential papers remained. To this end, the level of agreement between the two reviewers, who both screened the articles by titles and abstracts,

was calculated using Cohen's Kappa (McHugh, 2012). The weighted kappa score for agreement between the reviewers was 0.797, 95% Cl: 0.626 to 0.969, indicating substantial agreement (Landis & Koch, 1977).

The 15 papers were fully read and assessed against the inclusion and exclusion criteria. A total of 10 papers met the inclusion criteria and, therefore, were included in the review. These can be seen in Table 3B. 2. Most of the included papers were repeated measures, pre- and post-test study designs (Caro et al., 2017; Collins et al., 2015; Edwards et al., 2017; Flynn & Colon, 2016; Hilton et al., 2014). However, two were within-subject experimental designs with an A-B and A-B-A exposure (Anderson-Hanley et al., 2011; Chung et al., 2015, respectively), one was a two-arm parallel single-blinded trial (Lau et al., 2020), and another was an observational study (Pope et al., 2019). Only one study included in this review was a RCT (Rafiei Milajerdi et al., 2020).

Table 3B. 2 Characteristics of studies that met all the inclusion criteria, including study design, sample size, exergame platform used for the intervention and duration of intervention, outcome measures and findings.

Authors	Title	Study Design	Sample size; gender; age (mean age)	Platform	Intervention; delivery and occurrence	Outcome measures	Findings	Authors Conclusions
Anderson-Hanley et al., 2011	Autism and exergaming: effects on repetitive behaviours and cognition (Pilot I)	A within-subject experimental design, with A-B exposure; 2 pilot studies	*N* = 12; eight males and four females; between 10- and 18-years-old (14.8-years-old).	Kinect	Conducted across two weeks. Week one, participants completed the control condition, watching a 20-minute video of a school talent show. Week two, participants	Repetitive behaviours were measured by observations whilst playing for five minutes with Lego or Play-Doh, coded according to the repetitive scale of the Gilliam Autism Rating Scale-2.	Statistically significant condition × time interactions were found for repetitive behaviours ($P < 0.001$, Digits Backwards ($P < 0.05$) and Stroop Task ($P < 0.05$). Repetitive behaviours decreased after exergaming	The significant interactions suggest that the relative change from pre- to post-intervention condition was significantly different from the change in the control condition revealing improvement after

			All individuals had an ASD diagnosis		completed the exergaming session, engaging in Dance, Dance Revolution (DDR) for at least 20-minutes	Cognitive functions were measured by the Digit Span Forwards and Backward Test, the Colour Trails Test and the Stroop Task	compared with the control condition (P > 9.05), whilst performance on the Digits Backwards improved (P > 0.05). Time to complete the Stroop Task and the Colour Trials Test decreased for both the control and exergaming condition, with the control condition improving the most	exergaming when compared with the control condition, for repetitive behaviours and at least one measure of executive function within subjects. However, given the short intervention session it is difficult to attribute these differences to participation in the exergame
Caro et al., 2017	Using the FroggyBob by exergame to support eye-body	Repeated measures deployment study	*N* = 7; six males, one female; between 7- and 10-years-old	Kinect	Conducted within a school environment. Participants completed ~10-minute	Weekly interviews were conducted with the child's psychotherapists, acting as proxies to the children's potential	Emotional expression: when expressing emotions (representing 30% of the total time of the game session), most	The results indicate children with severe autism maintained positive emotions and their attention throughout the total

	coordination development of children with severe autism	(8.62-years-old). All individuals had an ASD diagnosis and were non-verbal	exergaming sessions, twice a week for 6-weeks. They played up to six levels of FroggyBobby	answers. All exergame sessions were videoed to be observed and later coded based on a framework quantifying children's behaviours and interactions with the game, such as emotional expression, attention, motor performance and prompts	of the time those emotions were positive (99%). Attention: on average, children were focussed in each session for 98% of the time, there was no significant change in attention from the first session to the last session. Motor: statistical significance was found in the percentage of time of aimed limb movements across the game sessions ($P < 0.05$) and aimless limb movements decreased significantly across	duration of the exergaming intervention. Furthermore, aimless limb movements were observed to decrease throughout the session, whereas successful aimed limb movements were observed to increase throughout the 6-weeks of the exergame within subjects

							the game sessions ($P < 0.05$). Prompts: results showed a significant decrease in the percentage time that children needed verbal prompts across the game sessions from 99% to 61% ($P < 0.0001$)	
Chung et al., 2015	Social Behaviours and Active Videogame Play in Children with Autism Spectrum Disorder	Single-case, within-subject experimental design, with an A-B-A exposure, observational study	*N* = 6; four males, two females; between 6- and 12-years-old (10.6-years-old). Three pairs of	Kinect	Conducted within the home environment. Each dyad (ASD child + sibling) completed a maximum of three, 30-minute gaming sessions per week for 12-weeks (12	All sessions were videotaped. Primary measures were observed and evaluated using a coding manual with measures for joint positive effect, reciprocal conversation and aggression. Parental	Dyad A: the intervention condition resulted in a mild elevation of joint positive affect but a decrease in reciprocal communication. Aggression was unchanged. Dyad B: the intervention condition resulted in a	In autistic children who already played sedentary videogames, active video gaming (exergames) did not sustainably improve the quality of social engagements with their siblings over sedentary video gaming. A larger sample size and the use

	dyads, consisting of the 'target' child who has an ASD diagnosis and their sibling	sessions in total). The format was four control sessions based on sedentary videogames, six exergaming intervention sessions based on Kinect active videogames, and then two control sessions again	interviews were also conducted	decrease in reciprocal communication and no changes in aggression and joint positive affect. Dyad C: the intervention condition resulted in decreases in joint positive affect and reciprocal communication. Aggression was unchanged. All parents thought the active videogame sessions were more positive social experiences than the sedentary gaming sessions	of standardised assessment are need to explore this further

Collins et al., 2015	Exergaming to improve physical and mental fitness in children and adolescents with Autism Spectrum Disorders: Pilot Study	Repeated measures pre- and post-test experimental design	*N* = 17 (13 due to drop out); 12 males, five girls; between 8- and 18-years-old (11.76-years-old)	Makoto Arena	Conducted at the Clayton Child Centre or the Washington University School of Medicine for 8-weeks. Participants completed up to three, 2-minute sessions of Makoto arena intervention in a row each day with a rest period between	Executive function was measured by the Behaviour Rating Inventory of Executive Function (BRIEF) and motor skills were measured by the Bruininks-Oseretsky Test of Motor Proficiency-2 *(*BOT-2)	The BRIEF overall score, the global executive composite, showed a significant improvement ($P < 0.05$). The metacognition index change was also significant ($P < 0.01$). The behavioural regulation index showed a large effect size but was not significant. BOT-2 scores showed significant improvement only in the motor area of strength and agility ($P < 0.01$)	The use of exergaming, specifically the Makoto arena, may be useful for improving EF and motor skills in autistic children and adolescents. However, future work is needed to confirm this with control or comparison conditions

Edwards et al., 2017	Does playing a sports active video game improve object control skills of children with ASD	Two-arm repeated measures pre- and post-test experimental design	*N* = 30; ASD *N* = 11; eight males, three females; between 6- and 10-years-old (7.64-years-old); TD *N* = 19; 10 males, nine females; between 6- and 10-years-old (7.89-years-old)	Kinect	ASD; conducted within the home environment for 2-weeks. Each child engaged in Kinect Sports Season 1/2 or Sport Rivals for 45-to-60-minutes, three times a week (six sessions in total). TD participants; delivered in their schools where each child completed 50-minute gaming sessions once a week during school lunchtimes	Control skills were measured by actual (Test of Gross Motor Development; TGMD-3) and perceived object skills (Pictorial Scale of Perceived Movement Skill Competence for Young Children). Parents also completed an interview post-intervention	There no were significant increases between the pre- and post-intervention mean scores on the TGMD-3 for the ASD group. Perception of skill in the ASD group significantly increased by 2 units ($P < 0.05$). Parents reported exergaming was a feasible intervention, though smaller, more frequent sessions would better fit into the daily routine and keep the children engaged	Exergaming was not observed to improve object control skills in this autistic sample. However perceived competence was reported to significantly increase

					for 6-weeks (six sessions in total)			
Flynn and Colon, 2016	Solitary Active Videogame Play Improves Executive Functioning More Than Collaborative Play for Children with Special Needs	Repeated measures pre- and post-test experimental design	*N* = 36 children; 25 males, 11 females; between 7- and 18-years-old; (12.31-years-old) All children had cognitive, social, and emotional disabilities, with 34% having an	Wii	Participants were randomly assigned to playing alone or paired play conditions and then participated in the exergame Just Dance 4, dependent on the condition for on average 20-minutes.	Parents completed a demographic questionnaire, and both children and parents completed a short media questionnaire to measure media exposure. Each participant's level of enjoyment during the activity was measured at the end of each activity session with the question, ''How much did you like the activity you just did?''. The Stroop Task and Flanker Task	There were no differences in the frequency of overall videogame play or active video game by condition. On average, participants enjoyed their experience and there were no significant differences in enjoyment by condition. Participants in the playing-alone condition had a significantly larger change from pre- to post-test on the Stroop task when compared to the paired-play	Children enjoyed playing the exergame Just Dance 4 and, when they played alone, they improved their executive function from pre- to post-intervention. The findings support previous studies that have shown that children with additional needs can improve Executive Function through active videogames play when they play alone

			ASD diagnosis			were used to measure executive function	condition ($P < 0.05$). In addition, participants in the playing-alone condition had a significantly larger change from pre- to post-test on the flanker task when compared to the paired-play condition ($P < 0.05$)	
Hilton et al., 2014	Effects of exergaming on executive function and motor skills in children	Repeated measures pre- and post-test experimental design	*N* = 7; five males, two girls; between 6- and 13-years-old (9.8-years-old). All	Makoto Arena	Conducted at the Clayton Child Centre or the Washington University School of Medicine. Participants completed 2-minute sessions	Executive function was measured by the BRIEF and motor skills were measured by the BOT-2	Significant improvements were observed in the BRIEF's Working Memory scale ($P < 0.05$) and the Metacognition Index ($P < 0.05$). Improvements were	This pilot study provides initial evidence that exergaming, specifically Makoto arena, may be useful for improving EF and motor skills in children on the autism spectrum.

	with ASD: a pilot study		individuals had ASD		of Makoto arena intervention for a minimum of three times per week (30 sessions in total)		observed in all areas of the BRIEF except the Inhibit scale. Motor scores showed significant improvement only in the motor area of strength and agility ($P < 0.05$), with some improvement was also noted in manual coordination and total motor composite	However, future work is needed to confirm this with control or comparison conditions
Lau et al 2020	Effectiveness of active video game usage on body composition, PA level and motor	Two-arm parallel, single-blinded trial	*N* = 203; Intervention *N* = 125; 92 male, 33 female; between 8- and 18-years-old	Kinect	Conducted with a school setting for 12-weeks. Participants completed two 30-minute intervention sessions per	Body composition and PA level measured by ACTi Graph GT3X + activity monitor. Motor proficiency was measured by the BOT-2	Body composition increased for both groups. Children's BOT-2 scores increased from 53.85 at baseline to 57.36 at post-test in the intervention group (P	Exergames were unable to improve motor proficiencies, body composition or PA levels over and above that of the control group who completed physical activity as usual

	proficiency in children with intellectual disability		(mean unknown); Control *N* = 78; 54 males, 24 females, between 8- and 18-years-old (mean unknown). All had an intellectual disability; 51.2% had comorbid autism		week, playing Kinect Sport Season Series 1 and 2. Control group received no intervention and continued with PA as usual		< 0.001), while it increased from 57.86 at baseline to 59.20 at post-test in the control group (P < 0.01). However, this was not statistically significant between groups	
Milajerdi et al., 2020	The effects of PA and Exergaming	Randomised controlled trial	*N* = 60; SPARK *N* = 20; 19	Kinect	Conducted within the Iran Autism centre. Children	The Movement Assessment Battery for Children-Second	Motor: There was a significant group x time interaction for	This study showed that a structured traditional PA intervention that

	on Motor Skills and Executive Functions in Children with ASD	males, one female; between 6- and 10-years-old (8.45-years-old); Kinect *N* = 20; 19 males, one female; between 6- and 10-years-old (7.95-years-old); Control *N* = 20; 19 males, one female; 6 - 10-years-	were randomly assigned to either the SPARK (Sports, Play and Active Recreation for Kids) group, Kinect Tennis group, or Control group. Children assigned to the SPARK and Kinect groups completed 35-minute sessions, three times a week, over 8-weeks (24 sessions in total). Children in the control group did not participate in	Edition (MABC-2) was used to measure motor skills and the Wisconsin Card Sorting Test (WCST) was used to measure executive function both pre- and post-test	aiming and catching ($P < 0.05$), where an improvement in aiming and catching on the MABC-2 from pre-test to post- test was observed in the SPARK group, whereas the Kinect group showed a decrease in these skills. The control group displayed a limited change in aiming and catching from pre- test to post-test. Executive function: there was a significant main effect of group for the number of correct	targets specific motor skills resulted in motor function improvement in autistic children. The findings also suggest that exergaming may improve EF in autistic children; however, future research is warranted

			old (8.15-years-old). All individuals had an ASD diagnosis		any structured PA program and continued with treatment as usual during the study period		responses during the WCST ($P < 0.01$). Post hoc comparisons revealed statistically significant differences between the Kinect and control group, and between the Kinect and SPARK group, where the Kinect group performed better	
Pope et al., 2019	Comparison of exergaming and adaptive physical education on PA, on-task	Mixed methods observational study	*N* = 5; all males; between 5.5- and 10.5-years-old (6.8-years-old). All individual	Wii	Conducted within a school environment for 3-weeks. Each child completed three sessions of exergaming, specifically Just Dance 4 or Wii	Sedentary behaviour, light PA and moderate-to-vigorous PA measured via an accelerometer during each condition. Direct observations during each condition including coded on	Children had a high affinity for Just Dance 4. Exergaming condition had higher average minutes of MVPA and lower average of LPA. Direct observation revealed greater	Exergames can increase levels of PA and promote on-task behaviour and communication. However, in this study, AdPE was observed to be better at promoting on-task behaviour and

behaviour and communication in children with ASD	s had an ASD diagnosis	Sports, and Adaptive Physical Education (AdPE; six sessions in total)	task and attentive behaviours and communication	percentage of on-task behaviour during AdPE than exergaming and a high percentage of communication also seen in AdPE	communication than exergames

(DDR; Dance Dance Revolution, ASD; Autism Spectrum Disorder, PA; Physical activity, BRIEF; Behaviour Rating Inventory of Executive Function, SPARK; Sports, Play and Active Recreation for Kids, TGMD-3; Test of Gross Motor Development-3, BOT-2; Bruininks-Oseretsky Test of Motor Proficiency-2, LPA; light physical activity, MVPA; moderate-to-vigorous physical activity, MABC-2; The Movement Assessment Battery for Children-Second Edition, WCST; Wisconsin Card Sorting Test

3.10.2 Study Characteristics

3.10.2.1 Characteristics of participants

As this review focuses on the effects of exergaming for young autistic individuals, it was decided not to include studies that had participants over the age of 18-years-old. The average age of participants included in the review, excluding Lau et al.'s (2020) study as they did not report mean age, was 9.56-years-old.

Most participants had a diagnosis of ASD, according to the Diagnostic and Statistical Manual of Mental Disorders IV or V (DSM-IV; DSM-V; American Psychiatric Association, 2013). The Autism Diagnostic Observation Schedule-Second Edition (ADOS-2; Lord et al., 2012) and the Gilliam Autism Rating Scale-Second Edition (GARS-2; Gilliam, 2005) were also used to assess autism severity and confirm a diagnosis. Some studies, such as Lau et al. (2020) and Flynn and Colon (2016) included participants that had various difficulties or intellectual disabilities, but where the majority of participants had an autism diagnosis. Additionally, TD participants were also included in Edwards et al. (2017) for between-group comparisons.

3.10.2.2 Characteristics of interventions

Interventions varied in duration. Some studies concluded within a day, whilst others lasted 12 weeks. Flynn and Colon, (2016) and Anderson-Hanley et al. (2011) both used a single, 20-minute intervention session to assess the effect of their chosen dance-based exergame on participant's EF, repetitive behaviours, and cognition. In comparison, Hilton et al. (2014) and Rafiei Milajerdi et al. (2020) conducted their interventions across 8-weeks, in which participants were required to complete several sessions of their chosen exergame; Makoto Arena and Kinect, respectively, each week. Chung et al. (2015) and Lau et al., (2020) both utilised the Kinect platform, requiring participants to complete up to three

exergaming sessions a week, for 12 weeks. However, Chung directed autistic children to play the Kinect-based exergame with their TD sibling in the home environment, whilst Lau asked autistic children to be 'paired-up' by their teachers and complete the intervention in a school environment. Across all studies, the average intervention duration was 6-weeks and the most popular platform utilised was Kinect, followed equally by Makoto Arena and Wii. The most popular type of active video games played were dance-based games, such as Wii's *Just Dance* or Kinect's *Dance Dance Revolution*. However, sports-based games such as Sports Season 1 and 2 or Kinect Tennis were also played frequently.

3.10.2.3 Characteristics of outcome measures used

The studies included in this review examined a variety of potentially beneficial outcomes of exergames for young autistic individuals including social, cognitive, and motor benefits. They did not, however, focus on or investigate the fitness-related benefits of exergames, as this was not the main aim of the review. Overall, seven of the studies investigated the effect of exergames on cognition, most frequently EF, seven of the studies examined motor function, and only two of the studies explored social behaviours. It is therefore apparent that some studies investigated the effects of exergames on both cognition and motor skills (Anderson-Hanley et al., 2011; Caro et al., 2017; Collins et al., 2015; Hilton et al., 2014).

To assess EF, tasks such as the Stroop Task (Stroop, 1935), Wisconsin Card Sorting Task (WCST; Grant & Berg, 1948), and the Digit Span Backwards Task were employed (see Ramsay and Reynolds (1995) for an overview). They were often administered pre- and post-intervention. To examine the effect of exergames on motor skills and motor proficiencies most studies enlisted the Bruininks-Oseretsky Test of Motor Proficiency-Second Edition (BOT-2; Bruininks & Bruininks, 2005), however one study used the

Movement Assessment Battery for Children-Second Edition (MABC-2; Henderson et al., 2007) and another used the Test of Gross Motor Development-Third Edition (TGMD-3; Ulrich, 2016). When exploring the effect of exergames on social behaviours, Pope et al. (2019) and Chung et al. (2015) both videotaped their participants during intervention sessions, subsequently observing the tapes to score behaviours according to a coding manual and to assess changes in social behaviours.

3.10.3 Study findings

3.10.3.1 Executive function

Overall, some studies reported that exergaming produced certain benefits for young autistic individuals. Collins et al. (2015), Flynn and Colon (2016), Hilton et al. (2014), and Rafiei Milajerdi et al. (2020) all noted improvements in EF following their exergame-based interventions. Both Collins and Hilton utilised the Behaviour Rating Inventory of Executive Function (BRIEF) to measure changes in EF and both observed improvements in all areas of the inventory. Collins reported a significant improvement in global executive composite ($P < 0.05$) and metacognition index ($P < 0.01$) and Hilton reported a significant improvement in the specific areas of working memory ($P < 0.05$) and global executive composite ($P < 0.05$). Rafiei Milajerdi used the WCST as a measure of EF. They showed that on average the exergaming group were able to significantly improve their correct responses on the WCST, between pre- and post-test from 0.50±0.71 to 1.52±2.00, which was greater than both the control and SPARK (Sports, Play and Active Recreation for Kids) groups included within the study ($P < 0.05$), suggesting an improvement in set-shifting and mental flexibility due to exergaming.

3.10.3.2 Motor skills

Caro et al. (2017), Collins et al. (2015), and Hilton et al. (2014) all reported an improvement in motor skills. Caro demonstrated that '*FroggyBobby*' was able to increase the percentage of time participants spent performing aimed limb movements from 56% in the second session to over 96% in the twelfth session, suggesting a significant improvement in motor coordination ($P < 0.05$). Collins et al. (2015) compared the means of pre- and post-test scores for the BOT–2 during their study, with results suggesting an improvement in all areas of the BOT-2 and a significant improvement in the motor area of strength and agility ($P < 0.01$) with a large effect size ($r = 0.54$). Similarly, Hilton et al. (2014) also noted a significant improvement in the motor area of strength and agility in the BOT-2 scores following their '*Makoto Arena*' intervention ($P < 0.05$), with a medium effect size ($d = 0.46$). Edwards et al. (2017) suggested that during their study exergames were unable to produce an improvement in actual motor skills but instead were able to increase the participant's perceived object-motor skills by approximately 2 units, from an average score of 27.36 ± 3.85 to 29.45 ± 3.91, on the Pictorial Scale of Perceived Movement Skill Competence ($P < 0.05$), which in future may have led to an improvement in actual motor skills with continued use.

In comparison, Lau et al. (2020) reported that exergames were unable to improve motor proficiencies, body composition or physical activity levels over and above that of their control group during their study, as no significant improvements were observed between the intervention and control group. Despite children's BOT-2 scores increasing from 53.85 ± 15.25 at pre-test to 57.36 ± 15.00 at post-test in the intervention group and only increasing by two units from pre-test to post-test for the control group, after adjustment for the intervention group relative to the control group, differences for motor proficiency were found to be non-significant.

3.10.3.3 Social skills

Chung et al. (2015) noted no substantial improvement in social behaviours, including positive joint affect, reciprocal communication, or aggression within their participants, during their active videogame intervention in comparison to the sedentary videogame condition. Pope et al. (2019) reported that exergames, mostly '*Just Dance 4*', were able to promote an increase in physical activity levels, on-task behaviours, and communication. However, their comparison condition which the same participants completed, Adaptive Physical Education (AdPE), was able to achieve this on a greater scale. For example, percentage of time spent communicating during the AdPE condition was 34.0% ± 11.8 compared to 16.1% ± 10.1 in the exergaming condition.

3.10.3.4 Enjoyment

In addition to positive outcomes for the development of specific skills, many of the studies included in this review reported that children enjoyed participating in their exergaming interventions. Both Flynn and Colon (2016) and Collins et al. (2015) measured participant's responses to participating in their exergaming interventions via questionnaires. Collins et al. reported that 88% of their participants experienced some degree of enjoyment from playing the '*Makoto Arena*' exergame and Flynn and Colon reported that on average all participants enjoyed their exergaming experience. Similarly, Chung et al. (2015) received parent feedback following their exergaming intervention inferring that the '*Kinect*' games were a positive and enjoyable experience, which was engaging and social for their children. Likewise, Caro et al. (2017) suggested that 99% of the emotions displayed by participants of their exergame were positive emotions.

3.10.4 Risk of bias

Risk of bias, including low, high, and unclear risk, were reported for all studies according to selection, performance, detection, attrition and reporting bias (Figure 3B. 2). However, the risk level was not applicable for all categories in each study. For example, studies that did not include two different groups (i.e., intervention vs. control), did not need to randomly assign participants to different groups. Therefore, selection bias, with regards to random sequence generation, was not applicable for these studies.

Most studies were unable to blind participants due to the nature of the interventions; however, it was believed this would not affect the outcomes of the studies. Additionally, most studies did not blind personnel during the outcome assessments, which may have led to detection bias. Authors that accounted for this either by having multiple coders and assessors and reporting interrater reliability for their outcome measures were regarded as having low detection bias. However, studies that did not reference how they attempted to limit detection bias or failed to note how detection bias may have impacted their results were regarded as having an unclear or high risk of bias. In addition, the authors of the Caro et al. (2017) study were involved in the development of the exergame used in their deployment study and therefore were noted as potentially having a high risk of bias for 'other biases'.

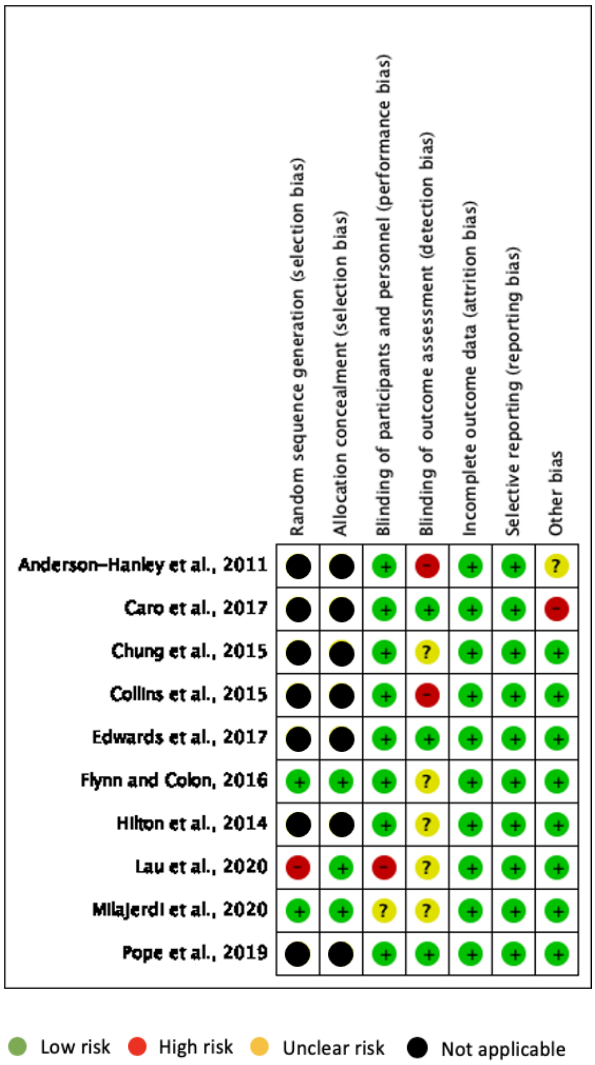


Figure 3B. 2 Risk of bias assessment of selected studies (Adapted from Cochrane Handbook; Higgins et al., 2019; Sterne et al., 2019) with key to the bottom.

3.11 Discussion

In answer to the research question "*To what extent can exergames have non-fitness-specific beneficial effects for young autistic individuals?"* the results suggest that interventions based on exergames can produce some beneficial effects for young autistic individuals. These included improving EF, increasing motor proficiencies and, to some extent, promoting communication owing to the diversity of exergames and skills needed to play various exergames. Additionally, results from the studies included within this review

suggest that participants enjoyed the exergames, which is a key component to helping autistic individuals engage with interventions (Finke et al., 2018). Flynn and Colon (2016), Collins et al. (2015), and Chung et al. (2015) reported that children enjoyed participating in their exergaming interventions, either via self-reported questionnaires or feedback from parents. Furthermore, no study reported any adverse consequences for children participating in their exergaming-based intervention.

3.11.1 Implications for practice and future work

Online media such as videogames and exergames are believed to be intrinsically motivating for many autistic individuals and, falling in line with the available literature, the results from this review suggest that exergames are engaging, motivating, and enjoyable for young autistic individuals (Caro et al., 2020; Finkelstein et al., 2010; Lyons, 2015). Furthermore, the availability of many different exergames that promote varying beneficial effects and involve different skills allow children to choose what games they want to play and have autonomy over their choices. It is thought motivation is essential for learning and is a key component in engaging with and committing to learn a new activity. Further, it is argued that the most optimal context for development is one that is selected based on the motivation and interests of the individual (Deci & Ryan, 2000; Koegel, 2000; Gee, 2009). This illuminates why exergames may elicit positive changes in executive function and motor skills, highlighting the strong potential exergames have for developing further skills in young autistic individuals, such as self-regulation, cooperative play, or communication skills.

Recognising that autistic individuals contend with various barriers throughout their day-to-day lives, challenges presented within videogames may be more manageable, enjoyable, and rewarding than tasks presented in their everyday lives (Durkin et al., 2013). Previous studies have indicated that individuals on the autistic spectrum play videogames

for a variety of reasons, including emotional regulation, immersion, social interaction, achievement, creativity, and mental stimulation (Finke Erinn et al., 2018; Mazurek et al., 2015). Given that exergames are observed to elicit some beneficial effects, are intrinsically motivating, and enjoyable for autistic individuals, it seems plausible that exergames can offer a viable platform for developing an array of skills in ASD in a therapeutic capacity, which is well-suited to the individual's interests. Exergames could be implemented into practice, with future work confirming the optimal duration and frequency of exergaming interventions and the ideal games to play for targeting specific domains of ASD. Further, exergames could readily be integrated into (or in addition) to schools' PE programmes to improve EF and motor skills in autistic children, following more rigorous studies confirming their benefits.

Despite differences in social and communication skills being a core diagnostic symptom of ASD and having a significant impact on QoL (Chiang & Wineman, 2014; Kuhlthau et al., 2010), only two studies were found by the systematic search to investigate the effect of exergaming on social behaviours in young autistic individuals. Both Chung et al. (2015) and Pope et al. (2019) observed communication and social behaviours during their exergaming conditions. Chung et al. reported no significant changes to positive joint affect, reciprocal communication, or aggression during their intervention condition; however, this study only included 3 participants, who had an autism diagnosis, in dyads with their TD siblings. Pope et al. (2019) noted an improvement in on-task behaviour and communication in autistic participants (n = 5), however their AdPE condition produced greater improvements in both outcome measures. As these were both observational studies with limited sample sizes, it may be beneficial to complete a pre- and post-intervention study design with a larger sample of autistic individuals, testing social skills using standardised

measures before and after the intervention to complement the observational findings and draw stronger conclusions from the findings.

It is noted that many autistic participants had a high affinity for dance-based exergames. Dance is a type of physical activity that emphasises the importance of movement and fitness in a variety of ways but also allows one to express their feelings and emotion, communicating through the use of rhythm and body positions (Calvo et al., 2015; Camurri et al., 2003). As previously discussed within this thesis, the use of dance has been extended to therapeutic practices, where DMT is employed for a variety of clinical populations, including those with depression and anxiety (Adam et al., 2016; Karkou et al., 2019), Parkinson's disease (de Natale et al., 2017; dos Santos Delabary et al., 2018), and autism (Scharoun et al., 2014; Takahashi et al., 2019). Within the realms of autism, DMT has been observed to enhance communication skills in young autistic individuals, with dance movement therapists reporting promising results through the successful use of mirroring, synchronous movement interaction, and rhythm (Field et al., 2001; Koch et al., 2015). Our first systematic review indicated that the techniques of mirroring and rhythm support communication skills and social development even when employed outside the realms of DMT (Morris et al., 2021). Both techniques are found within dance-based exergames such as '*Just Dance*' (Wii), which requires the player(s) to rhythmically mirror/copy the avatar on screen. Due to this cross over between exergames and successful elements of DMT, it seems plausible that dance-based exergames may still be able to improve social skills and warrants further investigation despite the limited findings from Pope et al. (2019) and Chung et al. (2015). More recently, '*Just Dance*' compared to another almost identical movement-based intervention was observed to produce significant positive psychological and psychosocial effects in a large sample of TD primary school children (n = 417; Quintas et al., 2020). Therefore, future work should attempt to further explore and

evaluate the beneficial effects of dance-based exergames on the social skills of young autistic individuals in larger studies to understand their true effect. Researchers could recruit an appropriate number of participants to allow for pre- and post-test comparisons of outcome measures between an intervention group (dance-based exergame) and a control group, where standardised outcome measures that relate to social skills, such as the Social Responsiveness Scale (Constantino, 2013), Social Skills Improvement Scale (Gresham & Stephen, 2007), or the Emotion Regulation and Social Skills Questionnaire (ERSSQ; Beaumont & Sofronoff, 2008) are used in combination with coded observations in a given context (Heimann et al., 2006; Nadel et al., 2000; White et al., 2007).

The findings from this review suggest an exergame intervention based on a timeframe of 6-weeks or greater, with participants completing the exergame for 2-to-3 times per week may be an optimal starting point for future studies. If the results from such a study demonstrated beneficial effects, for example an improvement in the ERSSQ, which was specifically designed for use in the autistic population, exergames could be more confidently integrated into practice for the development of social skills in the autistic population.

3.11.2 Limitations

Some of the studies included in this review present encouraging results for improving specific domains affected within ASD. However, they are not without their limitations, restricting the conclusions drawn regarding the effectiveness of exergames for autistic individuals. Out of ten studies, only two included a control group. The first was a RCT (Rafiei Milajerdi et al., 2020) and the second was a two-arm, single-blinded trial (Lau et al., 2020). One other study included an active comparison task for children to also complete (Pope et al., 2019). Although non-randomised studies are useful for feasibility studies and still allow for the critical examination and analysis of the available evidence, it is somewhat difficult to draw conclusions that the intervention generates the observed

outcome in studies that do not include control or comparison groups (Gerstein et al., 2019). Additionally, the absence of a control group prevents comparison of the experimental group to the changes that might be seen due to normal development, on-going therapies, or familiarity with the assessments (Collins et al., 2015). For example, whilst Caro et al. (2017) suggested that attention and enjoyability was maintained throughout their exergaming intervention, there is no indication or comparison available of what attention and enjoyability levels were prior to participating in the game or during a different intervention. To overcome this limitation and to confidently state exergames can elicit positive effects in young autistic individuals for a variety of traits, future studies should aim to include a control or active comparison group.

Small sample sizes were another reoccurring limitation across the studies reviewed. Recruiting participants with a diagnosis of ASD can present potential barriers. For example, when data is collected in schools there often needs to be specific student-to-teacher ratios, and so, if limited teachers are available this can also limit the number of children available to participate in the study. Additionally, families with autistic children already face an array of challenges and require additional support, therefore participating in scientific research on top of educational-, social-, and therapy-based commitments may prove too much, and again limit the number of young autistic individuals available to participate. The overall sample size of autistic participants ranged from n = 3 to n = 125. Over half the studies included in this review had less than 17 participants overall (Anderson-Hanley et al., 2011; Caro et al., 2017; Chung et al., 2015; Collins et al., 2015; Hilton et al., 2014; Pope et al., 2019). However, most of these studies utilised a within-subject design, which is more practical than randomly assigning participants to an intervention type. This study design also has greater statistical power than a between-subject design when working with smaller sample sizes (Bellemare et al., 2014; Hilton et al., 2014; Thompson & Campbell, 2004). Only one study

reportedly carried out a power analysis to determine the sample size needed for their analyses. Rafiei Milajerdi et al. (2020) concluded that with three groups at an 80% power with an a = 0.05, 60 participants would be sufficient to detect medium group, time, and group x time effects. To assess the effectiveness of exergames more robustly as a therapeutic intervention for autistic individuals, it would be beneficial for future studies to conduct experiments with larger sample sizes, using power analyses to determine sufficient sample sizes, which will allow the inclusion of control groups and between-group comparisons.

No study included in this review chose to conduct post-intervention follow-up data collection. Despite some interventions lasting up to 12-weeks and producing beneficial effects, it was not clear whether these beneficial effects continued after the intervention ceased. Therefore, it is somewhat difficult to suggest long-term and applied utility of exergaming for ASD. Previous research has indicated that participation in physical activity interventions is able to produce long-lasting beneficial effects for autistic individuals (Gabriels et al., 2018; Movahedi et al., 2013). For example, Nicholson et al. (2011) demonstrated that antecedent physical activity was able to improve academic engagement four weeks post-intervention and Bahrami et al. (2012) described behavioural gains that were maintained long-term (1 month), following a 14-week martial arts-based training programme in autistic children. As a result, future work may wish to explore the maintenance of improvements following exergaming by performing a follow-up assessment.

3.12 Conclusion

This systematic review collates the available evidence that suggests exergames may be a viable vehicle to elicit some beneficial effects in young autistic individuals, exclusive of physical activity levels/fitness-related outcomes. Research suggests that exergames may

lessen repetitive behaviours, improve EF, and enhance motor skills to some extent. Future work should strive to determine the effects of exergames on young autistic individual's social skills. Furthermore, prospective work is needed to overcome many of the limitations highlighted by this review; for example, establishing whether positive results are maintained post-intervention and further exploring the application of exergames to support social development. Caution is warranted to not overstate the benefits of exergames for the autistic population without the addition of robust studies to the literature, such as further feasibility studies and later adequately powered randomised control trials to confirm the potential benefits of exergame that have been highlighted in this review. Such work may allow for exergames to be integrated into clinical practice or school routines, where exergames are utilised to support specific domains of ASD that negatively impact an individual's QoL, in an enjoyable and person-centred manner, which is specifically tailored to the individual's interests and motivation.

4 Chapter Four: Empirical studies

Part A - Dance, rhythm, and autism spectrum disorder; an explorative study

4.1 Abstract

This topic of research moves the field of dance movement therapy (DMT) into an area of clinical and social relevance by exploring the most beneficial features of rhythm and music for autistic children. The current literature suggests that rhythm, used both inside and outside of DMT, can enhance communication skills and social development of autistic children. However, the optimum features of music and rhythm are ambiguous, consequently limiting the integration of rhythm-based interventions into practice. To answer the research question "*What are the most common features of music and rhythm used by registered dance movement therapists for autistic children*?", 113 registered dance movement therapists were surveyed, regarding the most common features of music and rhythm they used within their sessions with autistic children. Most dance movement therapists reported using music that had a 4/4 time signature (64%), was of a moderato tempo (45%), and included lyrics (76%). Qualitative findings validated why these were the most common features of music and rhythm. These musical elements could regularly be integrated into new music and rhythm-based interventions targeting communications skills and social development for autistic children to improve their therapeutic potential.

Keywords: Autism Spectrum Disorders, Children, Dance, and Movement Therapy, Rhythm, Communication Skills**,** Social Development**.**

4.2 Introduction

4.2.1 Rhythm revisited

Rhythm is a naturally intrinsic part of our basic human physiology. We are neurologically built to create, process, and respond to various rhythms (Cruz, 2018). These can be internal rhythms, such as our circadian rhythm, which are often entrained by external cues such as the light-dark cycle, or external rhythms, such as the rhythm of auditory stimuli like music. Multiple areas of the brain are required to process various rhythms. For example, the *motor cortex, somatosensory cortex, basal ganglia,* and *cerebellum* are dedicated to receiving and processing different rhythms and generating movement responses (Cruz, 2018; Thaut & Abiru, 2010). Evidence demonstrates that the auditory and motor systems are densely connected. The auditory system projects into the motor structures of the brain, creating entrainment between the rhythmic signal and the motor response (Thaut & Abiru, 2010).

As suggested in Chapter Two, the technique of utilising and emphasising rhythm is widely used throughout the DMT community. By creating internal rhythms within the body and using music to drive external rhythms by providing timing for movement, the element of rhythm proves fundamental to DMT. Additionally, the techniques used within DMT, such as mirroring and rhythm are effective elements that can be used outside the realm of DMT (Morris et al., 2021). For example, the technique of rhythm has been extended to rhythmically-facilitated interventions, such as dyadic drumming, melodic-based communication therapy, and also rock drumming for alleviating some of the traits associated with ASD that impair QoL (Lowry et al., 2019; Sandiford, 2013; Willemin et al., 2018; Yoo & Kim, 2018). Such rhythm-based interventions have shown several positive effects enhancing communication skills and developing social interactions by increasing verbal attempts, level of co-operation and self-regulation, alongside improving scores on the

Childhood Communication Checklist II (Srinivasan, et al., 2016; Stephens, 2008; Willemin et al., 2018; Yoo & Kim, 2018). Furthermore, DMT attends to interpersonal synchrony, whilst also synchronising to external rhythmical cues, which may be an important factor for ASD (Behrends et al., 2012). For example, Noel et al. (2018) conducted a study measuring body movement synchrony, in order to investigate non-verbal interpersonal synchrony in relation the multisensory temporal binding window, during spontaneous conversation in both autistic and typically-developing (TD) participants. The results suggested that non-verbal interpersonal synchrony was associated with the temporal binding window in TD participants but not in autistic participants, inferring that autistic individuals may exhibit an uncoupling between sensory perception and interpersonal synchrony. Therefore, attending to interpersonal synchrony and synchronising to external rhythmical cues, such as in DMT, may lessen this larger binding window typically observed in autistic individuals and help to reduce social communication challenges (Foss-Feig et al., 2010; Meilleur et al., 2020; Wallace & Stevenson, 2014).

Despite the auspicious results of rhythm used both within and outside of DMT, there are very few successful interventions or activities used by clinical practitioners or within schools that utilise rhythm's potential therapeutic benefit. Part A of Chapter Three suggests that it is unclear whether there is a common or most beneficial rhythm to use when working with the young autistic population and proposes that future research should explore this. Perhaps the lack of clarity surrounding rhythm in music hinders its application in practice? Currently, the optimum time signature or tempo of music played during DMT sessions is unknown, and it is unclear if the music played is purely instrumental or has lyrics. All these elements could potentially impact the effectiveness of new rhythm-based interventions for autistic children (Srinivasan, et al., 2016). Furthermore, no study to date has investigated these elements (time signature, tempo, or lyrics) within DMT sessions for autistic children.

As a result, before new rhythm-based interventions are introduced, the most beneficial elements of rhythm in music should be recognised. Once the optimum features of rhythm and music are known, these can be integrated with more confidence into extant or new interventions, enhancing their therapeutic potential. Interventions will subsequently have a greater positive impact for autistic individuals, supporting them to integrate more successfully into society whilst reducing the personal, familial, and financial implications often associated with the condition.

4.2.2 Research question

In order to understand the key components of rhythm and music used during DMT sessions, the following research question was proposed: *"What are the most common features of music and rhythm used by registered dance movement therapists for autistic children?".* It was hoped that by establishing how often the element of rhythm is employed and the most common types of music and rhythm used by experienced dance movement therapists, this music style can be confidently integrated into new rhythm-based interventions targeting communication skills and social development in autistic children. Additionally, it was important to know *why* these features of music and rhythm are most commonly used by experienced dance movement therapists when working with autistic children.

To our knowledge, this is the first study that investigates the elements of music and rhythm used by dance movement therapists during their sessions with the young ASD population. Therefore, an exploratory stance was taken rather than a confirmatory stance - instead of being driven by 'hypothesis testing', the research was driven by 'hypothesis building' (Casula et al., 2021; Locke, 2007; Reiter, 2013). Although it was predicted that some musical elements would most likely be used more frequently than others by

experienced dance movement therapists, it was unclear what these may be or why they are chosen as there was an insufficient knowledge base (Reiter, 2013). A mixed-methods survey approach was enlisted to explore quantitative measures, such as the most common time signature of music used and the qualitative measures, such as why this is the most common time signature used (Bryman, 2006).

4.3 Methods

4.3.1 Recruitment and participants

Similar to the Delphi Model, which only interviews 'experts' in the field, non-random purposive sampling was implemented, deliberately inviting registered dance movement therapists who have experience of working with children diagnosed with ASD to participate in the survey (Etikan, 2017; Shariff, 2015). To recruit the specific sample, details of dance movement therapists who were registered with professional boards either in the United Kingdom (UK) and/or the United States of America (USA) were collected via the Association for Dance Movement Psychotherapy (ADMP; UK) and the American Dance Therapy Association (ADTA; USA) online directories. Those who noted working with the ASD population were catalogued and later contacted. In total approximately 563 dance movement therapists were contacted via email (12 Men and 551 Women; unknown age; graduate level or above). To account for a less than 10% margin of error and ensure confidence in the data (whereby the margin of error is the range of values above and below the actual results from a survey) with a potential sample of 563, our initial aim was to gain responses from over 100 dance movement therapists.

Ethical approval for the study was given by the Science and Health Ethics sub-committee at the University of Essex (Ethics ID: ETH1920-1409). Prior to completing the survey, all respondents were required to give their informed consent to participating online

by answering a Yes/No checkbox as per the University's ethical guidelines regarding informed consent. A total of 155 participants were recorded accessing the consent form via the internet survey link; however, only 113 of these consented and fully completed the survey. After reviewing the available data, we assumed the remaining sample was representative of the population of interest and would not bias the analysis towards any subgroup as there were no observable trends or patterns in responses of those that did not fully complete the survey and those that did fully complete the survey (Salgado et al., 2016). As a result, the data was assumed to be missing completely at random and subsequently representative of the sample of potential participants, not biasing the results towards any subgroup (Liu, 2016). Similarly, the inclusion of only fully completed survey data aimed to ensure that all quantitative measures had a qualitative element and justification to aid the understanding of the quantitative selection. Accordingly, only the results of those who consented and fully completed the survey were analysed (n=113). As a result, there were no missing responses from the data set analysed.

4.3.2 Materials

Participants were asked to complete the online survey, which was hosted on the Qualtrics™ platform (Qualtrics, Provo, UT). Online surveys typically allow for enhanced access to geographically dispersed participants, reduced costs, increased participant safety and anonymity, greater flexibility for scheduling, and question diversity (Drabble et al., 2016; Evans & Mathur, 2005). The novel survey used within this study was designed to capture relevant information regarding the use of rhythm and music by dance movement therapists during their sessions with autistic children. To collect this information, survey items were compiled from the literature regarding time signatures of music, tempos of music, and whether lyrics were included in the music used by dance movement therapists.

The survey was structured into a sequential order, firstly requiring information on the dance movement therapist before moving onto questions regarding rhythm and music. These questions were distributed into five main sections, covering 26 items. These sections included: 1) the use of music, 2) the time signature of their music, 3) the tempo of their music, 4) the use of lyrics in their music, and 5) the use of rhythm. Once formalised, the survey was assessed for clarity, readability, and content by an independent researcher. Changes were made to the wording of some survey items based on their feedback before the survey was distributed to the dance movement therapists.

Appreciating that most DMT sessions are unique to each child (patient/person-centred), dance movement therapists were asked to focus on the most common types of time signatures, tempos, and lyrical/instrumental music they regularly used in their sessions. In addition, it was important to understand the therapists' reasons and justifications for using such rhythms, and the significance of their choices. Therefore, both quantitative and qualitative approaches were employed. Measures were taken via a wide range of question/response styles in the survey, such as multiple-choice questions, sliding scales, and open-ended textboxes. Logic breaks and skips were also included in the survey. For this reason, if a participant reported only using instrumental music in their sessions, they would not be asked the item question on what type of lyrics were usually included in their music. Consequently, the total number of respondents for each question differed.

Quantitative measures were taken via multiple-choice questions or sliding scales. For example, some multiple-choice questions involved asking participants to select what type of time signature they commonly used during their sessions for autistic children, out of 5 possible answers (A) *4/4 time*, B) *3/4 time*, C) *2/4 time*, D) *6/8 time* or E) *Other)*, or asking participants' if they found the rhythm of music important during their sessions via 'Yes' or 'No' choices. Similarly, participants were instructed to, for example, "Rate the extent to

which [they] emphasised rhythm during [their] sessions.". Items such as this were rated on a 10-point scale; from 0 *(I do not strongly emphasise the rhythm of music)* to 10 *(I strongly emphasise the rhythm of music)*, where 5 represented "*I somewhat emphasise the rhythm of the music"*.

Qualitative measures were used to establish why the dance movement therapists commonly used the features of music and rhythm they had selected. The qualitative measures were then taken via text-box answers, giving participants unlimited space to type their responses. Most followed the multiple-choice or sliding scale responses, for example, asking why they generally used music with that time signature or why they emphasised rhythm to that extent.

4.3.3 Procedure

Data collection ran for 5-weeks from June 2020 to July 2020. A standard email invitation was sent out to every catalogued dance movement therapist, outlining the project and providing a link to the online survey. A follow-up email was also sent a week prior to the survey closing, thanking those who had participated and reminding those who had not completed the survey that it would be closing soon. On average the survey took 22-minutes to complete, removing four outliers who appeared to take over 8-hours. Those who expanded on the open-ended questions took longer than respondents who only provided brief answers.

4.3.4 Analysis

Screening of the data was carried out on the Qualtrics platform and using SPSS (Version 27; IBM SPSS Statistics, 2020). Quantitative data (multiple choice answers and rating scales) were analysed using SPSS and GraphPad Prism 8 (GraphPad Software, 2020),

where the descriptive analysis was carried out, frequency tables produced, and graphs created.

Analyses of the open text-box answers, which mostly consisted of brief statements, including; short sentences, phrases, and paragraphs in response to the questions, were performed using the qualitative analysis software, NVivo12 (NVivo, 2018). As previously mentioned in the introduction, this study was not driven by confirming hypotheses, rather it was driven by building hypotheses. Therefore, an exploratory and data-driven stance was assumed when analysing the qualitative data (Braun & Clarke, 2013; Guest et al., 2012). Inductive thematic analysis was carried out as no previous studies had investigated this research question, therefore the coded themes were derived directly from the text data and not from predetermined categories (Guest et al., 2012; Hsieh & Shannon, 2005). Briefly, inductive thematic analysis is a qualitative method that allows for the identification, analysis, and reporting of patterns or themes within data (McLemore et al., 2014). Where themes capture important elements about data in relation to the research question and represent some level of response pattern or meaning within the data set (Braun & Clarke, 2006; Swart, 2019).

To this end, text-box answers were systematically read several times by an independent researcher to identify initial themes. As themes were identified, a coding framework was developed. Words, phrases, and sentences were coded under different nodes until no new codes were uncovered by the independent researcher and all relevant meaning was believed to be extracted from the data (*see below*; Glaser & Strauss, 2017; Guest et al., 2006; Strauss & Corbin, 1998). A team of researchers discussed the coding framework and outcomes of the thematic analysis, agreeing that the codes generated gave meaning to the data (Braun & Clarke, 2019). Codes were then later divided into themes and subthemes to provide a narrative of the data. Subsequent concept maps were created for each question in

order to identify possible connections between different main themes and their subthemes and to further enrich understanding of the data (Braun & Clarke, 2006).

The following demonstrates how the method described above was carried out using a part of participant's response to the question "Why do you choose to emphasise the rhythm of the music to this extent?":

> *"Rhythm is fundamental to relationships. Each of us have different rhythms/vibrations. Being able to be comfortable with our own rhythm and other people's rhythm can support what Trevarthen coined "interactional synchrony."*

This response was coded in the following way:

Rhythm is fundamental to relationships = Building relationships (subtheme) > Supporting social skills (main theme)

Each of us have different rhythms/vibrations = Emphasising body rhythms

Comfortable with our own rhythm and other people's rhythm = Emphasising body rhythms

Can support what Trevarthen coined "interactional synchrony" = Connection and synchrony (subtheme) > Unifying feature (main theme)

4.4 Results

4.4.1 Characteristics of respondents and sessions

Of the 113 analysed responses, participants of the survey were all working dance movement therapists, who were either registered with the ADMP or the ADTA. All respondents were English speaking or had English as their second language and were over the age of 18-years-old. Most resided in the USA (72%). However, 19% lived in the UK, 3% lived in Canada, 2% lived in India, 1% lived in the Netherlands and 3% lived in Japan,

Taiwan, or Israel. Participants were not specifically asked for their age, only to confirm that were over 18-years-old, or gender as it was believed that this would not impact the result and to limit the collection of special category data. However, all participants were asked how long they had been practising DMT for.

The sample was relatively experienced. The majority (51%) had over 10 years of experience and had worked with children diagnosed with ASD on a regular basis, or had previously worked with this population (Table 4A. 1). Survey results indicated that DMT sessions predominantly focused on encouraging social interaction and enhancing communication in autistic children and mostly lasted 45 minutes (Table 4A. 1).

Table 4A. 1 Demographics of respondents referring to the experience of working as a dance movement therapist, the frequency at which they work with autistic children, and the length of time of their sessions with this population in minutes (n=113).

Survey Questions	Survey Responses	N (%)
How long have you been a dance movement therapist/psychotherapist?	1 - 2 Years	6 (5.3)
	2 - 4 Years	13 (11.5)
	4 - 6 Years	14 (12.4)
	6 - 8 Years	11 (9.7)
	8 - 10 Years	11 (9.7)
	10+ Years	58 (51.3)
How often do you work with autistic children?	Once a week	17 (15.0)
	Twice a week	8 (7.1)
	Three times a week	9 (8.0)
	Four times a week	5 (4.4)
	Daily	5 (4.4)
	I am no longer working with this population; however, I previously have done	54 (47.8)

	Other	15 (13.3)
On average how long are your sessions with each child?	15 Minutes	2 (1.8)
	30 Minutes	38 (33.6)
	45 Minutes	49 (43.4)
	60 Minutes	21 (18.6)
	60+ Minutes	3 (2.7)
	Total	113

4.4.2 Use of music

The majority (n=102; 90.3%) of respondents reported regularly using music within their sessions. Only 11 respondents (9.7%) answered 'No' to the question "*Do you use music in your sessions?*". Those who did not use music were taken to the end of the survey and were not asked any more questions on music within their sessions, whereas those who did use music were asked what type of music they used. Pre-recorded music (n=92; 90.2%) was most commonly used over live music (n=10; 9.8%). Additionally, nearly half of the respondents who used music found it very important (n=48; 47%). The difference in the extent to which music was considered important to the respondents is indicated by the Likert Scale in Figure 4A. 1.

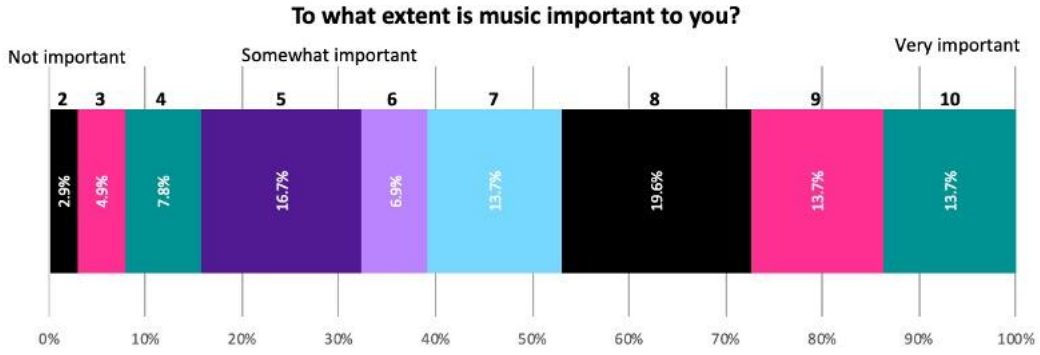


Figure 4A. 1 The extent to which music is important to the respondents during their sessions with autistic children as rated on a 10-point scale; where 1-3 is not very important, 4-7 is

somewhat important and 8-10 is very important (n=102). Points on the scale that had no responses were not included in the graph as they had a percentage of 0.

Respondents were asked why music was important to them and given a text-box to type their answers. Thematic analysis of the data revealed five main overarching themes detailing why music was important. These included: 1) music setting an appropriate environment, 2) music helping to establish a connection, 3) music increasing engagement and attention, 4) music being used as a vehicle to explore rhythms, and 5) music aiding expression. Each main theme was comprised of various subthemes, which helped to further explain why music was important to the respondents. Table 4A. 2 presents the main themes and subthemes and provides example quotes taken from the text-box responses that exemplify the given themes.

Table 4A. 2 Main and subthemes identified during thematic analysis of responses to the question "Why is music important to you?" (n=102). Exemplar quotes are also presented in the table for each theme and subtheme.

Main Themes	Subthemes	Quotes
Music helps to set the environment	Provides structure and organisation	"During sessions music to me is in the instrument of the body and the orchestra of the room/environment"
Music can establish a connection	Establishing a connection	"Music can often be a really useful intervention to find 'common ground' between therapist and client with which to start the therapeutic rapport and trust building"

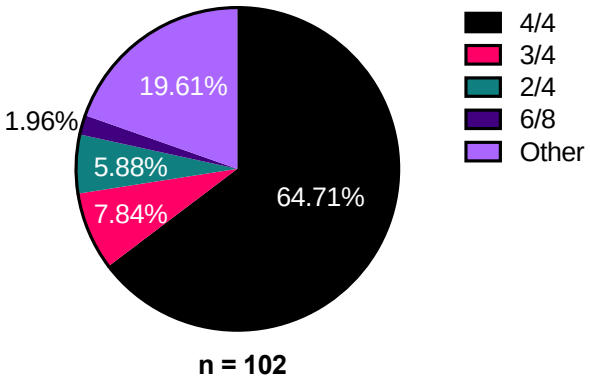
	Cohesion	"Particularly in group settings, music helps the children focus on the group tasks. It produces rhythmicity that allows the group to move together at the same time. It creates a feeling of one group"
Music aids engagement and attention	Client chooses piece of music	"I primarily use music to support the clients "buying into" the session. They pick their own music from a digital library"
	Fun stimulus	"Most of all the children I work with like it, and nothing works without an element of joy and play"
It is a vehicle to explore rhythms	A vehicle to explore rhythms	"Music is important in helping establish rhythm"
	Enhancing rhythmic movements	"It also provides rhythmic support, especially when working through movement development rhythms"
Music aids expression		"Music can create a calming atmosphere, it gives the participant choice and the opportunity to express their likes and taste, especially if they are non-verbal"

4.4.3 Elements of music

Specific elements of music were investigated during the survey, including the most common time signature of music used, the most common tempo of music used, and whether lyrics were commonly included in the music. It is apparent that there is a clear type of music commonly used during sessions for autistic children; this being, music of the 4/4 time signature, with a moderato tempo and including lyrics. Of the 102 dance movement therapists that responded to the question "*What, generally, is the most common time signature for the music you use?*", nearly 65% answered 4/4 time, whereas only 7.8% commonly used 3/4 time (Figure 4A. 2i). Similarly, 45% of dance movement therapists most commonly used music with a moderato tempo and just over 76% used music that included

lyrics, in comparison to 24% of dance movement therapists using instrumental music (Figure 4A. 2ii and 2iii, respectively). Interestingly, the choice of lyrics varied substantially between the respondents. Although nearly 40% of respondents reported using pop music lyrics, over half (51.3%) reported using 'other'. Text-box explorations revealed that most respondents chose 'other' because they used music with a variety of lyrics during their sessions. For example, they may have used both nursery rhymes and pop music during their sessions and, therefore, selected 'other' as selecting more than one choice was not an option.

i



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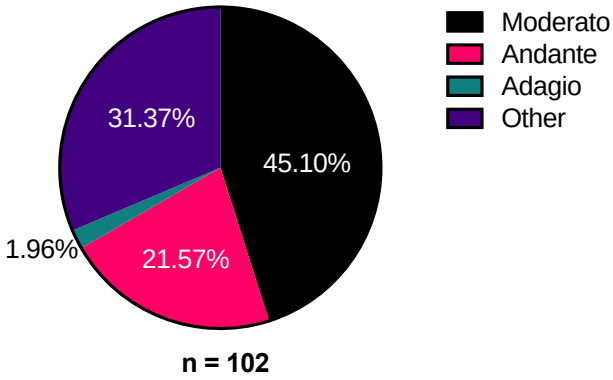

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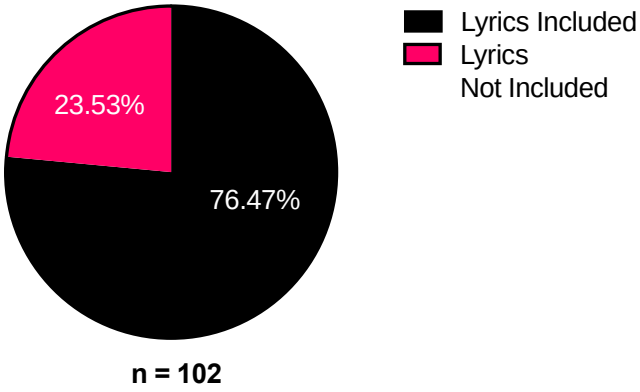

Figure 4A. 2 Parts-whole charts illustrating survey responses of (i) the most common time signature, (ii) the most common tempo, and (iii) if lyrics were included in the music used by dance movement therapists (n=102) during sessions for autistic children. Not all choices are shown as answers that had no responses were not represented on the parts-whole charts as they had 0%. Keys showed at the side.

Qualitative analysis of survey responses uncovered several main themes and subthemes that validated why most dance movement therapists used music with a 4/4 time signature and moderato tempo during their sessions for autistic children (Table 4A. 3). Examples of main themes include: 1) familiarity, 2) client preference, and 3) both elements were not overstimulating. Thematic analysis also revealed why pop music lyrics were often included in the music used for DMT sessions for autistic children; for example, pop music lyrics motivated the client and could often be used as positive reinforcement (Table 4A. 3). In addition, the majority of dance movement therapists used a mixture of lyrics as they were able to better relate the lyrics to the client.

Table 4A. 3 Main themes and subthemes that were identified during thematic analysis of responses by those who answered 4/4 time to the question "Why do you generally use this time signature?" (n=66), by those who answered moderato tempo to the question "Why do you generally use this tempo?" (n=46), and by those who answered pop lyrics (n=31) and those who answered 'other' (n=40) to the question "Why do you generally use music with these lyrics?". Quotes that strongly represented each theme and subtheme are also given in the table.

Element of Music	**Main Themes**	**Subthemes**	**Quotes**
Time Signature (4/4)	The time signature is familiar	Client Choice	"Music with the time signature seems to be relatable and familiar"
		Accessibility	"For me this is the most accessible signature"
	4/4 time signature is grounding	Naturally occurring rhythms	"The body naturally falls into rhythms of four... I repeat a phrase (in movement or song) four times helps to engage the body's natural rhythmicity"
	Time signature provides a regular beat	Regular Beat	"It provides a strong, habitable rhythm that most people can physically match"
		Simple	"It is the simplest rhythm to follow"
	It is not overstimulating		"The simplicity also means that there is one less stressful thing for children who are still settling into the therapeutic process, more complicated rhythms might make it an overwhelming experience, especially at the start"

	Can be easily used in combination with other timings		"I also use it with 3/4 and 6/8 too for more 'swaying' and regulating feelings"
Tempo (moderato)	Children prefer it	Children respond well to moderato tempo	"I work with children and they respond to this speed well"
		The tempo is fun	"I do like to use a moderato speed with a fun beat as a way of using rhythm to connect"
		The tempo engages the client	"Usually using an excited pace to encourage activity within the group"
	Easy to vary from this tempo		"Within this speed, we have more options to play with time, speeding up or slowing down when clinically appropriate"
	Moderato tempo is not overstimulating	Tempo is regulating	"Helps clients engage but stay regulated/not over-stimulated"

		Not too fast or too slow	"The music wakes up the brain, not slow not fast just above a walking pace, which seems to create an attentive state without creating a hyperactive feeling"
	The tempo encourages movement		"It seems to be a good tempo for rhythmic movement for them"
Lyrics (Pop Music Lyrics)	Client's preference	Client Choice	"As it is the music that is requested most often by the children that I work with. By increasing their choice, I hope to support the development of their agency within the therapeutic process"
		Familiarity	"Children know these songs"
	Motivation	Pop lyrics aid motivation	"Kids know and like this, it helps get their excitement and buy in [to the session]"
		Positive Reinforcement	"This is typically what the children have requested to hear as a reward for hard work"
	Connection to the lyrics		"Usually, can help participants feel connection to the social world around them"
	Attending to the lyrics		"For me sometimes the lyrics are important to share an uplifting message and promote communication"
Lyrics (Other/Mixture)	Relatable to client	Relatable to client	"I usually selected it because the client liked the song, the artist or the genre"

		Familiarity	“Familiar songs help people engage with one another and provides them with a shared experience. It is an opening point for increasing communication and socialisation”
		Client Expression	“Pop music is an option and choice that the participant has as a way of expression”
	Use of age dependent lyrics		“For the younger children, nursery rhymes are correlated to language. Familiar, repetitive words are helpful... For older students, they sometimes request things that are popular in the culture and it provides them with some structure and familiarity”
	Attending to a variety of lyrics		“I use educational lyrics to teach concepts or guide a group into moving in a more synchronised way”
	Building trust and communication		“Nursery rhymes are often learnt, very rhythmic and can be sung together with actions, this can create a link to bound to help build a relationship or create a structure”

4.4.4 Rhythm

It is evident that rhythm is extremely important to most dance movement therapists and is believed to be essential for DMT sessions. Almost all respondents reported finding rhythm important (n=100; 98%) and less than 2% (n=2) stated they did not find rhythm important. Additionally, when asked the extent to which the dance movement therapists emphasised the rhythm of music during their sessions over half of the respondents answered 'strongly emphasised' (n=54; 52.5%; Figure 4A. 3).

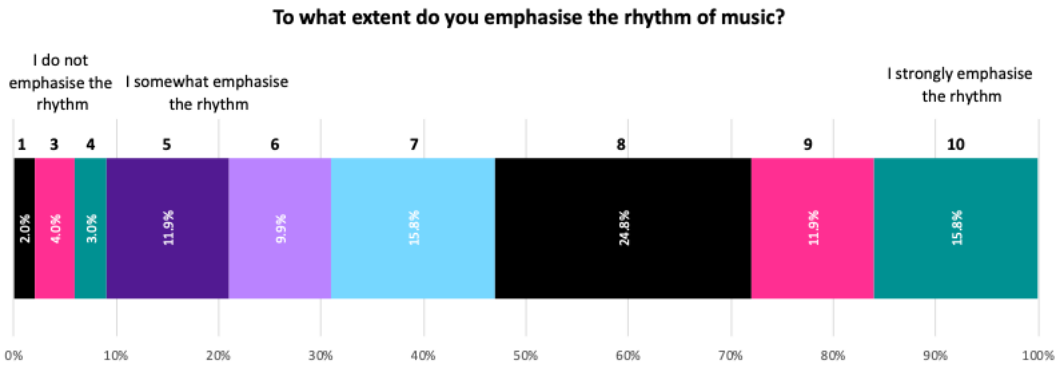

Figure 4A. 3 The extent to which respondents emphasised the rhythm of music during their sessions with autistic children as rated by a 10-point scale; where 1-3 is I do not emphasise the rhythm of music, 4-7 is I somewhat emphasise the rhythm of music and 8-10 is I strongly emphasise the rhythm of music (n = 102). Points on the scale that had no responses were not included in the graph as they had a percentage of 0.

Why dance movement therapists emphasised the rhythm of music was also investigated. Thematic analysis of responses given by those who found rhythm important (n=100) revealed several main themes, including: 1) rhythm used a unifying feature, 2) rhythm offered structure and organisation to the session, 3) it was grounding, 4) rhythm offered structure to movement, 5) helped to emphasise body rhythms, and 6) helped to build

social skills. Furthermore, each main overarching theme also comprised of subthemes that further highlighted why rhythm was an important element of music and DMT sessions for autistic children (Table 4A. 4).

Table 4A. 4 Main themes and subthemes revealed during thematic analysis of responses to the question "Why do you emphasise rhythm?" given by those who found rhythm important (n=100). Quotes that embody each theme and subtheme are also given in the table.

Main Themes	**Subthemes**	**Quotes**
Rhythm is a unifying feature	Unifying feature	"The ability to share rhythm unites humankind and it is through rhythm that we engage with others (for example, turn-taking) and with our environment"
	Connection and synchronicity	"Each of us have different rhythms/vibrations. Being able to be comfortable with our own rhythm and other people's rhythm can support what Trevarthen coined "interactional synchrony"
Rhythm provides structure and organisation of the session		"Rhythm decreases tension, increases relaxation by providing predictability, structure and movement (a language that is universal)"
Rhythm can be grounding		"When exploring movement with clients, it is helpful to ground them so they didn't become overwhelmed. Stressing the rhythm helped them stay grounded in the present"
Rhythm offers structure to		"It helps with the flow of movement and prevents the client from getting stuck (the rhythm helps them respond)"

the movement		
Rhythm helps to emphasise body rhythms		"Rhythm supports the human experience of presence especially when it is understood as a combination of exploring weight and time in movement. It supports the natural regulating aspects of biorhythms including the heartbeat and breathing patterns to allow for the development of emotional regulation practices that are transferrable outside of session"
Rhythm supports the building of social skills	Promotes self-awareness	"It is a brilliant tool for regulation and self-awareness without being too intrusive. It allows individuals to become aware of the timing of their behaviours which can be really useful in moments of difficulty"
	Building relationships	"Rhythm is fundamental to relationships"

4.5 Discussion

Overall, the findings highlight the importance of music and rhythm during DMT for autistic children and illuminate the reasons why they are important. Furthermore, the findings indicate that the most common elements of music include the 4/4 time signature, moderato tempo, and music that has lyrics; therefore, achieving the previously stated aims of the study. Each common element was validated by the qualitative findings, with key themes and subthemes developed from the thematically analysing the survey responses. The data represented here advances our knowledge of the most common elements of music and the reasons behind their use, whilst also allowing us to generate more informed hypotheses regarding the potential impact of particular musical features for autistic children. It is expected that these elements can now be used with greater confidence in new or existing interventions for autistic children, particularly targeting communication skills and social development.

4.5.1 Elements of music

4.5.1.1 Time signature

The data suggests that the 4/4 time signature is the most common time signature used by experienced dance movement therapists during DMT sessions for autistic children. Several themes were identified during thematic analysis highlighting why it may be the most common time signature (Table 4A. 3). For example, a key theme that was generated was the 'regular beat' of the 4/4 time signature. One dance movement therapist explained that the timing "*provides a strong, habitable rhythm that most people can physically match*". Research indicates that a regular accent structure is essential for recognising a beat in music (Bouwer et al., 2018). When regular perceptual accents are presented, reproduction performance (i.e. physically matching the beat) is improved (Grahn & Brett, 2007). Furthermore, functional Magnetic Resonance Imaging (fMRI) has demonstrated that the *basal ganglia,* pre-Supplementary Motor Area/Supplementary Motor Area (SMA), and *anterior superior temporal gyri* show increased activity to specific beat-based rhythms (Grahn & Brett, 2007). Therefore, in addition to their role in movement production, which is important during DMT, the *basal ganglia* and SMAs may mediate beat perception, and autistic children may respond better to 4/4 timing as it provides a regular accent structure and beat-based rhythm.

Similarly, it is well established that many autistic children prefer structured routines, rituals, and patterns. The repetitive and predictable nature of musical sounds, especially with this timing, may fulfil these preferences. Through the appreciation of musical sound patterns, each child may feel more engaged and comforted by the regular and repetitive pattern of music with 4/4 timing, compared to any other musical timings (Molnar-Szakacs et al., 2009). Perhaps, most importantly, the regular and repetitive pattern of music with 4/4 timing minimises the likelihood of autistic children becoming overstimulated by sensory

stimuli during DMT sessions. Such overstimulation via sensory input can elicit negative feelings for autistic children, causing children to cover their ears or eyes, rock backwards and forwards for self-soothing, or cause their muscle to tense. Preventing overstimulation was another key theme found for not only the use of music with 4/4 time signature but also for moderato tempo and lyrics. Given that autistic children can become overstimulated by new environments, bright lights, various noises, and/or new people, it appears important to use music and rhythms that limit the likelihood of autistic children feeling overwhelmed during DMT or future interventions that include music.

4.5.1.2 Tempo

Several themes and subthemes were generated during thematic analysis detailing why moderato tempo was most commonly used in music during DMT sessions (Table 4A. 3). Many dance movement therapists suggested that children preferred this tempo of music and responded to it best. Research suggests that young children often prefer faster tempos to slower ones (Flowers, 1988; Montgomery, 1996). Additionally, slower tempos are associated with sadness or reflection, whereas faster tempos are associated with activity and happiness (Levitin et al., 2018; Poon & Schutz, 2015). Typically-developing 5-year-olds are able to make these associations and autistic children may too be able to make these connections (Swaminathan & Schellenberg, 2015). Furthermore, autistic children are able to recognise and identify happy, sad, scary, and peaceful music (Heaton et al., 1999, 2008; Quintin, 2019; Quintin et al., 2011). Therefore, it is plausible that autistic children prefer and respond well to moderato tempo as they associate it with activity and happiness in comparison to other tempos.

Themes around moderato tempo also indicated that it was most commonly used as it was not overstimulating for most clients, in that it was not too fast nor too slow. One dance movement therapist noted "*Slower music I found lost my clients and they were unable to*

connect to the music, whereas faster music was overwhelming." For autistic children finding the balance is particularly important. A tempo is needed that engages and captivates the individual but does not overstimulate and overwhelm them. Most dance movement therapists found that the moderato tempo was able to achieve this.

The theme 'encourages movement' was also identified when qualitatively analysing responses to why moderato tempo was most commonly used. Many dance movement therapists reflected on moderato tempo being a good tempo for rhythmic movement and providing "*opportunities for children to work on building their movement repertoire*". This is known as entrainment of movement to music tempo, where we feel the desire to move to the beat/tempo of the music, which is only observed in vocal mimicking species (Schachner et al., 2009). Nietzsche, a famous musical philosopher, was believed to have said: "*We listen to music with our muscles*" (Sacks, 2006). It may be plausible that moderato tempo is the optimal tempo for entrainment in autistic children and, therefore, warrants further exploration and research to confirm this.

4.5.1.3 Lyrics

The single most common style of lyrics used by dance movement therapists was pop music lyrics, however, it was apparent that the majority of dance movement therapists used a mixture of lyrics, including pop music, educational lyrics, and nursery rhymes. Data from the thematic analysis indicated that pop music lyrics were most commonly used as it was the client's choice and could be used as a motivator via positive reinforcement.

Autistic children may prefer music with pop lyrics as it is the most familiar style of lyrics. Studies have shown that liking a piece of music is related to familiarity with it or its style (Hargreaves, 2016; Madison & Schiölde, 2017). This familiarity factor can account for why children often accept a wide variety of musical genres when they are younger,

before becoming increasingly fond of pop music as they grow older. Children begin to favour this musical style due to its familiarity and recognisability as it is regularly used in the commercial media (Woody, 2004). As children tend to prefer music with pop lyrics some dance movement therapists used it to motivate their clients through positive reinforcement. One dance movement therapist stated, "*This is typically what the children have requested to hear as a reward for hard work*". Many autistic children seem to ignore social reinforcers such as praise or affection; therefore, Toigo (1992) proposed that music, as it seemed to be so inherently pleasurable to children on the autistic spectrum, could be an important motivator or reinforcer. In addition, pop music may be pleasurable for autistic children as it often evokes a positive feeling. There is substantial literature exploring the relationship between music and emotion, whereby the power of music can regulate a listener's mood (see Moore (2013) for systematic review).

The majority of dance movement therapists, however, generally used a mixture of lyrics during their sessions. Themes identified, such as relatable to the client, use of age-dependent lyrics, and attending to a variety of lyrics, during the qualitative analysis. The theme 'relatable to the client' highlights the person-centred approach of DMT. Children prefer and respond differently to different musical lyrics. Therefore, using lyrics that are relatable to each client may produce further beneficial effects. Similarly, by using a variety of lyrics the dance movement therapist can help the client attend to a variety of lyrics increasing their knowledge of vocabulary and understanding of different concepts. Studies show that autistic children engage well with words and instructions sung to music (i.e. lyrics) in comparison to spoken words, and lyrics can increase engagement in language learning tasks (Dieringer et al., 2017; Simpson et al., 2013). Consequently, the use of lyrics during DMT and new or already existing psychotherapies may aid in the progress of communication skills and social development.

4.5.2 Rhythm

Over 98% of registered dance movement therapists surveyed in this study reported finding rhythm important. Moreover, 52% of survey respondents said they strongly emphasised the rhythm of music during their DMT sessions. It is, therefore, ostensible that the rhythm of music is fundamental for many dance movement therapists during their sessions with autistic children. When asked why rhythm was important to emphasise, thematic analysis revealed several key themes, including rhythm being a unifying feature, offering structure and organisation to not only to the session but also to movement, helping to build social skills, and helping to emphasise bodily rhythms.

Qualitative analysis revealed rhythm provided structure and organisation to the session. As previously established, autistic children have a need for structure, organisation, and routine. Music and rhythm offer several layers of form and structure that provide a container for the session, with the rhythm creating a consistent through-line, keeping the session moving forward and the client aware. The often repetitive and predictable nature of rhythm and music makes an intrinsically structured stimulus for autistic children, therefore offering organisation to the session (Darrow & Armstrong, 1999; Nelson et al., 1984). Similarly, certain rhythmic units have been shown to evoke positive responses and emotion regulation in some listeners, subsequently also offering a positive and enjoyable stimulus (Fernández-Sotos et al., 2016).

Rhythm was also described as providing structure to the movement by helping with the flow of actions and preventing the child from becoming "*stuck*" during DMT sessions. If a child is in a one-to-one DMT session, the rhythm of the music may inspire them to move more freely and provide a sense of structure to their movements. Research demonstrates that coordinated movement to the rhythm of music arises with no specific training at a young

age. For example, in the first 2-years of life infants can move their bodies rhythmically in response to music (Zentner & Eerola, 2010).

Due to the nature of music and rhythm, autistic children may feel less isolated in group DMT sessions. With rhythm acting as "*a non-verbal unifier*", the music can serve as a non-threatening environment in which autistic children and their peers can initiate and maintain communication (Darrow & Armstrong, 1999). As a result, it seems that rhythm is an essential element to group-based DMT sessions, where there may be one or more autistic individuals. The ability to share, attend, and move to the same rhythm of music can help unite individuals by increasing synchronicity and creating a connection. One dance movement therapist explained, "*Having a clear external stimulus [rhythm] can help with group cohesion and emphasizes the importance of being in synch with their peers*". Research has shown that adults who synchronously moved together to a shared musical rhythm are more likely to display prosocial behaviours towards each other than when moving asynchronously (Hove & Risen, 2009; Valdesolo & Desteno, 2011). Furthermore, infants who are bounced to music in synchrony with an experimenter are more likely to show altruistic behaviour towards the experimenter, than if they are bounced out of synch with the experimenter (Cirelli et al., 2014). Subsequently, interpersonal motor synchrony to rhythmical stimuli seems to increase social bonds between group members, and moving to the same rhythm creates a potential vehicle to increase the development of prosocial behaviours in autistic children.

Not only is rhythm an external stimulus, but it is also an internal stimulus. Many dance movement therapists documented exploring bodily rhythms when emphasising the rhythm of music, with one noting "*It is really important to emphasise or stay curious with rhythms, as they are every part of us*". Interest around the role of biological and behavioural rhythms during typical and atypical development has been fast-growing. Recent evidence

from cognitive and developmental psychology studies emphasise the significance of rhythmicity and synchrony of motor, emotional, and interpersonal rhythms during the early development of social communication (Tordjman et al., 2015). Autism illustrates the possible consequences of physiological and behavioural rhythm challenges on the development of social communication and repetitive behaviours or interests (Barnard & Nolan, 2008; Tordjman et al., 2015). Preliminary research suggests that such traits observed in ASD may result from the inability of an individual's circadian oscillator to entrain to environmental and social cues (Barnard & Nolan, 2008). Ultimately, the internal 'clock' cannot reliably or consistently co-ordinate internal rhythms with the external environmental and social rhythms of typical activity, leading to the profound difficulties observed in ASD (Amos, 2013). This also falls in-line with the notion that the multisensory temporal processing is challenged in autistic children (Meilleur et al., 2020). Therefore, attending to the rhythm and timing of music during DMT or any other therapeutic intervention, whilst focusing on the body's own rhythms may offer substantial therapeutic benefits for autistic children. Similarly attending to internal and external rhythms may reduce the multisensory temporal processing impairments observed in autistic children. Thus, ameliorating social communication challenges. Outside of this study, further research may wish to confirm how external rhythms specifically impact different internal rhythms. For example, how the rhythm and tempo of a piece of music affects one's heart rate or the ability to synchronise interpersonally (van Dyck et al., 2017).

4.5.3 Limitations

Overall, the response rate of the survey was approximately 27.5%. Some researchers suggest that studies should aim for a near 60% response rate of their proposed sample to reduce the non-response bias (Fincham, 2008; Sheehan, 2001). Despite the likelihood of

more responses improving the accuracy and reliability of the findings and reducing the non-response bias, the initial aim was to receive over 100 responses due to the small pool of potential respondents and to account for less than 10% margin of error within our participant pool (Schwartzberg & Silverman, 2014). This was achieved.

As USA- and UK-affiliated professional boards were used for recruitment, the demographics of the sample from across the globe were minimally representative of those who lived or practiced outside of the UK and the USA. Only 6% of respondents lived either in India, the Netherlands, Japan, Taiwan, or Israel. As a result, the present study is unable to indicate if the choice of music varied across diverse cultures. It would be interesting to delve deeper into how music choices may differ across certain cultures and ascertain responses from those affiliated with different global boards.

In addition, the survey was highly focused on rhythm and music. However, the results indicated that nearly 10% of dance movement therapists did not use music during their sessions. These participants were taken to the end of the survey and asked the final question - "*Besides music, what are the most important elements of your session for children diagnosed with ASD?*". Upon reflection, it may have been beneficial to ask further questions as to why they did not use music during their sessions and whether they successfully incorporated the element of rhythm without the use of music, especially for children who are overstimulated by any type of music. These questions may shed light on elements and use of rhythm that were not explored during this study.

Although online surveys have several benefits, they are not without their limitations. In comparison to interviews, the depth of qualitative findings obtained from online surveys is somewhat limited. Interviews allow researchers to ask further questions or ask respondents to elaborate on their answers, providing opportunities to probe and clarify any misunderstandings. Therefore, interviews may provide more detailed and in-depth

qualitative findings. However, given that this study was exploratory, the text-box answers implemented in the survey were useful and sufficient in gaining an initial understanding as to why 4/4 timing and moderato tempo were the most common elements of music used during DMT sessions for autistic children. Additionally, the perceived trustworthiness of the qualitative measures should be highlighted. The sample was well-experienced, with the majority of dance movement therapists either working or previously working with autistic children for over 10 years. Similarly, responses were given anonymously, increasing the chance of participants being honest and reliable. It was believed the responses given were authentic and a reflection of the personal or lived experiences of rhythm and music in DMT (Curtin & Fossey, 2007).

It must be highlighted that there is significant heterogeneity within ASD, therefore a 'one size fits all' approach is not suitable when working with this population. Whilst 4/4 timing with moderato tempo music may work well for one autistic child, it may overstimulate another child or they may respond better to 3/4 timing waltz music. Additionally, DMT prides itself on offering client-based, person-centred therapy, meaning each session differs from one autistic child to the next. Therefore, the results of this study may not be reflective of *all* types of DMT sessions. For example, despite many dance movement therapists reporting that they often let the child choose the music, it is unclear from the survey results if music choices differed when the music was chosen by the therapist or how it varied between sessions. Nonetheless, the aim of the study was not to create a 'one-size fits all' approach, rather identify where an optimal starting point may be for dance movement therapists to begin their practice or for researchers to integrate rhythm into new interventions. The results indicate that there are more common elements of music used by registered dance movement therapists for autistic children than others, implying these may be the optimal elements to use.

4.5.4 Future directions

During this investigation, an exploratory and descriptive, hypothesis-building stance was taken to explore the various elements of music that may have been common during DMT sessions for autistic children. Despite the study's limitations, it is evident that the 4/4 time signature and moderato tempo are most commonly found in music used by registered dance movement therapists for this clinical population. Equally, the music used most often had pop lyrics or a mixture of lyrics were used to reflect the client or goals of the session. To be able to compare and align the results of this study to the existing and future literature-base, it is recommended that researchers report the tempo and time signature of the music they use in interventions with autistic children and report the style of lyrics included. This will enable a greater understanding of the style of music used in interventions for autistic children both within research and practice.

Moving away from the hypothesis-building stance, it now seems plausible to test possible hypotheses with the developed knowledge in this study; for example, 'most autistic children will respond better to pop music, with a 4/4 time signature and moderato tempo compared to music of a 3/4 time signature and allegro tempo'. Behavioural observation measures could be implemented to record how children respond to pop music, with 4/4 time signature and moderato tempo compared to another type of music. Observations may include frequency and duration of repetitive/stereotyped behaviours, facial expressions, frequency and duration of challenging behaviours, and/or spontaneous movements to the music such as foot tapping or dancing (Bernardi et al., 2017; Juslin & Västfjäll, 2008).

Moreover, further quantitative studies could be performed to confirm the findings of this study. Moving towards a more empirical and neurobiological study-type, one could investigate the emotional and reward responses of autistic children to pop music, with 4/4

time signature and moderato tempo. For example, recording heart rate and skin conductance as autonomic measures of emotion and as an indicator of arousal when listening to this type of music (Rickard, 2012; Sloboda, 2010). Alternatively, neuroimaging techniques could be utilised to explore brain connectivity. Many studies have indicated specific brain regions are associated with emotional and reward responses to music. Employing Positron-Emission Tomography, Blood and Zatorre (2001) showed that pleasant musical stimuli activated the *dorsal amygdala*, which connects to the *ventral striatum* and *orbitofrontal cortex* (the 'positive emotion' network), whilst simultaneously decreasing activity in central regions of the *amygdala* that appeared to be associated with unpleasant stimuli. Additionally, frontal lateralisation of activity in the *cortex* is associated with positive affect and pleasant responses to musical stimuli (Arjmand et al., 2017). As a result, it could be hypothesised that similar responses will be observed in autistic children when listening to pop music, with 4/4 time signature and moderato tempo in comparison to other pieces of music. However, some autistic children may find neuroimaging tasks invasive and uncomfortable. Therefore, extra precautions should be taken if this type of research is pursued.

4.5.5 Implications for practice and future practice

By suggesting the most common features of music and rhythm, these elements can now be used with greater confidence in new or existing rhythm-based interventions, in order to improve their positive therapeutic outcomes, such as enhancing and supporting communication skills and social development. Several studies have previously indicated the positive effects of DMT on the social development of autistic individuals. For example, Koch (2015) reported that a 7-week DMT programme improved well-being, body awareness, and social skills in 31 individuals diagnosed with ASD, Torrance, (2003) revealed an increase in group cohesion, respect and turn-taking in a group of autistic

individuals following a 9-months DMT, and Hildebrandt et al. (2016) suggested a 10-week manualised DMT intervention reduced negative symptomology in a sample of autistic children. Tables 4A. 3 and 4 highlight that rhythm is often used to enhance social skills, with one dance movement therapist noting "*Rhythm is fundamental to relationships*" and another stating "*It is a brilliant tool for regulation and self-awareness without being too intrusive*". Therefore, inferring that rhythm is a fundamental technique used within DMT to enhance social skills in autistic children and can be more confidently integrated into new interventions targeting communication and social skills with the knowledge from this research.

Furthermore, it is suggested that rhythm and music are somewhat inseparable, and emphasising rhythm is extremely beneficial for autistic children because it offers substantial therapeutic benefits. As previously alluded to, literature has demonstrated rhythm-based interventions significantly improve communication skills and social development in autistic children (Daniel, 2019; Eren, 2015; Srinivasan, et al., 2016; Yoo & Kim, 2018). Therefore, it would be interesting to investigate if these effects are further enhanced by implementing the findings of this study. For example, Srinivasan et al. (2016) noted a limitation of their study was not tightly controlling or manipulating the individual effects of various musical elements (pitch, melody, tempo, etc.) on social attention skills. Therefore, replicating the study and including musical elements such as moderato tempo may increase the positive outcomes previously observed.

In addition, future studies may wish to incorporate rhythm into physical interventions, due to its beneficial effects in DMT. For example, sports-based interventions for autistic children may include rhythmic music in the background or rhythmic music to attend to whilst completing the physical activity (Imankhah et al., 2018). From this,

improved interventions could readily be implemented into practice at a relatively low cost or used in Special Education Schools during PE classes.

4.6 Conclusion

In conclusion, the results from this study suggest there are common elements of music and rhythm used by registered dance movement therapist during sessions for autistic children. These include 4/4 timing, moderato tempo, and the use of lyrics. It could be recommended that these elements of music can now be more readily integrated into new interventions targeting communications skills and social development for autistic children. Furthermore, the data from this study indicate the importance of rhythm in music and emphasising rhythm for autistic children. As a result, therapists, clinicians, and practitioners may wish to integrate music and movement into their practice, whilst strongly emphasising the rhythm of music. However, as ASD is an incredibly heterogeneous condition, it is not conclusive that all autistic children will respond well to the common elements of music identified in this study.

Part B - Assessing the Feasibility of a Dance-based Exergame for Improving Social-Communication Skills in Young Autistic Individuals in the Home Environment

4.7 Abstract

Creating naturalistic and accessible social communication interventions is one of the autistic community's top research priorities (Autistica, 2016). Therefore, this study explored the feasibility and potential effectiveness of a home-based exergame for enhancing autistic children's social communication skills. A within-subject, pre-test, post-test design was employed to investigate possible change, which may be attributed to participating in the exergaming intervention. Four autistic children (M age = 8.25, SD = 0.5) and their parents participated in the intervention; six bi-weekly *Just Dance* sessions consisting of five songs. Parents completed the Emotional Regulation and Social Skills Questionnaire (ERSSQ-P) for their child as this was developed for specific use within autistic populations and recorded in-home play-based activities for subsequent behavioural coding. Parents and children reported level of enjoyment and adherence to the intervention each week in a pre-distributed calendar. A final semi-structured interview was conducted to obtain parental views of the project. A positive trend in ERSSQ-P scores from pre-test to post-test was observed for the group. Overall, the majority of the group reported the highest level of enjoyment. Interestingly, the most common number of songs completed each session was three, suggesting the proposed five songs per session was too high. Thematic analysis of parental interviews reinforced this and highlighted considerations for further study. Results indicate that with minor improvements to the protocol, the current intervention is feasible, enjoyable, and may enhance children's social communication skills. A larger randomised control trial to confirm the true effectiveness of the dance-based exergame for enhancing autistic children's social communication skills is warranted.

4.8 Introduction

4.8.1 Challenges of current social communication interventions

Currently, there are few naturalistic therapeutic interventions that successfully target communication skills and social development in young individuals on the autistic spectrum in a person-centred manner and that elicit sustained positive responses (Paul, 2008). Most interventions targeting communication skills require vigorous training to be delivered by qualified professionals in an unfamiliar setting, consequently limiting the accessibility of many interventions for autistic individuals due to travel restrictions, financial costs, and excessive programme durations (Lee & Meadan, 2020; Raymaker et al., 2017; Tek & Landa, 2012; Wainer & Ingersoll, 2015). Likewise, relying on the availability of a trained professional often incurs long waitlist times, where diffident social behaviours can sometimes worsen (Myers et al., 2018). As a result, there is a clinical and social need to develop low-cost interventions that are accessible to geographically dispersed participants in remote locations, do not rely on face-to-face or in-person participation, and do not always require the attendance of a trained professional (Lee & Meadan, 2020).

In the more recent times, the coronavirus pandemic (COVID-19), which swept across the world, exacerbated the need for accessible interventions that can be delivered at home. Schools, clinics, and rehabilitation centres were forced to close for long periods of time during the COVID-19 outbreak, causing children to ‘miss out’ on important social development (Morris, et al., 2021). This stresses the importance of developing evidence-based interventions that can still occur even when conventional facilities are closed and traditional therapies are inaccessible.

As mentioned in the earlier chapters of this thesis, some studies have recently begun to draw upon the development of modern technology such as the application of virtual reality or the utility of online games and telehealth for conducting social skills interventions

in the home environment, alleviating some of the potential barriers of the more 'traditional' therapeutic interventions (Alfuraydan et al., 2020). For example, Fletcher-Watson et al. (2016) utilised an iPad intervention in the home environment for targeting social communication skills in autistic children, whilst Wainer and Ingersoll (2015) implemented telehealth to train parents to conduct an imitation intervention in the home environment. Further, Gao et al. (2016), Jouen et al. (2017), and Rubin et al. (2019) all reported successful application of their home-based interventions for autistic children. Conducting interventions within the home environment can increase accessibility by supporting parental[1] involvement, and encouraging parents to deliver the intervention can somewhat limit the need for qualified professionals to deliver every step of an intervention. In addition, parent-mediated interventions and increased involvement from parents during therapy is often associated with more successful outcomes for autistic children (Haine-Schlagel et al., 2020; Kasari et al., 2015; McConachie & Diggle, 2007).

4.8.2 Physical activity and exergames

As noted in Chapter Two, several studies and systematic reviews have suggested that participating in physical activity induces positive changes in social communication skills and emotional regulation for autistic individuals (Chan et al., 2020; Lang et al., 2010; Sam & Tong, 2015). Briefly, Caputo et al. (2018) demonstrated a formalised swimming programme generated significant improvements for the intervention group on subscales of the Childhood Autism Rating Scale (CARS) including, emotional response, adaptation to change, and activity level compared to the control group. Zhao and Chen (2018) reported that a 12-week structured physical activity programme was associated with significant

[1] The term parents is used to describe both a parent or the primary caregiver throughout the chapter.

improvements in communication, cooperation, social interaction, and self-control in autistic children. Similarly, Bahrami et al. (2012) found that karate training was able to improve communication in individuals on the autistic spectrum following improved scores in the communication subscale of Gilliam Autism Rating Scale-Second Edition (GARS-2). Moderate physical activity, in which heart rate and breathing are raised but it is possible to speak comfortably (O'Donovan et al., 2010), can be achieved in the home environment. Therefore, interventions focused on moderate physical activity for improving social skills could be of particular clinical and social interest for future research. Further, dance-based physical activities, such as DMT, have also been observed to improve communication skills and social development for autistic individuals through the use of mirroring and rhythm (Amos, 2013; Berlandy, 2019; Martin, 2014).

Despite physical activity- and DMT-based interventions being observed to improve social communication skills, it is well established that children on the autistic spectrum are less likely to engage in coordinated movement than their TD peers (Bandini et al., 2013; Fitzgerald & Yip, 2017). Additionally, autistic individuals are more likely to partake in sedentary activities, for example watching the television or playing videogames, than their TD peers (Engelhardt et al., 2017; Mazurek et al., 2012; Mazurek & Wenstrup, 2013). To overcome the challenges associated with engaging the young autistic population in physical activity, current research is utilising modern technology and investigating the use of exergames for developing skills in autistic children.

As stated in Part B of Chapter Three, exergames combine videogaming technology with exercise (Bogost, 2007), and thus offer an ideal platform to increase physical activity whilst drawing on the interests of many autistic children. Studies utilising exergames as interventions, such as Wii Sports or XBOX's *Dance Dance* Revolution, have provided initial evidence that exergames can support a range of skills including cognitive function

and motor capabilities (Jiménez-Muñoz et al., 2021; Fang et al., 2018; Hilton et al., 2014). However, reflecting on the outcomes of the exergaming systematic review in Part B of Chapter Three, the effect of exergames on social development does not appear to have been sufficiently explored. This is despite the available evidence suggesting that engagement in physical activity can improve social communication skills in autistic children (Morris et al., 2022). Therefore, the current study aims to investigate the feasibility of an exergaming intervention, in the home environment, for enhancing and supporting the naturalistic development of social communication skills in young autistic individuals.

4.8.3 Just Dance

As highlighted throughout this body of work and, more specifically, in Part A of Chapter Three, research indicates that both mirroring and rhythm are beneficial for autistic children. *Just Dance* is a commercially available exergame distributed by Ubisoft that offers an ideal platform to potentially enhance social development in young autistic individuals as it incorporates both mirroring and rhythm into a physical, game-based activity. It is a widely accessible exergame that is available to those who have a Wii, XBOX, or Nintendo Switch games console and/or those who have access to the internet via a tablet, phone or laptop.

The use of *Just Dance*, in comparison to a similar movement-based intervention, was observed to elicit positive psychological effects in a sample of typically-developing primary school children (n = 417) across multiple areas, including intrinsic motivation, external regulation, rhythmic movement, and academic performance (Quintas et al., 2020). Further, Part B of Chapter Three highlighted that many autistic children favour dance-based exergames and found them to be enjoyable. Therefore, providing an impetuous for its use in future interventions. Similarly, *Just Dance* typically includes choreography to songs that have a 4/4 time signature, moderato tempo, and age-appropriate pop lyrics, which in Part A of Chapter Four, were found to be the most common elements of music and rhythm used in

DMT sessions with autistic children. As a result, it is expected that *Just Dance* could be used by many young individuals on the autistic spectrum to stimulate positive enhancements in social communication skills, whilst still being enjoyable and intrinsically motivating.

4.8.4 Aims and Hypotheses

Overall, the previous chapters have streamlined the current body of research; presenting an avenue to explore a dance-based exergame in various environments to support autistic children's social communication skills. As community partnerships need to first be established, no study to date has used this exact protocol, and the results from previous studies investigating the use of exergames to improve social communications skills in young autistic individuals are inconclusive, a feasibility study is the most appropriate place to start. The overarching aim of the current research project is to assess the feasibility; guided by Bowen et al.'s (2009) eight criteria for feasibility studies, and consider the potential efficacy of a dance-based exergaming intervention for autistic children in the home environment.

To this end, it is hypothesised that participating in frequent sessions of *Just Dance* will support positive changes in the social-communicative skills of young autistic individuals, which will be apparent through the application and comparison of validated outcome measures and analysis of behavioural observations within-subjects at both pre-and post-intervention. Furthermore, it is hypothesised that children will enjoy the intervention and that the exergaming intervention is easy to implement. It is hoped that parents are able to comply with the intervention in the home environment and this will be assessed by measuring adherence to the structured programme and completing semi-structured exit interviews with the parents at post-intervention

4.9 Methods

4.9.1 Research design

A consultation with members of the autistic and wider autism community, including autistic individuals, parents of autistic children, and special education teachers, and researchers from outside of the research team was held to discuss, adapt, and finalise the current study before submitting the final research proposal for ethical approval. This was important to ensure that the voices of the autism community were heard and influenced the final research proposal. Briefly, participants of the consultation panel were sent a draft copy of the research proposal and were invited to attend an online consultation held on Zoom for a single day. A short presentation was delivered to support participants' understanding of the background of the research proposal. Next, an online questionnaire was presented to the panel on various aspects of the research proposal, seeking suggestions and recommendations to improve its acceptability. Once responses had been received from the panel a live discussion of the results was held and outcomes were agreed between the panel members and research team. Outcomes from the consultation and how they were implemented into the final research proposal was documented and sent out to all panel members. This can be found in Appendix I. Ethical approval for the study was then given by the Science and Health Ethics committee at the University of Essex (Ethics ID: ETH2122-0085). The proposal was subsequently pre-registered on the 'As Predicted' platform and the preregistration information can be found in Appendix II.

A mixed-methods, within-subject repeated measures study design was employed to assess the feasibility and potential effectiveness of a home-based dance exergame for enhancing autistic children's social communication skills. Quantitative and qualitative outcome measures were completed pre- and post-intervention. Furthermore, different outcome measures were also completed during the progress of the intervention.

4.9.2 Participants

A range of recruitment techniques were utilised, similar to that of Fletcher-Watson et al. (2016) and Gao et al. (2019), to promote the research study, including word of mouth and drawing upon contacts within the University, generating a recruitment poster and contacting schools, special education schools, and charities, such as the National Autism Society, Autistica, the MAZE group, and SNAP charity to share the study's recruitment poster with their members.

Children, aged between 8- and 12-years old, were eligible to participate in the study providing they had a formal diagnosis of ASD, confirmed by inviting a letter from the child's school, paediatrician, psychologist, or general practitioner (Table 4B. 1). Parent-child dyads were also eligible to participate if they had access to the internet, had a phone or laptop that allowed for videoconferencing to enable remote delivery of the intervention, and access to the *Just Dance* game through any gaming platform or online.

Table 4B. 1 Inclusion criteria for participants enrolling onto the research project.

Inclusion Criteria
Diagnosis of ASD confirmed by a professional
Child must be aged between 8- and 12-years-old
Must have access to *Just Dance* either via a games console or online
Must have access to videoconferencing software (i.e., laptop, tablet, or phone with video camera)
Must be willing and able to commit to the duration of the research project

Overall, eight eligible child-parent dyads consented to participate in the study. However, only five completed all the pre-intervention outcome measures and only four embarked on the intervention and completed the post-outcome measures. Therefore, a total of four autistic children (M_{age} = 8.25 years, SD = 0.50) and their parents participated in the

study. The pre-registered report aimed to recruit between 5 to 12 child-parent dyads; however, it also included a deadline for recruitment to ensure the timely completion of the project. Due to ongoing difficulties following the COVID-19 pandemic, which affected recruitment that many researcher faced (Harrop et al., 2021; Neale et al., 2022) and time constraints, the final sample size number differed from the pre-registered report. Social demographics, experience with videogames, and familiarity with *Just Dance* differed for each child-parent dyad (Table 4B. 2, 3, and 4). Descriptions for each child-parent dyad can be found below.

Table 4B. 2 Social demographics of children who assented and participated in the project.

	Child A	**Child B**	**Child C**	**Child D**
Age	8-years-old	8-years-old	9-years-old	8-years-old
Sex	Male	Female	Male	Male
Confirmed ASD diagnosis	Yes	Yes	Yes	Yes
Length of diagnosis	Over four years	Over four years	Over four years	Over four years
Additional diagnoses reported by parent	Dyslexia and Phonological Speech Disorder	None reported	None reported	None reported
School attended	Mainstream education	Mainstream education	Mainstream education	Special education

Table 4B. 3 Social demographics of parents who consented and participated in the project with their child.

	Parent A	Parent B	Parent C	Parent D
Age	41 – 45-years-old	41 – 45-years-old	Over 50-years-old	41 – 45-years-old
Sex	Female	Female	Male	Male
Relation to child	Mother	Mother	Father	Father
Education	Level 7	Level 7	Level 2	Level 7
Occupation	Employed (Part-time)	Employed (Full-time)	Employed (Full-time)	Employed (Full-time)
Marital Status	Married	Married	Married	Married

Table 4B. 4 Children's videogaming experience and familiarity with Just Dance.

	Child A	Child B	Child C	Child D
Plays regular videogames (at least once a week)	Yes	Yes	Yes	No
Hours per week spent playing videogames	10+ hours	Less than 1 hour	4 – 7 hours	less than 1 hour
Familiarity with *Just Dance*	Not familiar at all	Moderately familiar	Not familiar at all	Not familiar at all

4.9.3 Outcome measures

4.9.3.1 Semi-structured interviews

During the intervention, one informal conversation was hosted with each parent over the phone in the third week of the intervention to assess how well the intervention was going and to mitigate any potential barriers for the remaining weeks. A follow-up document was then sent to parents with helpful suggestions to overcome any barriers that were apparent, which can be found in Appendix III. At the end of the intervention, a 30-minute semi-structured exit interview with parents was hosted to discuss the overall feasibility of the

intervention from start to finish, including the pre-and post-intervention phases, and discuss children's enjoyment. Questions focused on the recruitment and training phases, intervention, use of outcome measures, and suggestions for future projects (Table 4B. 5).

Table 4B. 5 Topics of semi-structured interview and leading questions asked to structure the interview with parents.

Topic	Leading Question Asked
Recruitment Phase	How did you find the recruitment phase?
Training Phase	How did you find the training phase of the project; this includes both the training webinar and training manual/handbook?
Feasibility of Intervention	How did you find the intervention overall; i.e., the 6-week *Just Dance* programme?
Feasibility of Outcome Measures	How easy did you find it to complete all the outcome measures, including the parent rating scale, in-home recording, and calendar style grid?
Enjoyability and effectiveness via parent recall	Do you think your child enjoyed participating in the project and do you think it has the potential to enhance social communication skills?
Potential improvements for future projects	How did you find the project from start to finish, and do you have any suggestions on how to improve the project?

4.9.3.2 Asynchronous behavioural observations

"Store and forward" behavioural observations are a subtype of telehealth medicine used to asynchronously observe relevant scenarios in an environment of choice. It refers to the transmission of recorded videos through secure electronic communications to a

practitioner, or in this case, a researcher, who uses the information to evaluate a case (Myers et al., 2018).

In order to assess potential changes in children's social skills, parents were invited to record a 10-minute play-based scenario with their child, using an enjoyable activity one week pre-intervention and one week post-intervention. For example, playing a board game with their child or playing with their child's favourite toys. These observations were, therefore, controlled observations, both pre-and post-intervention, in a naturalistic setting with no participation from the experimenter. Previous studies including, Narzisi (2020) and Wainer and Ingersoll (2015) have used similar methods for observing children.

Once recorded, the videos were forwarded to the research team for subsequent behavioural coding using the BORIS coding software (Friard & Gamba, 2016). Based on previous studies (Heimann et al., 2006; Nadel et al., 2000) a coding scheme and ethnogram were devised to measure behaviours reflecting social interest during the play-based scenarios. Coded behaviours were grouped into two broad categories; distal social behaviours and proximal social behaviours (Nadel et al., 2000; Table 4B. 6). The percentage of time each child spent displaying proximal and distal social behaviours were then used to provide an overall percentage of time each child spent displaying social interest during the pre-intervention and post-intervention play-based activities. All videos were coded by the first author and a blinded independent researcher (SMG), who was trained in the use of BORIS. Inter-rater agreement was then calculated using Kappa's coefficient to ensure reliability of the coding scheme (McHugh, 2012). Reliability for the proximal and distal codes used in this study for each video achieved a kappa coefficient (*K*) greater than 0.86, suggesting near perfect agreement between observers (Landis & Koch, 1977).

Table 4B. 6 Coding scheme used to code relevant behaviours during play-based observations.

Behaviour coded	Behaviour type	Description of behaviour	Behavioural category
Touching the adult	State event	Child makes physical contact with parent; hugging, hand holding, patting, holding arm, etc	Proximal behaviours
Verbal interaction	State event	Child engages verbally with the parent; speaks to parent, makes vocalisations towards parents, (speech need not be words)	Proximal behaviours
Physical interaction	State event	Child physically interacts with the parent; passes toy/item, shows parent toy/item	Proximal behaviours
Eye contact	State event	Child makes eye contact with parent; eye contact is established between parent and child	Distal behaviours
Look/Gaze	State event	Child looks or gazes at parent; looks towards or in the direct of parent or looks where parent has directed their attention	Distal behaviours
Facial expression	State event	Child displays facial expressions; child's facial expression differs from their neutral expression (can be positive or negative)	Distal behaviours

In order to measure positive social affect, enjoyment, and interpersonal motor synchrony during the *Just Dance* game, parents were invited to record the first, middle, and last *Just Dance* sessions of the intervention with their children and forward the recordings to the research team for behavioural coding. Behaviours established in the Dyadic Parent-Child Interaction Coding System (DPICS; Eyberg et al., 2005), specifically focusing on duration of child positive affect verbal, child positive affect nonverbal, and child physical warmth were coded during the first, middle and last *Just Dance* sessions (Table 4B. 7). Codes were combined to form the percentage of time each child spent showing affect and enjoyment during recorded the *Just Dance* sessions.

To measure interpersonal synchrony (Georgescu et al., 2020; Rennung & Göritz, 2016), the duration of time parents and children demonstrated motor synchrony between one another was coded (Table 4B. 6). 25% of the *Just Dance* videos were selected at random and coded by the first author and a blinded member of researcher team (EH), who was also trained in the use of BORIS, to establish reliability. Inter-rater agreement was calculated using Kappa's coefficient to ensure reliability of the coding scheme (McHugh, 2012). Reliability for the intervention-based observational codes used in this study was above K = 0.80 for 25% of the randomly selected intervention-based videos. The first author then continued to code the remaining 75% of the *Just Dance* videos once near perfect agreement had been established (Landis & Koch, 1977).

Table 4B. 7 Coding scheme used to code relevant behaviours during intervention-based observations.

Behaviour coded	Behaviour type	Description of behaviour	Behavioural category
Child positive affect verbal	State event	Any positive evaluative verbal expression of pleasure, warmth, enthusiasm, or gratitude such as "This is fun", "Oh goody", "I like playing these games", "Thank you", "I'm a winner" or singing along to the songs. However, words do not always need to be spoken to code this – any verbal positive expression.	Affect and enjoyment
Child positive affect nonverbal	State event	Nonverbal expression of enjoyment, warmth or enthusiasm directed at the parent or game, such as smiling and laughing, or directing positive gestures towards the parents/game	Affect and enjoyment

Child physical warmth	State event	Child physical warmth is an explicit physical act of endearment initiated by the child or positively received by the child (positive physical interaction), such as hugging, touching the adult, climbing onto the adult, high-five, patting the parent on the body	Affect and enjoyment
Interpersonal synchrony	State event	Parent and child demonstrate motor synchrony between one another; i.e., moving limbs at the time or motor coordination (in time or with time-lag), measuring the length of time children and parents demonstrate interpersonal synchrony (moving together in time) in each video. Actions do not have to be *identical*, but must be similar in direction, movement, and action.	Interpersonal synchrony

4.9.3.3 Parent rating scale – emotional regulation and social skills questionnaire

In addition to the store and forward behavioural observations, parents completed a validated and standardised rating scale. The Emotional Regulation and Social Skills Questionnaire parent version (ERSSQ-P; Beaumont & Sofronoff, 2008) was used to provide a valid measure of overall social performance in participants. The ERSSQ-P was developed in response to the limitations of existing rating scales of social skills and intends to evaluate autistic individual's social communication skills (Butterworth et al., 2014). It consists of 27 items in the format of a five-point Likert Scale, from 0; never to 4; always. The questionnaire is designed to measure frequencies of effective engagement in social behaviours (e.g., "chooses appropriate solutions to social problems" or "deals effectively with bullying"). Further, the ERSSQ-P was specifically created to measure behaviours that are targeted

during various social skills interventions, rather than measure behaviours that differentiate autistic individuals from TD individuals. It is, therefore, more likely to be sensitive to treatment effects (Butterworth et al., 2014). Parents completed the ERSSQ-P online via the Qualtrics platform one week pre-intervention and one week post-intervention.

4.9.3.4 Adherence and enjoyability calendar

Following each completed *Just Dance* session, child-parent dyads were invited to mark the session on a pre-distributed calendar-style grid to help measure compliance and adherence to the intervention (Figure 4B. 1). Calendars and a set of stickers were emailed or posted to the home addresses of child-parent dyads. Children reacted to each completed session by choosing a sticker or drawing a face that best reflected their level of enjoyment based on a 3-point scale, similar to that found in the Fun ToolKit of Read and MacFarlane's (2006) study. For example, using a green smiley face (2) for “I enjoyed the session”, using an orange neutral face (1) for “The session was okay”, and using a red sad face (0) for “I did not enjoy the session”. Parents were asked to specify what songs they completed each session and leave any comments for the week in a small text box. Parents were asked to return the calendar to the research team at the end of the intervention.

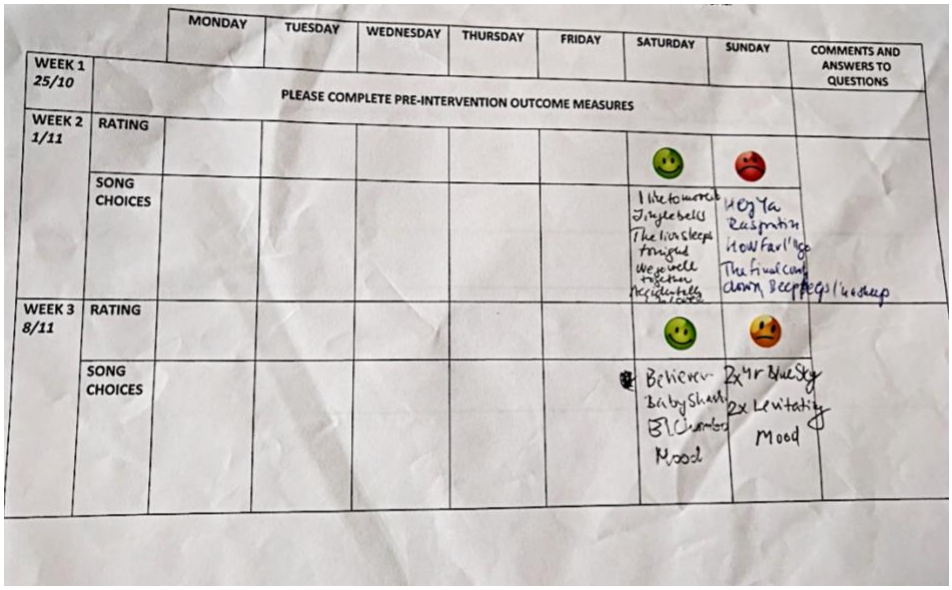

Figure 4B. 1 Photograph of the completed calendar-style grid and smiley face stickers that were sent to child-parent dyads and subsequently completed throughout the intervention to represent enjoyability of the session, where a green smiley face was used for (2) "I enjoyed the session", an orange neutral face was used for (1) "The session was okay", and using a red sad face was used for (0) "I did not enjoy the session".

4.9.4 Exergaming Intervention

The intervention comprised 6-weeks of structured *Just Dance* sessions. The exergaming systematic review of this thesis suggested participation in two, weekly *Just Dance* sessions lasting five songs, for at least six weeks, was sufficient to maintain the attention of young autistic individuals and elicit potential beneficial effects. It was expected that parents proactively engaged with their child during the intervention, asking what songs they would like to complete and praising their child for completing the dances and session as this was found to be beneficial by many practicing dance movement therapists when working with autistic individuals (Morris et al., 2021). Parents were asked to complete each dance with their child, as the involvement of parents in intervention is observed to be

valuable (Althoff et al., 2019; Oono et al., 2013). As a result, child-parent dyads were expected to complete 12 *Just Dance* sessions consisting of 60 songs throughout the 6-week programme.

4.9.5 Procedure

Before the intervention commenced, an online taster session for potential parents who registered their interest in the study was held. During the taster session, parents were informed on how the intervention would be structured, what was expected, and why this important work was being conducted. At the end of the webinar, a link was provided for parents to read the participant information sheet, sign a consent form, and complete an online survey providing socio-demographic information on themselves and their autistic child. A child-friendly participant information sheet and assent form was also created to gain assent from the child.

Consenting parents were then invited to attend a live training session or watch a pre-recorded training session online, which can be viewed here (https://youtu.be/udywn5psqj4). During this training session, parents were informed of how to conduct and complete several of the primary outcome measures, including how to set up a remote observation recording (i.e., store and forward telehealth observations; Myers et al., 2018), how to fill out the parent-rating scale, and how adherence to the programme should be recorded. Previous research has indicated that parents appreciate hybrid training sessions, which consist of both live videoconferencing and online static content that can be accessed at any point (Wainer and Ingersoll, 2015). Therefore, a training handbook for parents to access following the training session was devised. This comprised relevant 'how-to' videos for recording the play-based scenario and *Just Dance* sessions and written elements on how and when each of the outcome measures should be completed. The training handbook can be accessed in Appendix IV.

Parents then completed the ERSSQ-P and play-based recordings one week pre-intervention and one week post-intervention. During the six-week *Just Dance* intervention they also completed the calendar-style grid after each session and recorded the first, middle, and last *Just Dance* session of the six-week intervention. The semi-structured interview was held within two weeks of parents completing the final outcome measure. As such, a within-subject pre- and post-test experimental design was utilised for the current study, in which all child-parent dyads completed the intervention.

4.9.6 Data analysis

Qualitative analyses were conducted in order to establish the feasibility of introducing an exergame intervention into the home. Thematic analysis, using the NVivo12 software (*NVivo*, 2018), was carried out on the transcribed semi-structured interviews. Briefly, thematic analysis is a flexible qualitative method that allows for the identification, analysis, and reporting of patterns or themes within data (McLemore et al., 2014). Where themes capture important elements about the data in relation to the research question and represent some level of patterned response or meaning within the datasets (Braun and Clarke, 2006; Swart, 2019). To this end, the interview transcripts were systematically read several times to ensure familiarity with the dataset. Words, phrases, and sentences were categorised under different codes until code saturation was perceived (but ultimately never confirmed) by the first author (Braun and Clarke, 2021). Initial themes and sub-themes were generated by clustering similar codes together. These themes were then discussed and reviewed with the research team. During this discussion, domain summary themes (themes that "aim to capture the diversity of meaning in relation to a topic or area of focus" (p. 593; Braun and Clarke, 2019)) were deemed most appropriate to conceptualise themes and present a narrative. This was due to the sample size in which the semi-structured interviews

were conducted and the vast array of themes that were generated. Therefore, an extension of Braun and Clarke's (2006) thematic analysis is presented to provide a narrative more suited to this report.

The quantitative data (ERSSQ-P responses and coded behavioural observations) were analysed using SPSS (*IBM SPSS Statistics*, 2017) and GraphPad Prism 9 (*GraphPad Software*, 2020); where analyses were carried out, frequency tables produced, and graphs created. To establish whether data were suitable for parametric testing, Shapiro-Wilk tests were employed due to the small sample size. Once normality had been established, paired and parametric t-tests were carried out on the datasets to assess whether the play-based behavioural observations and ERSSQ-P were capable of detecting variances that might infer a change in social communication skills from pre- to post-intervention. Confidence levels (Cl) were calculated around the mean difference and effect sizes (represented by Cohen's d (d)) were also determined by dividing by the pooled standard deviation (Lakens, 2013).

4.10 Results

4.10.1 Group Results

4.10.1.1 Thematic analysis of interview transcripts

Seven key domain summaries were identified following thematic analysis of the transcribed semi-structure exit interviews with parents. Each domain summary included a variety of related key themes, sub themes and nodes. A detailed overview of the key domain summaries, themes, sub-themes, and specific codes with quote examples can be found in Appendix V. Overall, themes focused on what worked well within the feasibility study, what did not work well, and improvements for future studies. Furthermore, analysis of the transcripts identified themes that focused on delivery of the intervention itself and positives that can be taken away from the project.

Domain summary one: Appreciation for the organisation and the information provided throughout the project.

Parents were forthcoming highlighting the successful organisation of the project and expressing their appreciation of the information provided. Thematic analysis of the transcripts indicated that parents valued the taster and training webinars, as they provided a "build up" to the project and ensured relevant information was conveyed. Parents also enjoyed the hybrid approach to training, where an online training webinar was held and an electronic training manual was also distributed. Parents were keen to convey that the organisation of the project was "straight forward" "easy to navigate", and "streamlined"; expressing appreciation for the visual presentations, design of the materials that were made available, and clear instructions. Furthermore, parents valued being able to contact a member of the research team either by WhatsApp or email at a time that was convenient to them.

> *"But I mean speaking specifically to how the project was organized and presented and so on, I think you did a spectacular job like, and I mean I've seen quite a few, you know research projects because I've worked in a University in research for a while, so I've seen you know a lot of you know, research projects put together and like just like the care for the visual and visual presentation, like everything from typography to the general design of all the material that you put together, I think, was impeccable." - Parent C*

> *"You kept in touch with us and on a regular basis and we knew, well I knew, that I could contact you if there was any problem at any time." – Parent B*

Domain summary two: Importance of preparing children and offering them options before and during the intervention.

The second domain summary identified through the thematic analysis of exit interview transcripts was the importance of preparing children for the introduction of the intervention and the significance of "enabling a choice" in order for each child to feel more "in control" of their intervention. Many parents informed that giving their children "several options" and allowing them to choose was "comforting" and ensured that they were more "willing to take part". This was facilitated by giving children the option to choose what songs they wished to complete each session. Parents also suggested preparing their children for the intervention was important. Therefore, parent B showed her daughter the recorded webinars to help her understand why they were starting *Just Dance* and preselected the songs with her daughter before each *Just Dance* session, so that she was prepared for each session.

> *"Having a sense that he can actually choose amongst several options is really important to him, and then knowing what's going to come in, in advance, is also really soothing and comforting to him." – Parent C*

> *"I tried to prepare her and to say, "look we're going to do thing, we're going to do some dancing" before it even started, so I was trying to get her prepared." – Parent B*

Domain summary three: Personal circumstances affecting the delivery of intervention.

As the intervention was delivered at home, analysis of the transcripts emphasised different family-specific circumstances that affected delivery of the intervention giving rise to the third domain summary. There were various personal commitments that each family

encountered, which restricted the number of sessions they completed. For example, one child-parent dyad was on holiday the first week of the project and another family fell ill with a cold during the intervention. Yet, each parent felt that two sessions a week was "do-able". Furthermore, parents spoke about the importance of "creating structure and routine" in their home and that, for at least two parents, "doing it on a weekend" helped to achieve this structured routine.

"I think two days a week - it should be feasible, it should really yeah I think it's okay, the two a week." – Parent A

"Again, it's really weekend-based that we did the work for the project." – Parent C

Domain summary four: Feasibility of outcome measures used within the project.

Domain summary four centres around the promising feasibility and utility of the outcome measures used in the project, as reported by the parents. Several parents informed that the outcome measures were "easy to use" and complete, including the ERSSQ-P, play-based recordings, and the calendar-style grid. However, one parent felt that the ERSSQ-P could be made more "individualised" to reflect the skill set of their child. Additionally, parent D reported losing their calendar-style grid halfway through the intervention, suggesting a possible downfall of the feasibility of the calendar-style grid. Nonetheless, parents appreciated the visual aspect of the calendar-style grid and the use of different coloured faces to reflect levels of enjoyment.

"As far as I remember, the questionnaire that was very easy." – Parent A

"Yeah, but it was easy to fill in and all that was straightforward, it's quite good as well to have the visual side of things; you know, having the red, amber, green faces." – Parent B

Domain summary five: Positives to take away from the project.

After thematically analysing the semi-structured exit interviews, various themes and sub-themes were identified demonstrating positives to take away from the project. Overall, parents provided positive feedback and expressed that they would be "happy to continue" with the intervention. Furthermore, parents emphasised the importance of the intervention being "physically active" and being able use dance as a way of "expression". Furthermore, parents were keen to participate in the project as they could see "value" in movement aiding communication skills, were keen to "learn something", and have "an enjoyable experience" with their child.

Importantly, parents found using *Just Dance* "easy and not too onerous" and appreciated that it could be used on various platforms, including Nintendo Switch, XBOX Kinect, and also YouTube. Again, providing options for children to choose what platform they would like to complete the sessions on, if they had more than one option available to them. Parents also expressed that their children enjoyed playing *Just Dance*, especially the "visual aspect" and being able to "follow" the avatars on screen. Many parents appreciated that this involved children "mirroring" the avatar and moving in synchrony with one another. All parents explained that their children had an innate "love for dancing and music" and were able to express themselves in the non-verbal realm of movement, indicating the prosperous use of the dance-based exergame.

"That's one thing that don't feel as if you're forcing her to do it [Just Dance] because she actually enjoys it." – Parent B

"Oh, he already asked, because we have got one more session but yeah, he's already asking me 'we don't have to finish just dance now, do we?' He really wants to continue." – Parent A

"Children have a craving for communicating and sometimes they don't have the tools or the knowledge to do so and expressing themselves bodily through dancing I think is a great outlet and it's a great idea." – Parent C

"Uh, I agree with you, you know, so the first step to learn is to mimic or mirror, and then, yeah, and this is what I generally try to do as well." – Parent D

Domain summary six: Challenges to the intervention.

Despite the many positives highlighted by parents, some challenges to the intervention were raised, generating domain summary six. Parents expressed concerns that their children were "burned-out" and introducing another activity to their schedules may "overload" them, suggesting a negative impact and challenge to the intervention. Furthermore, parents informed that children often associated "home-time with down-time" and, therefore, were occasionally reluctant to take part in the intervention – indicating another drawback of home-based interventions. A negative aspect of utilising the *Just Dance* platform already discussed was that sometimes dances were "too fast" for children to follow accurately, making the experience "challenging" for them.

"The problem that I've kind of had with it, with her, is that she associates home time with her kind of down time, when she can kind of do what she wants." – Parent B

"Yeah, because he shattered, he is tired mentally." – Parent A

Domain summary seven: Potential improvements and changes for future studies.

Parents suggested various changes that could be made to the protocol to improve it for future studies, generating domain summary seven. For example, "providing a more in-depth social story", in addition to the social story we provided to gain children's assent. Interestingly, all parents suggested five songs were "too much" for their child. As a result, many child-parent dyads completed two or three songs together instead. This was also reflected in their calendar-style grids. Furthermore, one parent echoed that some of the songs available on the *Just Dance* platform were "too fast" and proposed that the videos could be made "slower so that they are easier to follow". Parents also suggested that providing an "incentive", such as a "five pound voucher" to improve children's "buy-in" to the project. Despite many parents struggling to meet the proposed number of sessions across the six weeks, some parents suggested that due to the "small time-scale of the project", they were unsure if it would "generate measurable differences" and recommended a greater timescale; for example, "three-months".

"Five songs are quite a lot, even for me. I'm very unfit so yeah, I think, so I think it's quite a lot because yeah normally, as I said that we do three or four song that's well over 10 minutes, for example. Yeah, I think five is a bit, five was a bit too much." – Parent A

"You could suggest to parents that you could make the video slower so that they're easier to follow as some steps are quite complex." – Parent D

4.10.1.2 Play-based behavioural observations

The group means and children's individual percentages for time spent displaying socially proximal (touching the adult, engaging with the adult physically, and verbal interactions) and socially distal (initiating or maintaining eye contact, showing joint attention via gaze or looking, and displaying facial expressions) behaviours towards their parent are presented in Figure 4B. 2. Results from the two-tailed paired t-test on the play-based behavioural observation data revealed a large improvement between pre-intervention and post-intervention ($n = 4$, $t(3) = 2.240$, $p = 0.111$, 95% CI [-3.936, 22.640], Cohen's $d = 1.146$). Although a large effect was observed, this was deemed statistically non-significant, most likely due to the small sample size in the home-based feasibility study. Three out of the four children showed a positive increase in overall social interest (determined by percentage of time spent being socially proximal and distal) during their play-based observations between pre- and post-intervention. Child B remained the same on this measure.

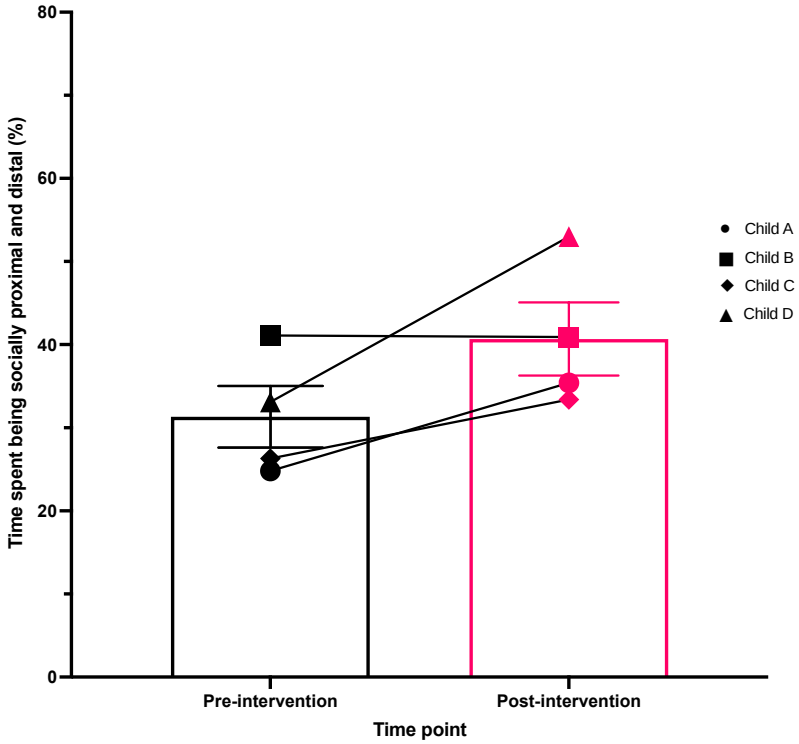

Figure 4B. 2 Mean (±SEM) bar chart overlaid by an individual stacked scatterplot of the percentage of time children (n = 4) spent showing social interest (displaying proximal and distal social behaviours) towards the adult during the play-based observation recorded before and after six weeks of Just Dance sessions. Key shown on graph for each child's individual dataset marker.

4.10.1.3 Intervention-based behavioural observations

The group means and children's individual percentages for perceived time spent enjoying the first, middle, and final *Just Dance* sessions are presented in Figure 4B. 3. Parent-child dyad D were unable to return their middle session recording. Children were observed to either maintain or increase their levels of enjoyment across the recorded sessions as demonstrated by verbal and nonverbal positive affect and physical warmth directed to or received by the adult.

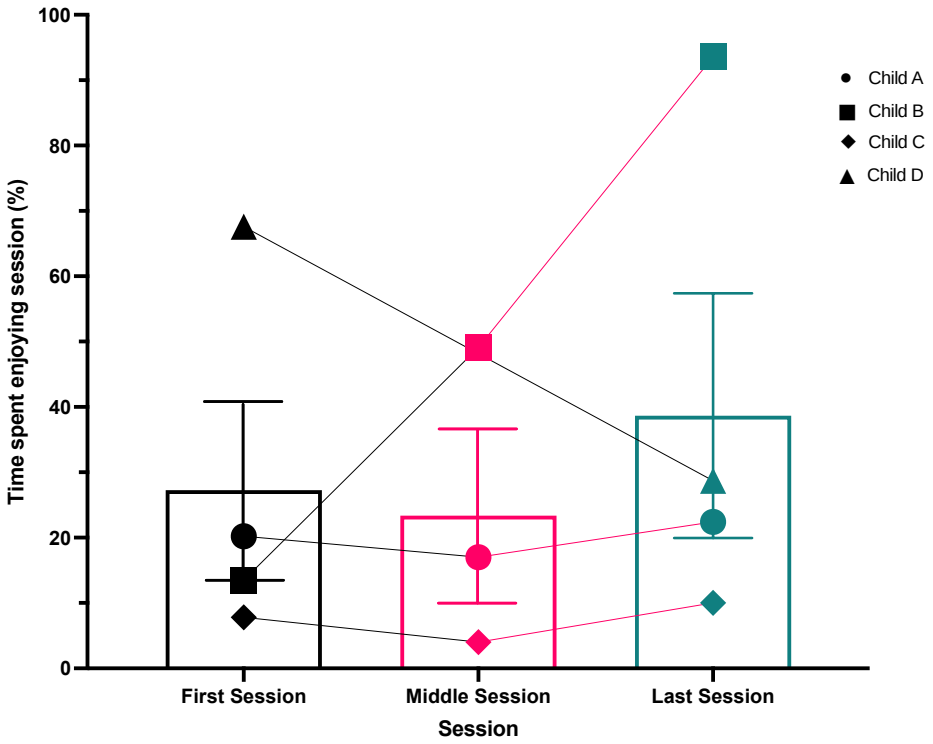

Figure 4B. 3 Mean (±SEM) and individual percentage of time children (n = 4) spent enjoying the session (displaying positive verbal and non-verbal affect and physical warmth towards the adult) during the first, middle, and last recorded Just Dance sessions. Key shown on graph for each child's individual dataset marker.

The group means and children's individual percentages for time spent moving in synchrony with their parents during the first, middle, and last *Just Dance* sessions are shown in Figure 4B. 4. Overall, synchrony was greatest during the middle session for the group. However, it was not possible to establish time spent moving in synchrony for two of the group participants in this session.

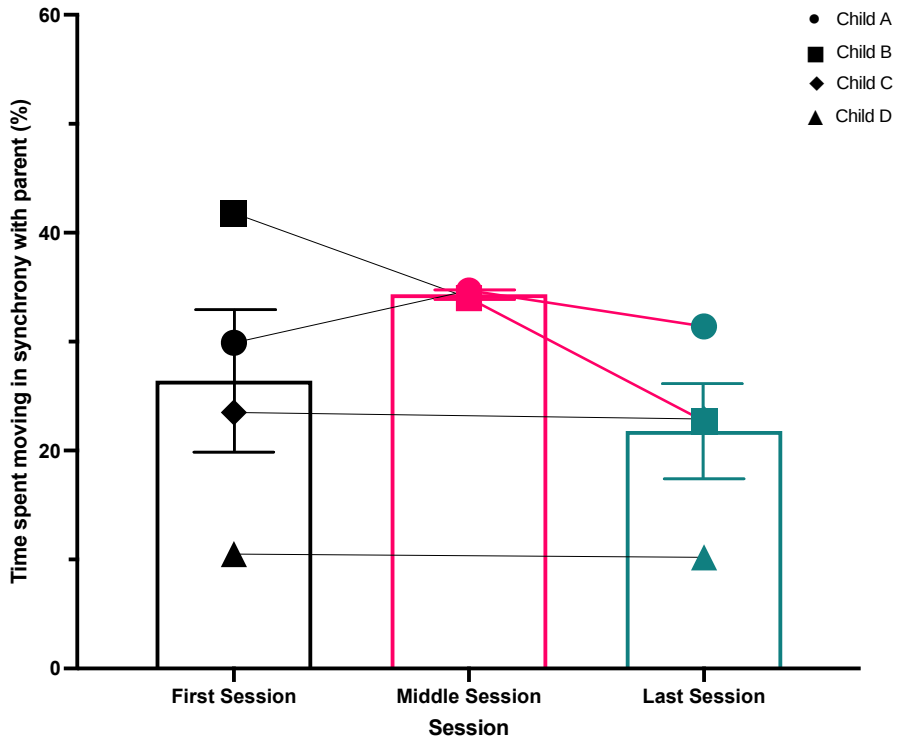

Figure 4B. 4 Mean (±SEM) and individual percentage of time children (n = 4) spent moving in synchrony with their parent during the first, middle, and last recorded Just Dance sessions. Key shown on graph for each child's individual dataset marker.

4.10.1.4 Emotional regulation and social skills questionnaire

The group means and children's individual scores for the pre-intervention and post-intervention ERSSQ-Ps are displayed in Figure 4B. 5. Results from the two-tailed paired t-test on the ERSSQ-P data revealed a statistically non-significant small-medium positive effect between pre-intervention and post-intervention, (n = 4, t(3) = 1.290, p = 0.287, 95% CI [-6.970, 16.470], Cohen's d = 0.291). The absence of statistical significance was most likely due to the small sample size. On average, the group's ERSSQ-P score improved by 4 points from pre-test to post-test.

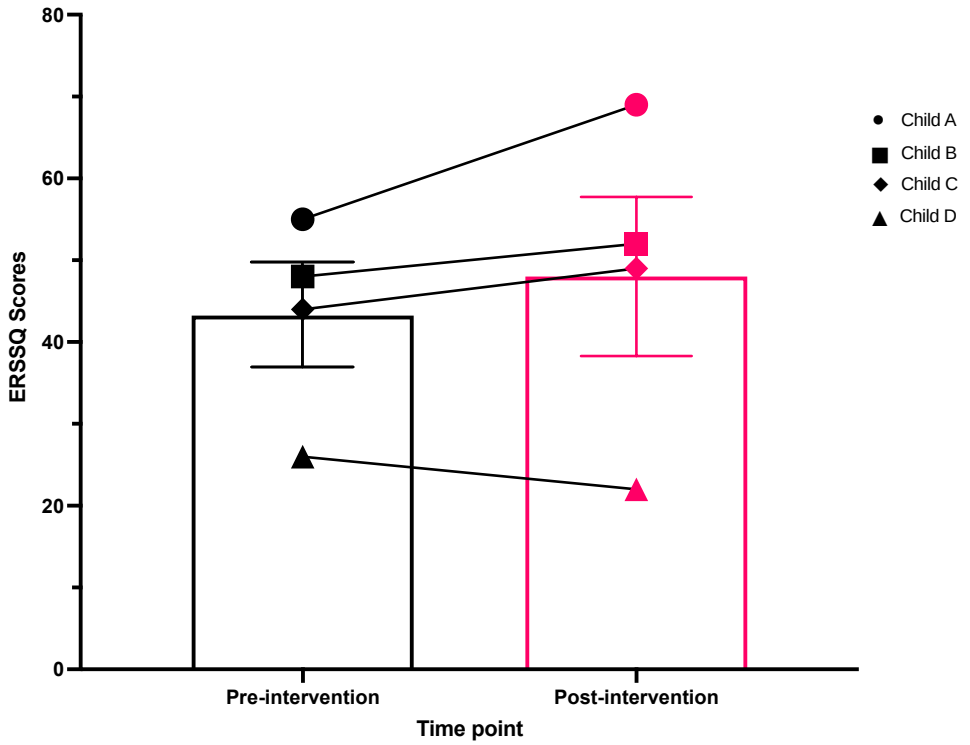

Figure 4B. 5 Mean (±SEM) bar chart overlaid by an individual stacked scatterplot of children's (n = 4) Emotional Regulation and Social Skills (ERSSQ) scores before and after six weeks of Just Dance sessions. Key shown on graph for each child's individual dataset marker

4.10.1.5 Adherence to intervention and enjoyment

Only three child-parent dyads (A, B, and C) returned their calendar-style grids with which to measure adherence from. A verbal discussion was held with parent D to retrieve an approximation of the necessary information that would have been on the calendar-style grid. On average the group completed 61% of the sessions, approximately seven sessions out of 12. The most common number of songs completed each session was three and the most common rating for the sessions completed was 2 – "I enjoyed the session". A range of songs were chosen each session between the child-parent dyads; however, most songs danced to were songs with a 4/4 time signature, moderate-allegro tempo, and included age-appropriate pop lyrics. These included, Katy Perry's 'Roar', Survivor's 'Eye of the Tiger', and Shakira's 'Waka Waka'.

4.10.2 Case-by-case results

4.10.2.1 Child A

Child A was the only child to complete 100% of the required sessions, completing 2 sessions per week. The most common number of songs they danced to each session was 5; however, they also completed three sessions dancing to only 2 songs. The most common rating for the sessions from child A was 1 – "The session was okay", yet they did rate five sessions as 2 – "I enjoyed the session". Child A danced to a range of songs, however the most frequent songs they danced to included Shakira's 'Waka Waka', ELO's 'Mr Blue Sky', and Europe's 'Final Countdown'.

Child A showed a 4-point increase between pre- and post-intervention ERSSQ-P scores (Figure 4B. 5), reflecting a potential improvement in social communication skills as observed by their parent. Likewise, an 11% increase in time spent displaying social interest was observed between the pre-intervention behavioural observations and the post-intervention observations (Figure 4B. 6). Verbal interaction was observed to increase by 8.6%, meanwhile joint attention (represented by look/gaze) increased by 4.5%, frequently used indicators of social competence. In contrast, a small reduction in physical interaction and eye contact were observed between pre- and post-intervention time points. Overall inter-observer agreement for Child A's pre-intervention and post-intervention play-based videos were K= 0.97 and K= 0.96, respectively.

Child A appeared to maintain their level of enjoyment throughout the intervention, showing the most enjoyment in the final sessions with 22.4% of time spent enjoying the session (Figure 4B. 3). Similarly, Child A maintained a similar percentage of time spent moving in synchrony with their parent (Figure 4B. 4). However, the greatest percentage of time spent moving in synchrony was observed during the middle session at 34.7%.

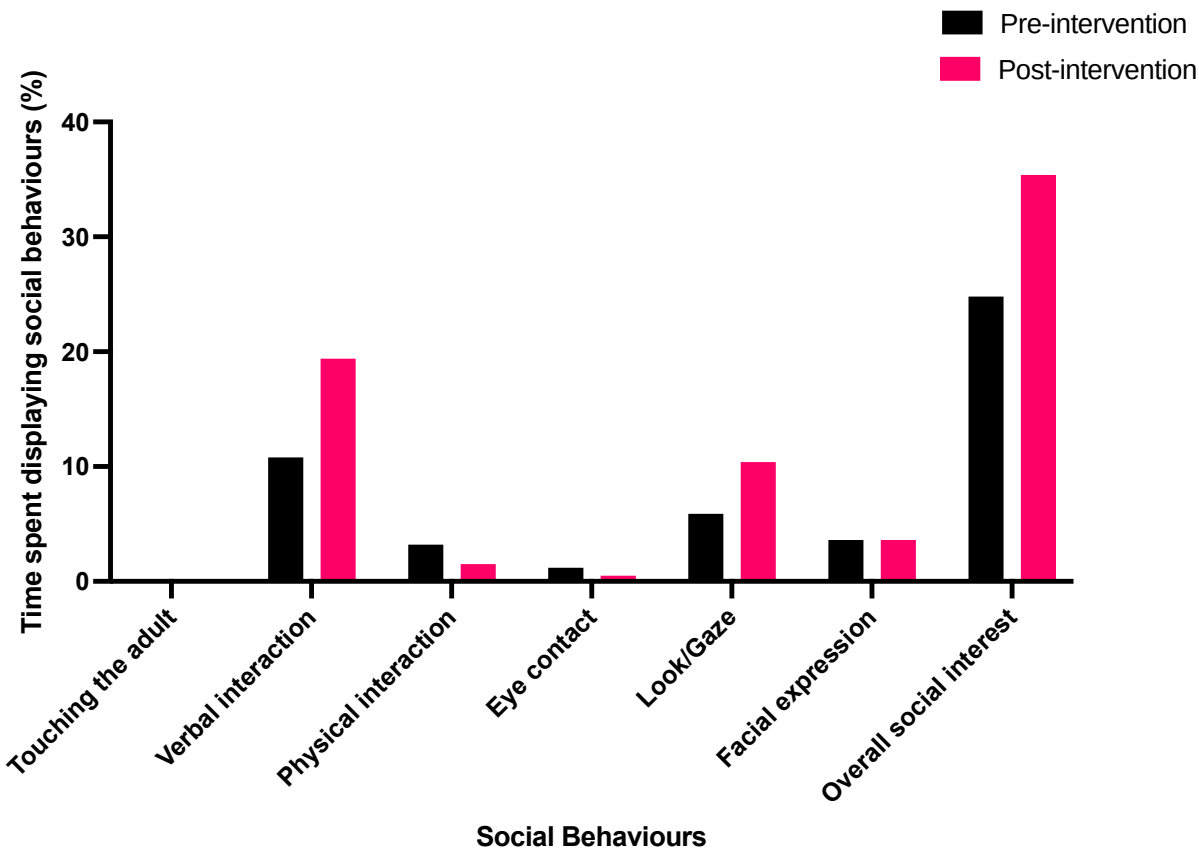

Figure 4B. 6 Percentage of time spent displaying social behaviours by Child A, including touching, verbally, and physically interacting with the adult, initiating or maintaining eye contact, directing social gaze, and using facial expressions. The overall percentage of time spent directing social behaviours towards the adult by Child A is also shown.

4.10.2.2 Child B

Child B completed only 33% of the sessions; four sessions overall. Each session, Child B danced to three songs. Child B danced to a range of songs and for the final session chose to dance to Christmas-themed songs as it was mid-December. For example, they danced to Wham!'s 'Last Christmas' and Mariah Carey's 'All I want for Christmas'. On average, Child B's most common rating was 2 - "I enjoyed the session".

Child B demonstrated an impressive 14-point increase between pre and post-intervention ERSSQ-P scores (Figure 4B. 5), suggesting a potential enhancement of social

communication skills observed by their parent between starting the intervention and finishing the intervention. Child B was observed to maintain their percentage of time spent displaying social interest between pre-intervention and post-intervention observations (Figure 4B. 7). Time spent verbally interacting with the adult increased from 17.3% pre-intervention to 26.5% post-intervention and joint attention (represented by look/gaze) increased by 2.3%. However, a reduction in facial expressions and physical interaction was observed between pre- and post-intervention observations. Overall inter-observer agreement for Child B's pre-intervention and post-intervention play-based videos were K= 0.86 and K= 0.94, respectively.

Across the three sessions, Child B's time spent demonstrating enjoyment increased with each session. The final session revealed Child B spent 93.6% of their time enjoying the session; represented by non-verbal and verbal positive affect and physical warmth between them and their parent (Figure 4B. 3). Interestingly, Child B's time spent moving in motor synchrony with their parent decreased with each recorded session; falling from 41.8% in the first session to 22.7% in the final session. However, this may be due to more spent time enjoying the session, such as offering and receiving positive physical warmth (Figure 4B. 3 and 4).

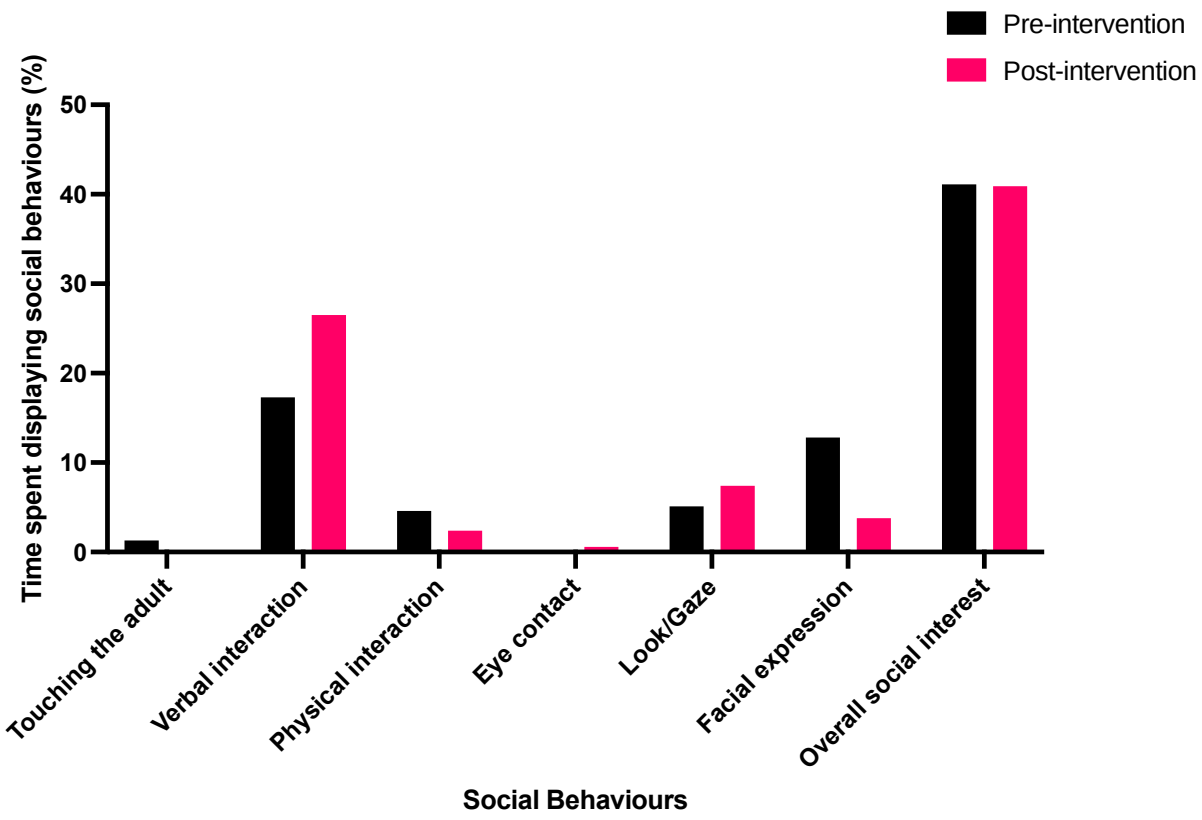

Figure 4B. 7 Percentage of time spent displaying social behaviours by Child B, including touching, verbally, and physically interacting with the adult, initiating or maintaining eye contact, directing social gaze, and using facial expressions. The overall percentage of time spent directing social behaviours towards the adult by Child B is also shown.

4.10.2.3 Child C

Child C completed 7 sessions, equating to 58% of the required sessions. They most commonly danced to four songs each session and rated the sessions as 2 - "I enjoyed the session". Child C appeared to dance to similar songs each week, including Pharrell's 'Happy', Capital Cities' 'Safe and Sound', Katy Perry's 'Firework', and Will.i.am's 'That Power'.

Child C showed a 5-point improvement between pre and post-intervention ERSSQ-P scores (Figure 4B. 5), suggesting a possible enhancement of social communication skills

as reflected on by the parent. Similarly, a 7% increase in time spent displaying social interest was observed between pre- and post-intervention behavioural observations (Figure 4B. 8). Verbal interaction and joint attention (represented by social look/gaze) saw the greatest increase. However, a small reduction of 0.3% was observed for changes in facial expressions between pre-intervention and post-intervention time points. Overall, inter-observer agreement for Child C's pre-intervention and post-intervention play-based videos were K= 0.93 and K= 0.98, respectively.

Child C demonstrated a moderate increase in enjoyment between the first and last sessions; increasing from 7.8% to 10% of their time demonstrating enjoyment within each session respectively (Figure 4B. 3). Unfortunately, Child C's parent was out of the frame for the middle session and, therefore, it was not possible to establish the percentage of time spent moving in motor synchrony for the middle session. However, between the first and last session, time spent moving in motor synchrony was maintained (Figure 4B. 4).

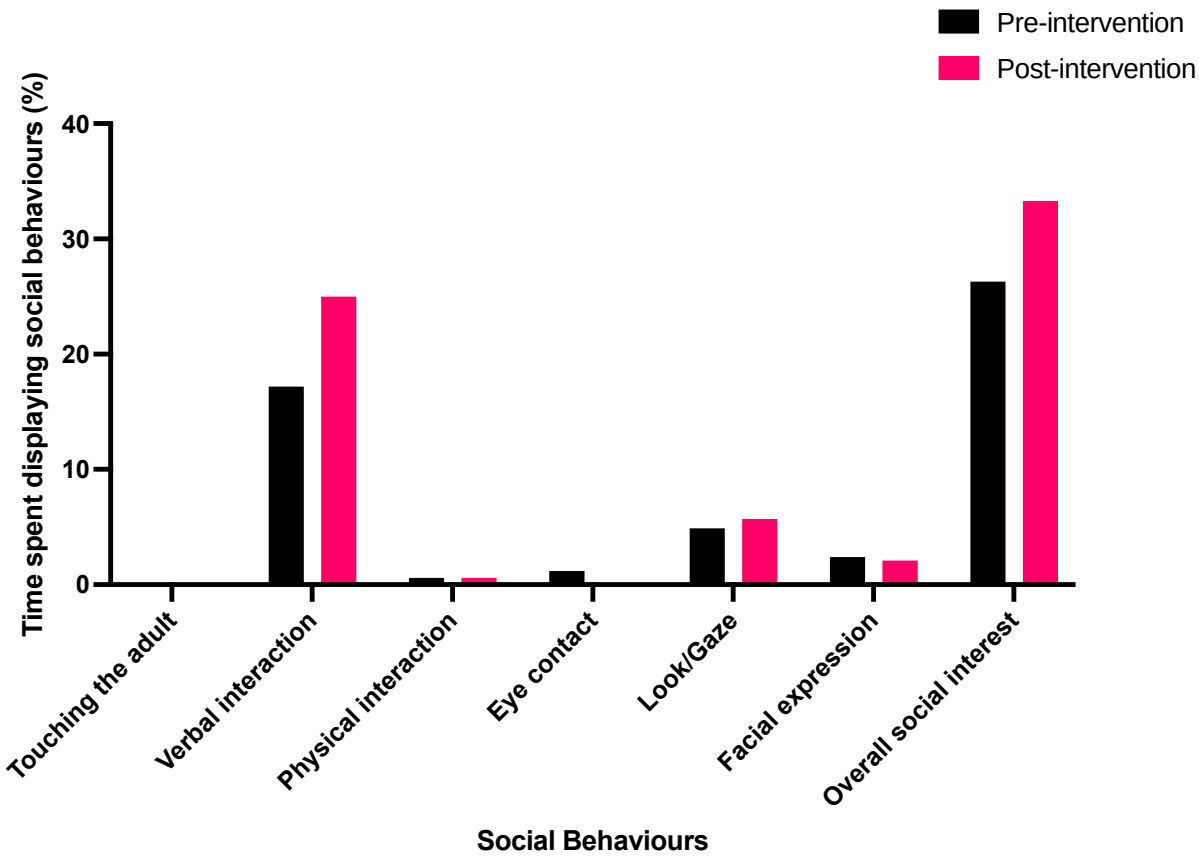

Figure 4B. 8 Percentage of time spent displaying social behaviours by Child C, including touching, verbally, and physically interacting with the adult, initiating or maintaining eye contact, directing social gaze, and using facial expressions. The overall percentage of time spent directing social behaviours towards the adult by Child C is also shown.

4.10.2.4 Child D

Child-parent dyad D misplaced their calendar-style grid and were, therefore, unable to return the calendar to the research team. However, after discussing with Parent D, they reported that Child D completed approximately 50% of the required sessions – 6 sessions overall. Parent D also informed that their child appeared to enjoy most of the sessions, suggesting that their most common rating would have been 2 - "I enjoyed the session". Furthermore, Parent D reported that they danced to either two or three songs each session.

Child D demonstrated a 4-point reduction in their ERSSQ-P scores between pre- and post-intervention (Figure 4B. 5), suggesting the parent observed no overall improvement in their child's social communication skills between starting the intervention and finishing the intervention. Interestingly, the behavioural observations revealed a 20% increase in time spent being social towards the adult between pre- and post-intervention time points (Figure 4B. 9). Overall, verbal interaction saw the greatest increase, where child D made vocalisations for 46.3% of the post-intervention behavioural observation in comparison to 19.5% of the pre-intervention behavioural observation. However, no attempts at eye contact or changes in facial expressions were observed for either pre-intervention or post-intervention observations. Overall inter-observer agreement for Child D's pre-intervention and post-intervention play-based videos were $K = 0.91$ and $K = 0.96$, respectively.

Parent-child dyad D were unable to record and return their middle *Just Dance* session. As a result, only observations for the first and last sessions are included in the results. Child D appeared to enjoy the first session, spending 67.6% of their time displaying positive behaviours during the first session (Figure 4B. 3). However, this fell by 38.9% in the final session. Child D appeared to maintain their time spent moving in motor synchrony with their parent between the first and last *Just Dance* sessions (Figure 4B. 4).

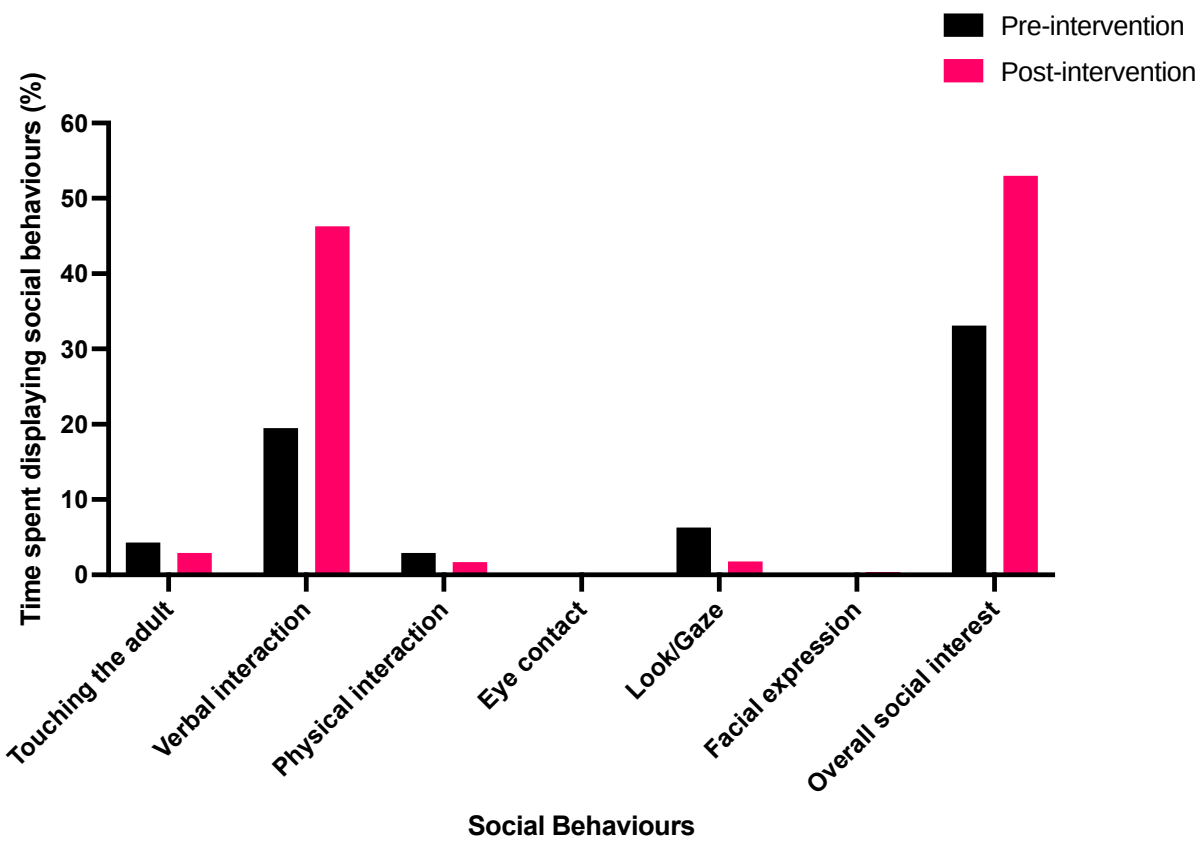

Figure 4B. 9 Percentage of time spent displaying social behaviours by Child D, including touching, verbally, and physically interacting with the adult, initiating or maintaining eye contact, directing social gaze, and using facial expressions. The overall percentage of time spent directing social behaviours towards the adult by Child D is also shown.

4.10.3 Overall feasibility

As addressed in the aims, the purpose of this study was to assess the feasibility of the intervention guided by Bowen et al. (2009) criteria for feasibility studies. Table 4B. 8 provides and describes the eight areas of focus outlined by Bowen et al. (2009), the outcome measures used to assess each focus, and comments regarding the intervention's feasibility. Overall, the results described above indicate that the intervention is acceptable, holds demand, can be implemented into the home environment, allows for adaption and integration, and with minor adaption to the scheduling is practical for parents and children.

Limited efficacy testing suggested a positive trend in children's social communication skills.

Table 4B. 8 Assessing the feasibility of the home-based intervention according to Bowen et al.'s (2009) criteria for feasibility studies.

Focus	**Bowen et al.'s (2009) definitions**	**Assessed**	**Comments**
Acceptability	How the intended individual recipients react to the intervention and outcome measures	Calendar-style grid, interview, and behavioural observations	Children and parents responded positively to the intervention and were observed to enjoy the intervention during the behavioural observations. The most common rating was 2 – "I enjoyed the session" on the calendar-style grids. This was also reflected in the thematic analysis of the interviews. Parents suggested outcome measures were easy to use and referred to continued use of the intervention following the project
Demand	Gathering data on estimated use or by actually documenting the use of selected intervention activities	Calendar-style grid and interview	On average parents and children completed 61% of the 12 sessions and two-to-three songs each session. Thematic analysis suggested parents wanted to participate in a physical activity with their child and saw the value in the intervention
Implementation	The extent, likelihood, and manner in which an intervention can be fully implemented as planned and proposed	Calendar-style grid and interview	Parents were able to implement the *Just Dance* sessions into the home with ease following a single training session from a member of the research team. However, the quantity of songs each session was too large. This was reflected by the most common number of songs being two-to-three songs. Furthermore, differing family commitments meant that on average only 61% of the planned and proposed sessions were completed

Practicality	The extent to which an intervention can be delivered when resources, time, commitment, or some combination thereof are constrained in some way	Calendar-style grid and interview	Interviews and calendars suggested parents were flexible in their scheduling (i.e., completing the sessions when time and resources allowed); however, there were some weeks where family commitments constrained the planned bi-weekly intervention sessions. Importantly, the sessions did not cost the participants financially to implement into the home routine. Both benefits and challenges to the intervention and project were highlighted during the thematic analysis of the transcribed interviews
Adaptation	Changing program contents or procedures to be appropriate in a new situation	Mid-intervention check-in and interview	Parents became more flexible as the sessions progressed, allowing children to have more autonomy over their sessions. For example, choosing what platform their child completed the sessions on. Directions for future studies are provide to include minor adaptions to the protocol to improve feasibility
Integration	The level of system change needed to integrate a new program or process into an existing infrastructure or program	Calendar-style grid and interview	Parents did not report a great level of adaptation or change needed within their home environment to integrate *Just Dance.* Thematic analysis of the transcribed interviews suggested parents were willing to continue with the intervention after the project had finished
Expansion	Examines the potential success of an already-successful intervention with a different	Interview	Direction for further study are provided to expand on the finding of this research and later explore the use of *Just Dance* in a school setting following thematic analysis of the transcribed interviews

	population or in a different setting		
Limited efficacy testing	Testing an intervention in a limited way. Such tests may be conducted in a convenience sample, with intermediate rather than final outcomes, with shorter follow-up periods, or with limited statistical power	Emotional regulation and social skills questionnaire and behavioural observations	Outcome measures were capable of detecting changes that may have been attributed to participating in the intervention. Both outcome measures suggested an overall positive trend in children's social communication skills for the group with a small-to-medium effect size, though the statistical power was limited due to the small sample size.

4.11 Discussion

The present study aimed to assess the feasibility and limited-efficacy of a dance-based exergame in the home environment for enhancing autistic children's social communications skills. It was hypothesised that participating in frequent *Just Dance* sessions would have a positive impact for autistic children's social-communicative skills. The findings indicated a small-to-medium positive trend in children's ERSSQ scores and a large effect was observed in children's social interest scores from behavioural observations at home. On average children demonstrated a 4-point improvement on the ERSSQ outcome measure; however, a case-by-case approach afforded a deeper and more thorough investigation into each child's differing social skills. Furthermore, it was hypothesised that children would enjoy the intervention and that it would be easy to implement in the home environment. The results suggested that most children found the exergame enjoyable and were willing to participate in over half of the required sessions. Semi-structured interviews presented high quality and in-depth discussions regarding the feasibility of the current protocol from parental perspectives. Parental feedback revealed preparing children and allowing "choice" within the intervention was a crucial factor for children's motivation. Furthermore, the significance of movement and dance was highlighted by most parents during the semi-structured exit interviews. Suggestions were put forward to improve the protocol for future studies, including reducing the number of songs per session and slowing down the songs to make them easier for children to follow.

On balance, the results of this study suggest that *Just Dance* is a feasible intervention for parents and children to complete in the home environment. With minor adaptions to the protocol integration, implementation, and practicality of the intervention could be improved to further enhance its feasibility. Importantly, for a feasibility study, no adverse outcomes were reported from parents, children, or observed by the research team from participating

in the project. Furthermore, all children who started the intervention in week one continued to week six, indicating there were no ‘drop-outs’ from the intervention.

4.11.1 Social implications and future directions

The results from this study support the notion, observed in the exergaming systematic review of Chapter Three, that children enjoy dance-based exergames. For example, both Flynn and Colon (2016) and Collins et al. (2015) measured participant’s responses to participating in their exergaming interventions via questionnaires and reported that children enjoyed the exergaming interventions. Specifically, Flynn and Colon (2016) reported that children in their study had a high affinity for the *Just Dance* exergame and enjoyed participating in the intervention. In the current study the most common enjoyability rating was “2 – I enjoyed the session”, therefore strengthening the notion that many autistic children enjoy participating in exergames on the *Just Dance* platform. Furthermore, the ‘no drop-out’ rate paralleled similar rates that were observed in the first systematic review of this thesis, which investigated interventions involving mirroring and rhythm. Therefore, the present study corroborates with much of the available and existing literature surrounding these two topics; that 1) children enjoy dance-based exergames and 2) drop-out rates are low for mirroring- and rhythm-based interventions.

In the literature, increased interpersonal motor synchrony has commonly been associated with a rise in prosocial behaviours, empathy, and connection between social partners (Cirelli et al., 2014; McNaughton & Redcay, 2020; Rennung & Göritz, 2016). Likewise, mirroring and the attendance to rhythmical stimuli is suggested to have beneficial effects for autistic children’s social communication skills (Morris et al., 2021) During the present intervention, children attempted to mirror the avatars on screen during *Just Dance* and attended to rhythmical stimuli, as observed in the intervention-based observations.

Similarly, by participating in the intervention with their parents, most children were seen to be moving in motor synchrony with their parent for sustained periods of time - completing the same actions to an external rhythmical stimulus together. Overall, this combination of mirroring, increased interpersonal synchrony, and attendance to rhythmical stimuli may have contributed to the positive trend in children's social communication skills, which was reported through the use of a validated and standardised outcome measure and behavioural observations in a naturalistic setting. This somewhat contrasts with the results observed during Chung et al.'s (2015) study as they noted no substantial improvement in social behaviours between the autistic participant and their typically-developing sibling during their exergaming intervention in comparison to a sedentary videogame condition. However, this study design differed from the current study as it followed an A-B-A study design, rather than a repeated measures pre-test/post-test design that was employed during the present feasibility study. Therefore, it is difficult to determine whether any improvement in social skills was observed following Chung et al's (2015) exergaming intervention as social skills were only observed during the intervention itself. Nonetheless, following parental-exit interviews, Chung et al. (2015) reported that the parents of the sibling-dyads found the exergaming sessions a more positive social experience for their children than the sedentary gaming sessions, which most parents reported in the current study.

It appears *Just Dance* offers a feasible and low-cost home-based intervention that may support and enhance children's social communication skills. It appears to overcome many of the barriers, such as travel, unfamiliar environment, and financial costs, that are often associated with some of the more traditional styles of therapies. As a result, a larger RCT with great statistical power is warranted to further explore the findings of this study and confirm the true effectiveness of exergaming for enhancing autistic children's social

communication skills. However, before commencing an RCT, minor alterations to the protocol are put forward and explored to further enhance the feasibility of the present study.

Parents suggested that shorter sessions would be more beneficial for children when participating at home. Therefore, it is suggested that the number of songs per session be reduced to 3, rather than the current 5 for future studies. This will help to improve the implementation and practicality of the intervention. Similarly, parents stressed the importance of preparing children for the intervention; therefore, future studies should aim to design and implement a social story that introduces the intervention in a child-friendly manner, which may further enhance the acceptability of the intervention by autistic children. Although we created a social story to gain children's assent and briefly explained the intervention, a more detailed and thorough social story is warranted for future studies. In contrast, parents reported that they felt well-prepared for the intervention and appreciated the "build up" to participation, including the taster session, training webinar, and training manual. This supports the available literature that suggests parents acting as the interventionalist in research studies appreciate a hybrid approach to training (Wainer and Ingersoll, 2015). For example, being able to attend live training webinars, being able to rewatch recorded training sessions, and being able to refer to a training manual whenever necessary as employed in the current study. Alongside previous research, this study suggests that parental involvement or parent-mediated interventions can have successful outcomes for autistic children (Haine-Schlagel et al., 2020; Kasari et al., 2015; McConachie & Diggle, 2007). Therefore, to ensure parents are well informed and can conduct interventions with their children with maximal adherence, it is suggested that an emphasis is also placed on preparing parents for participation in future projects for best research practice.

Helping to manage expectations and create structure within the intervention was highlighted as an important factor for participating children. One parent found it beneficial

to pre-select songs with their child and input these into the calendar at the start of each week, ticking off the songs when completing the sessions. This not only helped to manage their child's expectations of the individual sessions, but also afforded them the opportunity to choose their own songs. As a result, it is suggested that a similar method is used for future studies, asking children and parents to choose the songs they would like to complete in each session at the start of the week – giving children something to work towards and taking ownership of their individual sessions. Similarly, to further heighten children's motivation, a financial incentive could be provided in a funded RCT (Mitchell et al., 2013).

Challenges to the current protocol; for example, children associating "home-time with down-time" and parents finding it difficult to implement a regular and structured routine due to various and ongoing family commitments, could be mitigated by conducting the intervention in a school-based environment. Therefore, demonstrating an expansion of the current intervention. The school environment is typically grounded in structure and routine, providing predictability and comfort for many autistic individuals (Groden et al., 2001). Therefore, the school environment may provide an optimal setting to employ the *Just Dance* intervention, alleviating some of the limitations of the present feasibility study. Furthermore, conducting a school-based research project may allow for greater access to more children to participate in the project, improving the statistic power and generalisability of the results, as is explored in the final study of this thesis.

4.11.2 Limitations

Despite the positive inferences that can be drawn from this feasibility study, it is not without its limitations. Firstly, the research was not capable of, and did not attempt to seek, the true effectiveness of the intervention. Rather, it endeavoured to establish the acceptability of the protocol, validity of outcome measures, and potential changes in

outcomes measures that may have been attributed to taking part in the intervention, which have all been confirmed. Although the mean ERSSQ-P scores and social interest scores increased at post-test for the group, this change did not reach statistical significance. Whilst the sample size of only four child-parent dyads afforded a rich and in-depth exploration regarding the feasibility of the research project, it meant that the present study did not have the statistical power to detect the plausibly sized effects in this study. Secondly, the exclusion of a control group limits the conclusions that can be drawn from the data regarding the potential effectiveness of the intervention. Changes observed in the data for both the ERSSQ-P scores and behavioural observations may be a result of children's maturation and unblinded parents providing the ratings for the ERSSQ-Ps. Nonetheless, it was important to first confirm the scheduling and utility outcome measures before recruiting a control group due to the nature of a feasibility study. In the future, placing emphasis on a control group and sufficiently powered sample sizes in future research could overcome these limitations.

Whilst the methods attempted to pragmatically capture the voices of autistic children in the study; for example, through the use of the calendar-style grid, observing children completing the intervention, and through the voices of their parents, the authentic voice of the child may be been neglected. Therefore, additional measures could be introduced in future studies to enhance understanding from the child's perspective. More recently, 'Autism Voices' was developed by a team of researchers as method to capture the first-person perspectives of autistic children and adolescents with various levels of language and functioning abilities (Courchesne et al., 2022). It aims to provide the lived experiences of autistic youth. Similar processes could be integrated into a future study at post-intervention to ensure the true voices of autistic participants is reported regarding the use of the dance-based exergame in the home environment and elevate the pragmatically captured voice of the child.

The play-based and *Just Dance*-based observational outcome measures relied on human observations to code the recordings into meaningful and usable data. Subsequently, biases and human error may have been introduced. In an attempt to mitigate these inherent challenges of qualitative data collection, two coders were assigned for each dataset, with at least one coder blind to the time-point of the recordings and the other coder's results. Nonetheless, behaviours such as look/gaze, eye contact, and facial expressions, were difficult to code and quantify consistently and movement in synchrony was somewhat subjective to the viewer. Software, such as OpenPose (Cao et al., 2021) is available that can quantify the duration two subjects move in synchrony during a videorecording and can be extended to code facial expressions using an addition known as OpenFace (Baltrusaitis et al., 2018). The use of software such as OpenPose and OpenFace could overcome some of the challenges associated with human observations. However, software such as this was not used in the current study due to the quality and variation in video recordings that were received. For example, one parent used a mirror and a stationary camera to record one of their *Just Dance* sessions, whilst another parent's recording was not stationary and gave different angles of the parent and child dancing throughout the recording. As a result, human observations were used to circumvent the different variables that made computerised-coding untenable.

4.12 Conclusion

In conclusion, the present study suggests that *Just Dance* is a fun and enjoyable exergame that can be implemented into the home environment with relative ease. Furthermore, *Just Dance* may positively influence autistic children's social communication skills through the successful inclusion of mirroring, attendance to rhythmical stimuli, and affording an opportunity for interpersonal motor synchrony due to moving at the same time as their parent. The study indicates that the protocol, with minor adjustments, is acceptable,

feasible, and has no known risks associated with it. Therefore, additional research is needed to ascertain the true effectiveness of participation in *Just Dance* for autistic children's social communication skills through adequate sample sizes and comparison groups. Nonetheless, the present feasibility study advocates that *Just Dance* is an engaging physical activity that children and parents can participate in together within their home environment, overcoming the limitations and challenges of many traditional styles of therapies and interventions. Future directions include shortening the length of sessions to two-to-three songs and exploring the use of *Just Dance* in the school environment.

Part C - Assessing the feasibility of a dance-based exergame for improving social communication skills in young autistic individuals in the school environment

4.13 Abstract

Autistic individuals often display social-communicative and emotional differences that can affect various aspects of daily living. Furthermore, autistic children are more likely to partake in sedentary activities than their neurotypical counterparts. Therefore, the present study assessed the feasibility and potential efficacy of a dance-based exergame for enhancing autistic children's social communication skills in the school environment. A mixed-methods, within-subject, pre-test, post-test study design was employed. Children in two school environments (n = 31; M_{age} = 10.87-years-old, SD = 1.61) participated in a structured dance-based exergaming intervention for six weeks, dancing to two songs on the *Just Dance* platform each day. Measures consisted of a pre-distributed calendar, the Emotion Regulation and Social Skills Questionnaire teacher version, and a semi-structured exit interview for staff members. The intervention positively influenced autistic children's social communication skills between pre-intervention and post-intervention ($P < 0.01$) and further results suggested that *Just Dance* was a fun and enjoyable exergame that was easily implemented into both special education provider settings. The present feasibility study advocates that *Just Dance* is an engaging physical activity that autistic children can participate in together at school. A larger randomised control trial is warranted to confirm the true effectiveness of the dance-based exergame for enhancing autistic children's social communication skills and implement adaptations to the protocol suggested by this study.

4.14 Introduction

4.14.1 School-based Interventions

Following on from the home-based feasibility study in Part B of Chapter Four, it was suggested that the intervention could be expanded into schools to overcome some of the limitations associated with the home-based approach. Schools are increasingly being employed as settings to conduct research evaluating the effects of interventions for autistic children's social communication skills. The school environment provides an optimal setting to conduct intervention-based research as it is underpinned by structure and routine, providing predictability and comfort for many autistic individuals (Groden et al., 2001). Several systematic reviews are available suggesting interventions conducted in school-based settings can be beneficial for autistic children and enhance their social communication proficiencies. For example, Sutton et al. (2019) reported that school-based interventions can increase the frequency and duration of initiating and responding social behaviours in young autistic children. Similarly, Garrote et al. (2017) found that school-based interventions, including group activities in the academic or social context facilitated and improved social participation of autistic children at school. Reflecting on the outcomes of the home-based feasibility study, parents suggested that implementing the intervention into schools may be beneficial for their autistic child as it limits the stresses at home, provides a more rigid structure to follow, and fulfils the association that home-time is for "down-time", which some autistic children expect.

However, research indicates that many school-based interventions require additional staff members or professionals to be present, extra resources or equipment to be provided, and supplementary spaces needed to deliver the interventions (Locke et al., 2015, 2017; Wilson & Landa, 2019). Furthermore, many previous social communication interventions were not embedded into the curriculum or activities based in the classroom, subsequently

causing timetabling disturbance meaning that many autistic children were often removed from the social environment of their classroom with other peers to participate in the intervention (Sutton et al., 2019). Therefore, developing person-centred interventions that enhance autistic children's social communication skills, whilst requiring limited additional resources, and still allowing for children (if they wish) to remain in the social environment of their classroom with their peers, should be of high importance in autism research.

4.14.2 Social exergaming

As previously noted within this thesis, exergames are exercise-inducing videogames that can span across a range of different sports and physical activity types. However, social exergaming (i.e., playing with numerous players) is perceived to not only encourage motor movements but to also provide a valuable platform for social exchanges between individuals playing each game (Marker & Staiano, 2015; Rüth & Kaspar, 2021). Exergaming has been observed, both in the home and school environment, to foster social motivation, game continuance, and self-efficacy (Marker & Staiano, 2015), while increasing prosocial behaviours and group cohesion between typical-developing pupils (Quintas et al., 2020; Rüth & Kaspar, 2020). Furthermore, social exergaming is proposed to induce numerous psychological effects at the motivational, emotional, and cognitive level in many clinical and non-clinical populations (see Fang et al., 2020; Joronen et al., 2017; Lima et al., 2020; Morris et al., 2022 for reviews). Therefore, the exploration of *Just Dance* in the school environment appears warranted.

4.14.3 Aims and Hypotheses

Guided by Bowen et al.'s (2009) criteria for feasibility studies, the present study aimed to explore the feasibility and potential effectiveness of implementing a dance-based

exergame into the school routine to enhance autistic children's social communication skills. It was expected that introducing relatively short, but frequent *Just Dance* sessions into the typical school routine across one academic half-term (6-weeks) would be manageable and feasible for teaching staff to implement, whilst being enjoyable for children to participate in with their peers. It is hypothesised that children participating in the exergaming intervention would show gains in their social communication skills as measured by a standardised assessment completed by staff members who work closely with each child.

4.15 Methods

4.15.1 Research design

The research project was conducted in two separate schools in different geographical locations, albeit both in the United Kingdom. The first school was based in Manchester and is a non-maintained special needs school providing education for pupils aged between 2- and 19-years-old. The second school was based in Essex and is a specialist school that caters for children and young people aged between 5- and 16-years-old, all of whom have moderate and complex learning difficulties.

Prior to commencing the study, an initial discussion was held between the research team and the school's project liaisons (LR; School One and IC; School Two) to consider how the intervention could most beneficially be delivered within each school. Reflecting on the outcomes of the home-based feasibility study, for example; children preferring to complete two-to-three songs each sessions, it was decided that children would only be required to participate in two songs per session, as more than two songs could potentially become overwhelming and/or inhibit engagement. During the discussion with the two school project liaisons at the start of the project, it was proposed that students in the school-based study would complete the intervention every day and that the intervention would run

for one half-term (6-weeks) at school. This helped to ensure structure and routine could be established and to manage children's expectations. As a result, 60 songs should be completed across the 6-weeks akin to the initial 60 songs proposed for the home-based study. Furthermore, it was decided that only staff members, rather than staff members and parents, would complete the outcome measures due to various arrangements and parental commitments at each school. Often, specific staff members work closely with particular children on a daily basis, providing 1:1 support at each school. Therefore, it was considered that staff alone would provide an appropriate insight into each child's social communication skills at school. Communications were then held with the data governance officers from the schools to ensure all ethical, safeguarding, and confidentially matters were observed and addressed correctly in the ethics application. Ethical approval for the study was granted by the Science and Health Ethics committee at the University of Essex prior to gaining parental consent for the participating children, alongside staff members' consent (Ethics ID: ETH2122-0085).

A mixed-methods, within-subject, repeated measures study design across two settings was then employed to assess the feasibility and potential effectiveness of a dance-based exergame for enhancing autistic children's social communication skills in the school environment. Each child participating in the project was assigned a member of staff at their school who worked closely with them throughout the duration of the project. Each staff member then completed the pre- and post-intervention outcome measure on behalf of their assigned pupil. Some staff completed multiple questionnaires due to regularly supporting more than one child. Quantitative measures were used to assess the potential effectiveness of the dance-based exergame within participants and adherence to the protocol. Additionally, qualitative measures were employed to give an overview of the feasibility of

the intervention and perceived level of enjoyment for participating children by their staff members, whilst complementing the quantitative data.

4.15.2 Participants

Seven autistic children were recruited from School One (Manchester), including six males and one female. 24 children were recruited from School Two (Essex), including 16 males and eight females. The mean age of the group was 10.87-years-old (n= 31, SD = 1.61). All children had a confirmed diagnosis of Autism Spectrum Disorder.

In each school setting, three staff members consented to participate in the project. All staff members (n=6) were female and educated to at least a level six qualification or above. Staff members were between 26- and 45-years-old. Staff experience ranged from less than a year to over five years working in their current setting.

4.15.3 Exergaming Intervention

The intervention comprised daily *Just Dance* sessions, completing two songs each day. During the initial discussion held with the project liaisons, it was suggested that staff members introduce the songs at the start of each school day; however, if pupils were not comfortable completing the sessions at the beginning of each day, staff members were granted flexibility in their scheduling of their sessions to best reflect their pupils' preferences. Staff projected the *Just Dance* videos onto the classroom boards and asked children to follow the avatars on screen and joined in with the children dancing. As a result, children were expected to complete 30 *Just Dance* sessions consisting of two songs each session throughout the six-week programme; therefore, completing 60 songs in total.

4.15.4 Measures

4.15.4.1 Semi-structured interview

Once the intervention had ceased, a short semi-structured exit interview was held with members of staff involved in the delivery of the intervention (n=3). A 30-minute meeting was organised via Zoom Videoconferencing at a time most convenient to the staff member. During the interview, staff members discussed the overall feasibility of the intervention from start to finish, including the pre-and post-intervention phases, and considered children's enjoyment. Questions focused on the planning phase, intervention, use of outcome measures, and suggestions for future projects (Table 4C. 1).

Table 4C. 1 Topics of semi-structured interview and leading questions asked to structure the interview with parents.

Topic	Leading Question Asked
Planning Phase	How did you find the planning phase?
Feasibility of Intervention	How did you find the intervention overall; i.e., the six week *Just Dance* programme?
Feasibility of Outcome Measures	How easy did you find it to complete all the outcome measures, including the teacher rating scale and calendar style grid?
Enjoyability and effectiveness via staff recall	Do you think children enjoyed participating in the project and did you notice any changes in their social communication skills?
How staff found the project overall and any improvements	How did you find the project from start to finish, and do you have any suggestions on how to improve the project?

4.15.4.2 Teacher rating scale – emotional regulation and social skills questionnaire

Parents of the home-based study suggested that completing the ERSSQ-P online was easy and straightforward. The Emotional Regulation and Social Skills Questionnaire Teacher version (ERSSQ-T; Beaumont & Sofronoff, 2008) was therefore used to provide a standardised measure of overall social performance in pupils. In contrast to the parent version, which has 27 items, the teacher version consists of 25 items in the format of a five-point Likert Scale (from 0; never to 4; always); excluding two questions that focus on behaviours shown in the home. Staff members who worked closely with each child were invited to complete the ERSSQ-T online via the Qualtrics platform one week pre-intervention and one week post-intervention.

The final section of the post-intervention ERSSQ-T also included two simple questions designed to gain an insight into children's individual responses to the intervention and whether they enjoyed the experience. The first question asked, "Do you believe the child you support enjoyed the *Just Dance* sessions" and was answered via a simple 'Yes/Unsure/No' tick box. The second question asked, "Please could you elaborate on your answer" and was answered via an unrestricted text box.

4.15.4.3 Adherence and enjoyability calendar

Similar, to the home-based study, staff members were issued with a pre-distributed calendar to complete at the end of each session to measure adherence to the intervention and children's perceived enjoyment. Staff members were asked to include the songs selected each session, the percentage of children who joined in with the session, and the group's overall enjoyment level as rated on a 3-point Likert scale (from; 0 – Children did not enjoy the session to 2 – Children did enjoy the session). Upon completing the intervention, staff were asked to return the calendar to the research team.

4.15.5 Data analysis

Transcripts from the semi-structured exit interviews were thematically analysed using the NVivo12 software (*NVivo*, 2018), following similar methods outlined in Braun and Clarke (2006) and in the home-based study. Similarly, an extension of Braun and Clarke's (2006) methodology for thematic analyses was necessary due to the small sample size of the interviewed staff members (n=3). Themes and subthemes were subsequently integrated to curate domain summaries, which aimed to provide and "capture the diversity of meaning in relation to the topics or area of focus", which had been identified by the research team. (p. 593; Braun & Clarke, 2019).

Responses to the ERSSQ-T were analysed on GraphPad Prism 9 (*GraphPad Software*, 2020). To establish whether the data was suitable for parametric testing, a Shapiro-Wilk test was applied to the pre- and post-intervention ERSSQ-T data sets. Once normality had been established, paired and parametric two-tailed t-tests were carried out on the datasets to assess whether the teacher rating scale was capable of detecting changes that might infer an enhancement in social communication skills from pre- to post-intervention. Confidence levels (Cl) were calculated around the mean difference and effect sizes (represented by Cohen's d (d)) were also determined by dividing by the pooled standard deviation (Lakens, 2013).

4.16 Results

4.16.1 Staff feedback via thematic analysis of the semi-structured interviews

Six key domain summary themes were generated during thematic analysis of the transcribed semi-structure exit interviews with staff members. A detailed summary of the outcomes with verbatim comments can be found in the Appendix VI. Staff were keen to highlight that the information provided was sufficient and the process was "streamlined"

and well organised. This gave rise to domain summary one. Staff also frequently reiterated the importance of creating structure and managing expectations within each session and during the 6-weeks of the intervention, giving rise to domain summary two. Staff frequently highlighted the "individual-ness" of their pupils; thus, generating the third domain summary. Domain summary four comprised of benefits and positives of the intervention and project. Whereas domain summary five highlighted challenges to the intervention and potential drawbacks of the project. Finally, domain summary six centred on adaptions to the protocol that teachers introduced during the project and suggestions for future studies to improve the success of the intervention and uptake.

Domain summary one: Appreciation of collaborative planning, organisation, and information provided throughout the project.

Domain summary one highlights the successful planning and organisation of the project. Staff indicated that sufficient information was provided throughout the intervention and that they felt well-informed of what was required to complete the project. Staff suggested that they felt "prepared to deliver the intervention" and key staff members were able to "train" other participating colleagues, such as assistants and support workers, to deliver the intervention in the school environment. Interviewed staff members also highlighted the responsiveness of the research team and valued their "quick responses" to resolve any issues or answer any questions. A key outcome of the successful planning and organisation was that staff members felt able to participate in the intervention with children and "support pupils to take part".

Domain summary two: Importance of creating structure and routine both within the sessions and throughout the intervention.

This domain summary centres on the importance of creating structure and routine as emphasised by the interviewed staff members. Staff were keen to ensure that the intervention could be "built" into the children's routine and felt that completing the intervention daily made this easier. Furthermore, this approach helped to manage children's anxieties as they began to "expect" the intervention day-to-day. Some staff members also used a visual timetable so that children knew when the intervention would be taking place each day.

Staff were also able to create structure within each session by using the songs and their differing tempos; for example, starting with a high-energy dance and song, then finishing with a steady-energy dance and song to signify the session was "drawing to a close". One school also utilised singing to complete the sessions, citing "it's finished, it's finished" as a class to bring the session to a close.

Domain summary three: Emphasising the individual-ness of each child within the classroom.

Domain summary three highlights the importance of recognising and attending to the "individual-ness" of the children participating in the intervention. Interviewed staff members were eager to emphasise that all pupils were different and would respond differently and participate in different ways to one another. For example, some pupils "danced with confidence at the front of the classroom", whilst other pupils danced near their support workers and other pupils simply "watched the other children dancing in the classroom". The exergaming intervention permitted this "individual participation". Furthermore, staff were keen to integrate the intervention into the children's school day at a time that was most beneficial for children; for example, using the intervention to help

"pick up the children" if there was a lull in energy or to "take a break in between maths" and re-energise.

Domain summary four: Benefits of participating in the intervention and positives of the project, including ease of implementation and flexibility.

Domain summary four was the largest summary containing many themes and subthemes that covered a vast array of comments made my staff members, which focused on the benefits of the intervention. These included its ease of implementation and flexibility, alongside providing a vehicle to "bring children together" and engage in "music and movement".

Staff suggested that adherence to the intervention was relatively easy to achieve and agreed that two songs was an appropriate length of time to maintain children's attention and enjoyment. However, one class occasionally split up the two songs, completing one in the morning and one song in the afternoon. Staff highlighted the flexibility of the exergaming intervention and being able to fit it into the children's schedules were key benefits of the intervention itself and the project. Similarly, the flexibility of being able to complete the intervention in different environments; for example, inside the classroom or outside the classroom, based on the child's preference further enabled staff to cater to different children's requirements. Furthermore, the variety of songs and dances available meant that pupils and teachers could be flexible and find the most appropriate and liked songs for each class, enhancing enjoyability and participation.

Staff emphasised positives of the intervention for children and stressed the "importance of physical activity" and movement for their pupils, alongside children "enjoying music" and using the intervention as an outlet to help "regulate" mood and emotions. Staff also suggested that they could see the "potential of *Just Dance* to support

learning" and "help with [children's] attention" during class. Additional positive outcomes that can be taken away from the project include staff continuing with the intervention following completion of the study, their willingness to "recommend the intervention to other schools and classes", and ease of completing the outcome measures. Furthermore, an encouraging subtheme generated in relation to the questionnaire was the school's desire to "increase awareness" of ASD in academic research. Specifically, the school wanted to highlight that often their pupils are "complex" and a 'one size fits all approach' is not appropriate with regards to the questionnaire used within this feasibility study, raising the issue is "there a better way of doing this" and reaffirming the need for person-centred research and outcome measures.

Domain summary five: Challenges to the intervention and drawbacks of the project.

Domain summary five encompasses challenges to the project, including negatives of the questionnaire and reliance of staff to integrate a new activity into the school day, whom were already "stretched". It also highlights drawbacks to the intervention, such as the songs being "too fast" or potentially overwhelming for some children. Although staff found the outcome measures easy to complete, one school highlighted that items on the questionnaire did not aways "relate to skills of the children" when taken at "face value". As a result, concerns were raised by a parent who questioned how the results would reflect or relate to their child. The school's liaison for the project (LR) ensured parents that the questionnaire was elected for use in the study due to it being curated for specific use within the autistic population and that the questions were to be answered on an individual basis for each child by staff members who worked closely with them. In the thematic analysis it was identified that a more "abstract view" of specific items on the questionnaire may help to mitigate this challenge.

Domain summary six: Adaptations to the protocol during delivery and suggestions for future studies.

The final domain summary focuses on adaptations to the protocol staff members implemented during the intervention to improve its application and uptake. It also includes suggestions made by staff members for future studies. One staff member introduced a "*Just Dance* Champion" to enhance children's motivation, whereby pupils engaging and participating with the intervention were able to choose the next song. This enabled many pupils to enjoy the "freedom of choosing different songs" and have "ownership" over the sessions. Staff members felt that they soon became "facilitators" of the sessions, allowing children to choose the songs they wanted to complete, essentially "leading the sessions" themselves. Another staff member found that "splitting" children up into distinct groups based on their needs and preferences during the sessions was beneficial, rather than keeping all children in the classroom at one time.

Suggestions for future studies included creating visual instructions to introduce the sessions and selecting staff members who had the greatest capacity to complete the outcome measures, specifically the ERSSQ-T. Another interviewed staff member proposed the idea of working with other groups of pupils, including "older pupils" and pupils with additional needs outside the realms of autism as they believed that the intervention could hold beneficial effects for different groups of pupils and adolescents.

4.16.2 Emotional regulation and social skill questionnaire responses

The group means for the pre-intervention and post-intervention ERSSQ-T scores are displayed in Figure 4C. 1. Results from the two-tailed, paired, and parametric t-test on the ERSSQ-T data revealed a statistically significant improvement in children's ERSSQ-T scores between pre- and post-intervention as recorded by their teachers (n = 31, t(29)=

3.052, p = 0.005, 95% CI [2.167, 5.433], Cohen's d = 0.200). On average children's scores improved by 4 points on the ERSSQ-T from pre-test to post-test.

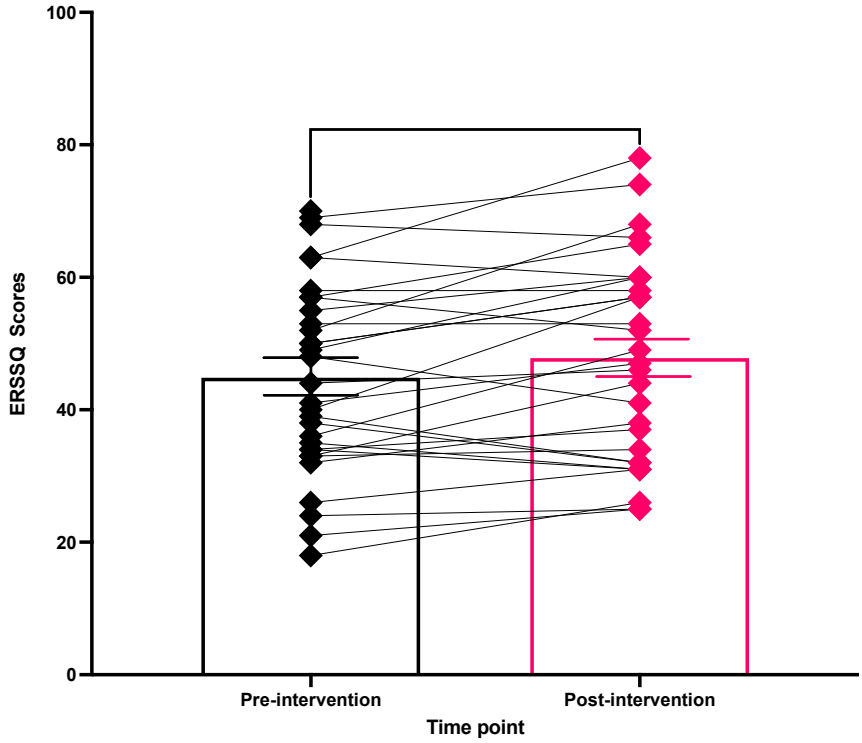

Figure 4C. 1 Mean (±SEM) bar chart overlaid by an individual stacked scatterplot of children's (n = 31) Emotional Regulation and Social Skills (ERSSQ) scores before and after six weeks of Just Dance sessions at school. A two-tailed, paired, and parametric t-test revealed a significant difference between pre- and post-intervention means for the group; P < 0.01 (**).

4.16.3 Adherence to the intervention and enjoyment

School One (Manchester) reported that they completed 100% of the sessions, playing two *Just Dance* videos each day. They reported varying levels of participation from the children, however, on average 71% of the children from School One participated in the sessions each day.

School Two (Essex) reported that they completed 90% of the sessions, playing two *Just Dance* videos each day. They reported varying levels of participation from the children,

however, on average more than 75% of the children from School Two participated in the sessions each day.

Overall, 20 children were reported to enjoy participating in the intervention, whereas 3 children were reported to not enjoy participating in the intervention, and 7 children showed varying levels of enjoyment during the intervention meaning staff were unsure on the extent to which they enjoyed the experience (see Figure 4C. 2).

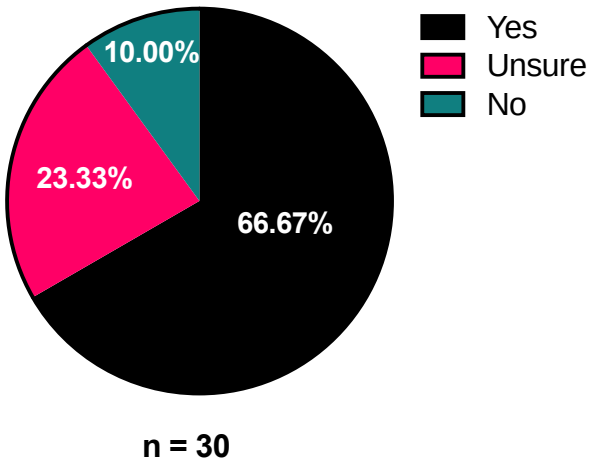

Figure 4C. 2 Parts-whole chart illustrating staff members observations of whether children (n=30; one missing response) enjoyed participating in the six-week intervention. Key shown to the side.

Staff feedback from the text box answers at the end of the post-intervention questionnaire reflected on children's experience of the sessions. Most reported that children "looked forward to the daily *Just Dance* sessions" and "enjoyed dancing". One child was said to be "up at the front and leading the class" and another child "loved dancing and participated very well - you could see how much he enjoyed copying the moves". However, staff reported that some children "did not join in at all" or were "shy" and "needed a little encouragement". For example, one staff member stated, "to begin with [one child] did not

want to participate but he soon gained in confidence and participated more towards the end of term". Additionally, one child, "participated by staying in the room but did not actively participate in the dances" and another child was reported to "stand and watch the other children, though he quite enjoyed watching the others and listening to the music". Some staff members reported that for certain children the sessions were "overstimulating" due to the music being played or "being in a group situation".

4.16.4 Overall feasibility

As addressed in the aims, the purpose of this study was to assess the feasibility of the intervention guided by Bowen et al. (2009) criteria for feasibility studies. Similar to the outputs of the home-based study, Table 4C. 2 provides an overview of Bowen et al.'s criteria and findings from the study. Overall, the results described above suggest that the intervention is acceptable, in demand, and was expanded into a school-based location, where it was implemented and integrated into the environment. Furthermore, the intervention was flexible and could be adapted to suit children's individual preferences. Limited efficacy testing suggested a statistically significant enhancement in children's social communication skills.

Table 4C. 2 Assessing the feasibility of the home-based intervention according to Bowen et al's (2009) criteria for feasibility studies.

Focus	**Bowen et al.'s (2009) definitions**	**Assessed**	**Comments**
Acceptability	How the intended individual recipients react to the intervention and outcome measures.	Post-intervention ERSSQ, calendar-style grid and interview	Over 66% of children responded positively to the intervention and this was also reflected in the thematic analysis of the interviews. Staff suggested that the sessions were acceptable and the outcome measures were easy to use and complete
Demand	Gathering data on estimated use or by actually documenting the use of selected intervention activities	Calendar-style grid and interview	Staff and pupils complete over 90% of the required sessions and found it useful to incorporate *Just Dance* into the school day as it provided activity breaks during lessons and/or help to wake up and regulate children at the start of the day. Thematic analysis suggested staff saw the value in the intervention for their pupils
Implementation	The extent, likelihood, and manner in which an intervention can be fully implemented as planned and proposed	Calendar-style grid and interview	Staff were able to implement the *Just Dance* sessions into the school environment with ease following a single training session between a member of the research team and the project liaisons from each school. Staff reflected that the number of songs was suitable and were able to commit to over 90% of the sessions across both locations.

Practicality	The extent to which an intervention can be delivered when resources, time, commitment, or some combination thereof are constrained in some way	Calendar-style grid and interview	Interviews suggested staff were flexible in their scheduling (i.e., completing the sessions when time and resources allowed). Though most completed the sessions in the morning. Importantly, the sessions did not cost the schools financially to implement into the school routine. Both benefit and challenges to the intervention and project were highlighted during the thematic analysis of the transcribed interviews
Adaptation	Changing program contents or procedures to be appropriate in a new situation	Calendar-style grid and interview	Staff became more flexible as the sessions progressed, implementing a *Just Dance* champion, allowing children to have more autonomy over their sessions. For example, choosing what songs they would like to complete each session. Directions for future studies are provided to include minor adaptions to the protocol to improve its feasibility
Integration	The level of system change needed to integrate a new program or process into an existing infrastructure or program	Calendar-style grid and interview	Staff did not report a great level of adaptation or change needed within the school to integrate *Just Dance* into the environment. Thematic analysis of the transcribed interviews suggested staff were willing to continue with the intervention after the project had finished and recommend it to other schools

Expansion	Examines the potential success of an already-successful intervention with a different population or in a different setting	Interview	Following thematic analysis of the transcribed interviews, directions for further study are provided to expand on the findings of this research and potentially explore the use of *Just Dance* with older autistic pupils
Limited efficacy testing	Testing an intervention in a limited way. Such tests may be conducted in a convenience sample, with intermediate rather than final outcomes, with shorter follow-up periods, or with limited statistical power	ERSSQ	Outcome measures were capable of detecting statistically significant changes that may have been attributed to participating in the intervention. The ERSSQ-T scores suggested an overall positive change in children's social communication skills for the group with a small-to-medium effect size

4.17 Discussion

The present study assessed the feasibility and initial effectiveness of introducing a dance-based exergame into the school environment for enhancing autistic children's social communications skills. We hypothesised that completing two songs via the *Just Dance* platform would be manageable and feasible for teaching staff to implement, whilst being enjoyable for children to participate in with their peers. We also hypothesised that children participating in the exergaming intervention would show gains in their social communication skills as measured by a standardised assessment completed by staff members who worked closely with each child. Following analysis of the qualitative data, results indicated that *Just Dance* is a feasible activity to incorporate into the school routine and can be adapted to suit children's individual routines and schedules. Additionally, the majority of children participating in the daily *Just Dance* sessions were perceived to enjoy the activity. Analysis of the ERSSQ-T data suggested children also showed a statistically significant improvement in their scores between pre-test and post-test ($P < 0.01$), with a small effect.

4.17.1 Social and educational implications

Preliminary findings suggest that participating in short, daily *Just Dance* sessions may potentially enhance autistic children's social communication skills in the school environment. The successful inclusion of mirroring and rhythm within the exergame may have contributed to these advances in perceived social communication skills and emotional regulation. Furthermore, *Just Dance* provided a vehicle for children to engage in a physical activity together with their peers. Despite a small minority of children preferring to complete the sessions in smaller groups or 1:1 with their support workers, most children remained in the classroom and participated in the sessions together. This facilitated an opportunity for

communication, social interaction, and interpersonal synchrony between peers. The results from this study echo the results observed in Pope et al.'s (2019) study, which reported that that exergames, mostly '*Just Dance 4*', were able to promote physical activity levels, on-task behaviours, and communication in autistic children in the school environment. However, Pope et al. (2019) only completed intervention-based observations and did not compare communication skills pre- and post-intervention. Therefore, the current work breaks new ground in the field of exergaming interventions for enhancing autistic children's social communication skills in the school environment.

Within the ASD literature, imitation skills are consistently linked with social capabilities, and research indicates improving imitations skills also advances social development (Dadgar et al., 2017; Ingersoll, 2008). During the sessions, children mirrored and copied the avatars on screen to perform the choregraphed actions, consequently *Just Dance* provided a vehicle to practice imitation. Furthermore, previous research indicates that autistic children are more likely to mirror and imitate others and objects when provided with a non-social reward; for example, the sensory feedback via lights and music from the *Just Dance* exergame (Ingersoll et al., 2003). Akin to previous research suggesting imitation enhances social development (Cardon & Wilcox, 2011; Field, 2017; Ingersoll, 2012; Wainer & Ingersoll, 2015), practicing imitation by mirroring the avatar on screen may have led to improved ERSSQ-T scores at post-test for participating children. Likewise, social exergaming has been observed to induce numerous psychological effects at the motivational, emotional, and cognitive level (Fang et al., 2020; Joronen et al., 2017; Lima et al., 2020). For example, social exergaming (either playing with others or against others) has been observed to reduce perceived exertion, foster motivation, promote prosocial behaviours, and increase affective outcomes in children and adolescents (Lisón et al., 2015; Marker & Staiano, 2015). Similarly, typically-developing children used a dance-based

exergame in a school environment and reported not only game enjoyment across a four-week intervention, but also considerable group cohesion in terms of social attraction to group members (Rüth and Kaspar, 2020). Therefore, the social environment of the classroom and participating in the exergame with peers in the current study may have promoted the encouraging results observed and the results echo the positive results of social exergaming observed in the literature.

Throughout the literature, it is well observed that physical activity is beneficial for cognitive functioning, with single sessions or long-term participation in physical activity improving cognitive performance and brain health (see Kohl et al., 2013 for review). Furthermore, partaking in exergames, such as Makoto arena and Kinect Tennis, has been reported to advance executive functioning and working memory in autistic individuals as highlighted in the previous systematic review (Hilton et al., 2014; Rafiei Milajerdi et al., 2020). Several studies have also highlighted that physical activity, including participation in exergames, reduces inattention and increases on-task behaviour in school-aged typically-developing children, with academic achievement also improving (Booth et al., 2014; Gao, 2013; Ruhland & Lange, 2021). Although not directly assessed in the present study, thematic analysis of the semi-structured exit interviews suggested that participation in daily *Just Dance* sessions "supported learning" and provided "breaks" to regain children's attention during tasks such as mathematics. Relevant literature supports the notion that mathematics and reading are among the academic topics that are most commonly influenced by physical activity as the subjects depend on efficient and effective executive functioning (Kohl et al., 2013). Furthermore, providing physical activity breaks within the classroom improves on task behaviour, thus helping to facilitate learning (Broad et al., 2021; Mahar et al., 2006; Ruhland & Lange, 2021). Therefore, participation in brief but daily *Just Dance* sessions may provide a vehicle to enhance executive functioning, increase on task

behaviours, and aid learning, whilst facilitating children's social communication skills in the school environment. Enriching academic achievement from a young age and creating opportunities to thrive in a learning environment is often associated with better career prospects and overall greater life satisfaction (Powdthavee et al., 2015). Consequently, the results from this feasibility study may have important social and educational implications if explored further.

4.17.2 Limitations

Despite the many encouraging outcomes that can be observed from this small-scale feasibility study, including the delivery of the intervention in two separate specialist education provider locations and the positive reception of the intervention by the staff and pupils, the present study is not without its limitations. The absence of a control group only permitted limited-efficacy testing and subsequently restricts the generalisability of the results observed and their clinical significance.

Data regarding children's social communication skills was based solely on the information collected via the ERSSQ-T. As a result, only one measure of children's social communication was gained. The decision to only issue the ERSSQ-T teacher version in the schools followed collaborative discussions during the planning phase of the project, where project liaisons suggested that due to the varying circumstances of children attending the schools it would be more appropriate to seek this information solely from a staff member who worked closely with each child. Nonetheless, Butterworth et al. (2014) recommend using a variety of measures, including both teacher and parent measures, to obtain a comprehensive assessment of children's social communication skills and understand the true effect of an intervention. Furthermore, including observational outcome measures, such as observing and coding children's social skills during play, would help to enhance the validity and generalisability of the findings.

4.17.3 Future directions

The limitations of the present study may be addressed and overcome through further research. For example, a RCT with sufficiently powered sample sizes would help to establish the true effectiveness of the dance-based exergame for enhancing autistic children's social communication skills using a variety of outcome measures. Our limited-efficacy testing within the present study established a statistically significant small-to-medium effect of the intervention on children's social communications skills in a modest sample size ($n = 31$) with an $\alpha = 0.05$ and strong power of 95%. Similar to the power analysis conducted by Rafiei Milajerdi et al. (2020), at least 128 participants would be needed (with 64 children in each group) to detect a medium effect size between an intervention group and a control group with an 80% power and an $\alpha = 0.05$. Alternatively, with greater power, such as the one used in the present study (95%), over 200 participants would be needed and greater time for recruitment would be necessary. Enlisting multiple education providers would support recruitment and ensure adequate sample sizes are met.

Continuing with further research from this feasibility study, a future RCT should strive to incorporate the adaptions and improvements highlighted by staff members during the semi-structured exit interviews to increase implementation and acceptance of the intervention. For example, it should be recommended that staff participating in the intervention include the use of a '*Just Dance* Champion' to bolster motivation and enhance children's participation. Furthermore, providing children the opportunity to select the songs they would like to dance to and take ownership of their sessions is likely to increase children's involvement and create a more person-centred and tailored intervention. Similarly, ensuring staff are flexible and able to incorporate the intervention into the children's routine, whilst guaranteeing the intervention takes place daily will help create an

expectation for children and manage anxieties. Additionally, staff suggested the use of visual instructions and a visual timetable to support structure and routine. It should also be emphasised that the environment in which the sessions are completed can be adapted to meet the participating children's needs. For example, some pupils may be supported to complete the intervention in the classroom, whilst other pupils may find this more challenging and require completing the sessions on a 1:1 basis with their support worker. Similarly, the lights in the environment may need to be dimmed and the volume of *Just Dance* reduced to prevent overstimulation for some children.

Whilst the focus of the present study was the use of *Just Dance* as a vehicle to enhance autistic children's communication skills, staff members suggested that the intervention may also be beneficial to older children and adolescents, such as post-16 year olds within their schools. Often, early intervention is thought to be most beneficial to support the development of social communication skills with research suggesting those who enter social skills interventions at younger ages make greater gains than those who enter programs when older (Corsello, 2005). Therefore, many studies investigating social skill interventions focus on the younger autistic population for early intervention (Zwaigenbaum et al., 2015). Despite adolescence being a historically understudied age range in the ASD literature (Reichow & Volkmar 2009), researchers are beginning to understand the importance of social skill interventions at this pivotal developmental stage and recognising that continued intervention efforts are still needed as autistic individuals navigate these key development years. As a result, exploring the effectiveness of *Just Dance* to support the social communication skills of autistic adolescents provides an interesting avenue for future research. Furthermore, autistic adolescents are statistically more likely to be overweight than their TD peers and less likely to engage in regular physical activity (Curtin et al., 2010; McCoy et al., 2016). Autism severity is also observed to predict higher body mass and

decreased odds of participating in physical activity, sport, and clubs (McCoy et al., 2016). Therefore, autistic adolescents are in need of targeted programs that increase physical activity levels and encourage participation with peers. *Just Dance* may offer an ideal platform for this, whilst also potentially enhancing social communication skills. The inclusion of autistic adolescents in an RCT would also strengthen the sample size and provide evidence for the longevity of the dance-based exergame across a wider age range.

4.18 Conclusion

The present study indicates that *Just Dance* can be integrated into the school routine and can be tailored to children's individual needs. The intervention was well accepted by most children in the classrooms and preliminary analysis of the ERSSQ data suggests a positive and significant trend in children's social communication skills from pre-test to post-test. On average children's ERSSQ-T scores improved by four points between pre-test and post-test. Therefore, with minor adaptions, which were highlighted during the thematic analysis of the transcribed semi-structured interview, the current protocol could be extended into a RCT to confirm the true effect of participating in *Just Dance* sessions in the school environment for autistic children's social communication skills. The use of the exergame could have important social and educational implications for autistic pupils and subsequently warrants further study with sufficiently powered sample sizes and control groups.

5 Chapter Five: General discussion and conclusion

5.1 Introduction

In this concluding chapter, the aims and hypotheses are restated and considered. Furthermore, the specific research questions and the overall aim of the thesis are addressed in relation to the findings. The strengths, limitations, and future directions of the research are acknowledged, before discussing the implications for practice and wider recommendations for future research.

The overall aim of this thesis was to '*investigate the use of a dance-based exergame in the home and school environments as a vehicle to enhance autistic children's social communication skills*.' This goal was addressed by tailoring the research to answer a series of specific research aims. The first objective was to collect, synthesise, and narratively review the literature of interdisciplinary fields, including psychology, sports psychology, neuroscience, and dance movement therapy. This afforded a comprehensive understanding of communication and coordinated movement in the ASD literature; outlining what is meant by communication challenges, exploring the benefits of coordinated movement for autistic traits, and delineating how coordinated movement may elicit positive outcomes for autistic children. Therefore, providing a sound introduction to the thesis. The second aim was to understand how beneficial the techniques of mirroring and rhythm were for autistic children's communication skills when used outside the realms of DMT. This was achieved by systematically reviewing the relevant literature and helped to provide an evidence base for the use and inclusion of mirroring and rhythm in the final studies. Following on from the systematic review, the third research aim investigated the most commonly used and beneficial elements of rhythm and timing for autistic children, responding to a gap in the scientific literature. This ensured that the most favourable elements of rhythm and timing were recommended for use in the final studies. The fourth goal investigated the beneficial use of exergames (virtual exercise games) for autistic children by employing a systematic

review of the literature. This work highlighted that not enough was known about the beneficial use of exergames for autistic children's social communication skills, subsequently giving rise to the final objective of the thesis. To this end, the final aim was to assess the feasibility and potential effectiveness of a dance-based exergame for enhancing autistic children's social communication skills in multiple environments; both in the home and school.

5.2 Overview of the findings

The first systematic review conducted within this body of work, is the first and only synthesis of the available literature (to our knowledge), to explore the techniques of mirroring and rhythm outside the scope of DMT for autistic children's social communication skills. The results from the systematic review suggested the therapeutic potential of mirroring and rhythm for enhancing autistic children's social communication skills and highlighted a small evidence base for the use of mirroring and rhythm in non-DMT interventions. A subsequent finding of the systematic review was that drop-out rates of mirroring- and rhythm-based interventions were low, somewhat contrasting with the existing literature that suggests drop-out rates are typically high in the autistic population for various interventions (Magán-Maganto et al., 2017; Parracho et al., 2010). The first systematic review of the thesis also spotlighted a gap in the literature regarding the most common type of rhythm and music used when working with autistic children, thus providing a direction for further research. Through systematically reviewing the available literature centred on mirroring- and rhythm-based interventions for autistic children's social communication skills, a wide variety of outcome measures were observed to be employed. It became apparent that observational data and standardised questions were most commonly used to index children's social communication skills. On reflection, it appeared most studies

either used only observational data or a standardised questionnaire. Yet, it is becoming increasingly recognised that a combination of both quantitative and qualitative data in a mixed-methods approach provides a richer insight into autistic children's social communication skills rather than a single entity (Alcover et al., 2019; Regnault et al., 2018; Zhao & Chen, 2018).

The second systematic review completed within the scope of this thesis focused on the potential beneficial effects of participating in exergames for autistic children. The systematic review revealed varying impacts of exergaming for autistic children's cognitive functions (more specifically executive functioning) and motor capabilities. Most studies found that exergaming, including Makoto Arena and XBOX Kinect positively influenced children's cognitive and motor skills. However, the effect of exergaming on autistic children's social communication skills was under-reported, with only two studies out of the included ten reporting on this, and the available results proved inconclusive. Importantly, the systematic review highlighted that no studies reported any adverse outcomes for children participating in the considered exergames. Furthermore, many children enjoyed the interventions, particularly the dance-based exergames. This systematic review provided a platform for the final feasibility studies, aiming to further explore the feasibility and potential effect of a dance-based exergame in two environments for autistic children's social communication skills and contribute to the paucity of scientific literature on this topic.

Although the first systematic review (Part A of Chapter Three) suggested mirroring techniques and attending to rhythmical stimuli were beneficial for autistic children's social communication skills, it was unclear what type of rhythm was most commonly used when working with the young autistic population. Therefore, the first investigational study of this thesis aimed to address this gap in the literature. In Part A of Chapter Four, registered dance movement therapists (n = 113), who had experience of working with autistic children, were

surveyed to address the research question '*What are the most common features of music and rhythm used by registered dance movement therapists for autistic children?'*. A mixed-methods survey approach was adopted to explore the quantitative measures, such as the most common type of time signature of music used, alongside the qualitative measures, such as why this is the most common time signature were employed. Quantitative results highlighted that most dance movement therapists used music that had a 4/4 time signature (64%), moderato tempo (45%), and included a range of lyrics (76%). Qualitative analysis suggested that rhythm was an important feature to attend to as it could be used as a unifying feature, helped to offer structure and organisation, was grounding for children, facilitated body awareness, and finally, aided social skills. Furthermore, the predictability of the 4/4 time signature, the energy evoked from moderato tempo, and the familiarity of pop lyrics were all contributing features to the common use of these elements of rhythm and timing for autistic children. For the first time in the literature, exploratory and preliminary evidence suggested that these common features of rhythm could be more confidently used in interventions for autistic children targeting their communication skills and social development. Therefore, it was recommended that songs with a 4/4 time signature, a moderato tempo, and age-appropriate lyrics were integrated into the final feasibility studies.

The aforementioned reviews and study tunnelled the research, providing a clear direction and need to explore the feasibility and initial effectiveness of a dance-based exergame that included mirroring and rhythm for autistic children's social communication skills in multiple locations. Due to the turbulent nature of the last few years amid the coronavirus pandemic and the challenges of traditional interventions, it felt important to explore the use of exergaming first in the home environment before expanding into the school environment (Lee & Meadan, 2020). Furthermore, a feasibility study was deemed the most appropriate place to start due to the questionable evidence-base, the need to form

community partnerships, and the first time using a mixed methodology to explore the benefits of a dance-based exergame for enhancing autistic children's social communication skills in multiple locations (Bowen et al., 2009).

The final project proposal consulted an expert panel with lived experiences of autism, including autistic individuals, parents of autistic children, special education teachers, and academics from outside the research team, to provide a fresh and informed perspective. Again, a mixed methodology was used because a single type of data would not have been sufficient for addressing the studies' aim (Creswell & Clark, 2017). Both qualitative and quantitative data were collected and synthesised for different purposes. Within the home-based study, qualitative data was used to better understand the appropriateness and feasibility of the recruitment process, training, and evaluation methods, as well as the adherence and reactions to the *Just Dance* programme from the perspectives of the parents (n = 4) and children (n = 4). Additionally, the qualitative information, specifically the play-based observational data, was used to understand if *Just Dance* had any observable effects on children's social skills during play with their parent. This helped to inform limited-efficacy testing. The quantitative data (ERSSQ-P) was used to supplement this information, providing a standardised measure of children's social skills. Findings suggested that most children participating in bi-weekly *Just Dance* sessions at home with their parents demonstrated a positive change in their social communication skills, as measured by a standardised questionnaire and behavioural observations. Furthermore, children appeared to enjoy the sessions across the 6-weeks and either maintained or improved their interpersonal motor synchrony with their parents using *Just Dance* as a vehicle to facilitate this. The study highlighted the importance of offering children choice and flexibility within their interventions, affording a person-centred approach. In sum, the mixed-methods feasibility study, contributed to this small, yet important, field of research

and provided an impetus to further explore and confirm the true effectiveness of *Just Dance* for autistic children's social communication skills.

As it was important to ensure the intervention could also be completed across multiple locations, the feasibility study was extended into two special education centres. Children (n=31) and consenting staff (n=6) were expected to complete daily *Just Dance* sessions during the school day. Akin to the home-based study, staff completed a series of measures including the ERSSQ-T, the calendar style grid, and a semi-structured exit interview. Results indicated that *Just Dance* was a feasible activity to incorporate into the school routine and could be adapted to suit children's routines and schedules. Furthermore, *Just Dance* provided a vehicle for children to engage in physical activity together with their peers at school, facilitating an opportunity for communication and social interaction between peers. Similarly, participating in the exergame encouraged interpersonal synchrony between pupils due to completing similar movements at the same time. As noted within the study, increased interpersonal motor synchrony and improved imitation skills have been associated with an increase in prosocial behaviours, empathy, a connection between social partners, and social development (Cardon & Wilcox, 2011; Cirelli et al., 2014; Field, 2017; Ingersoll, 2012; McNaughton & Redcay, 2020; Rennung & Göritz, 2016; Wainer & Ingersoll, 2015). Therefore, the unconscious practicing of interpersonal motor synchrony between peers and teachers in the classrooms may have contributed to the significant positive change in the group's social, emotional, and communication skills as reported by the teachers.

In addition to the core social traits associated with autism, it was recognised within this thesis that autistic individuals often have sensory, executive functioning, and/or motor differences that may further affect their emotional regulation, social engagement, and development of social competency (Bhat et al., 2011; MacDonald et al., 2013; Marsh et al.,

2009; Robledo et al., 2012). For example, motor challenges include atypical coordination, fine and gross motor difficulties, and postural differences (Bhat et al., 2011; Dziuk et al., 2007; Gargot et al., 2022; Marsh et al., 2009). These motor challenges may restrict an autistic individual's ability to initiate or maintain joint attention and achieve interpersonal synchrony, which are often essential features of effective social communication; coordinating actions in time with a social partner (Bhat et al., 2011; Dadgar et al., 2017; Fulceri et al., 2018; Pusponegoro et al., 2016; Robledo et al., 2012). Therefore, supporting and enhancing motor proficiencies may lessen the cognitive demand needed for social interactions for autistic individuals, enhancing their perceived social skills (Huang et al., 2020; MacDonald et al., 2013; Mastrominico et al., 2018; Najafabadi et al., 2018).

The embodiment theory may provide an overall plausible explanation for how bodily movements enhance social functioning. This theoretical framework proposes that cognition, including social cognition, and emotion are grounded in bodily states, suggesting a relationship between actions and social-emotional cognition (Barsalou, 1999; Eigsti, 2013; Niedenthal et al., 2005). The embodiment theory argues that the mind is rooted in the whole body and that interactions between the body, the environment, and those in the environment drive the formation of perception, knowledge, and emotion (Huggins et al., 2019). Ultimately, we learn through action and moving our body. There are number of research findings that are consistent with embodied learning. For example, when individuals hear descriptions of tall buildings, such as sky scrapers, they tend to make vertical eye movements (Spivey, 2000). Likewise, individuals are more likely to agree with a statement when nodding their head than when shaking their head (Wells & Petty, 1980) and those receiving botulinum toxin injections, which restricts facial movements, are more likely to report reduced emotional intensity post-treatment (Davis et al., 2010). In social exchanges, communicative partners may also embody one another, synchronising their movements,

mirroring facial expressions, and matching their rates of speech. This co-ordination with another social actor can influence rapport, feelings of connection, and social competence (Romero et al., 2018). However, it is noted in mismatched dyads, for example a social exchange including a neurodivergent individual and a neurotypical individual, that this social coordination is reduced and, subsequently, difficulties arise regarding the translation of information and understanding of one another (double empathy problem; Crompton et al., 2020; Milton, 2012; Morrison et al., 2020). Some researchers have argued that challenges observed in autism, including social communication, creative imagery, imitation, and motor difficulties may arise from difficulties with embodied processing (Eigsti, 2013; Loveland, 1991; Pérez-Fuster et al., 2019). As a result, body-based or movement-based interventions, such as participating in frequent *Just Dance* sessions may foster embodied experiences and positively influence social cognition and social skills, whilst reducing double empathy problem. For example, the practicing of interpersonal synchrony, mirroring, and attending to rhythmical stimuli via the *Just Game* may encourage embodied learning for use in social exchanges and support children to be more aware and responsive to the rhythms of others during social interactions, thus increasing rapport and social competence during exchanges with neurotypical and neurodivergent individuals. Analysis of the ERSSQ data suggested children showed an improvement in their scores between pre-test and post-test (significant in school-based study; $P < 0.01$) as rated by their parent or teacher following the physical and body-movement activity. As a result, these dual feasibility studies break new ground by suggesting that *Just Dance* can easily be incorporated into the home and school environment to support communication skills with no reported adverse effects and may rely on processes including the embodiment theory.

Overall, the research conducted within the scope of this thesis suggests that participating in short and frequent *Just Dance* sessions may positively influence autistic

children's social communication skills adding to the limited literature surrounding this topic. Moreover, it provides suggestive evidence that children enjoy participating in the dance-based exergame, both in the home and school environment. Notably, the feasibility studies indicated that no adverse outcomes resulted from participation in the exergame, similar to the outcomes observed in the second systematic review and that the scheduling of the intervention was acceptable. Furthermore, ensuring structure, choice, and flexibility were observed to be key aspects of the intervention that encouraged children's motivation. As a result, further research is required to investigate the true effectiveness of *Just Dance* for enhancing autistic children's social communications using a similar mixed methodology as outlined in the dual-environment feasibility studies, albeit with statistically powered sample sizes and the presence of a control group.

5.3 Strengths of the thesis/research

One of the major strengths of this thesis is the neurodiversity and affirmatory stance it takes and the inclusion of participatory research. Throughout the body of work presented here, it was ensured that neurotypical social functions should not be imparted or enforced onto autistic individuals, rather the work aspired to enhance social abilities already upheld by each autistic individual and increase feelings of responsiveness and connection between social partners. At no point did the final intervention aim to 'normalise' autistic children or require them to 'mask' their autistic traits (Leadbitter et al., 2021). Rather, the intervention aimed to foster an enjoyable experience for children to engage in mirroring, practice interpersonal motor synchrony, and attend to external rhythmic stimuli to support social development and enhance communication skills already upheld by the individual. Furthermore, teachers perceived the final intervention supported both physical (providing an outlet for energy), and emotional regulation. Finally, it is well-noted in the literature that

autistic children enjoy music, movement, and computer-based technology (Johnston et al., 2018; Martin, 2014; Molnar-Szakacs & Heaton, 2012; Reinders et al., 2019). This was corroborated throughout the two feasibility studies. Therefore, the research appears to incorporate and enhance factors that bring happiness and joy to the individual – a key feature of neurodiversity-informed interventions (Leadbitter et al., 2021).

Pivotal to the neurodiversity movement is ensuring the opinions and values of the autistic and wider autism communities are well regarded throughout any research. Supporting the advancement of interventions that target communication skills was highlighted as one of the autistic population's top research priorities (Autistica, 2016). Similarly, increasing access to physical activities has also been noted as a priority. Therefore, the overall ambition of the thesis - to support autistic individual's (specifically children's) social development through physical movement, sought to address these aforementioned autistic-prioritised outcomes. Furthermore, prior to submitting the ethics application for the intervention, a consultation was held with members of the autistic and the wider autism community to understand their views and opinions on the proposed research and invite suggestions and improvements from the expert-by-experience panel. All comments and thoughts put forward by the consultation panel were taken on board and implemented into the project proposal, which was subsequently approved by the ethics board. As a result, the final feasibility study methodology and intervention were co-produced through collaboration with the autism community.

An additional strength of the thesis is the mixed-methods approach that it adopted. The quantitative measures permitted the recognition of the common elements of rhythm and timing used by practicing dance movement therapists, the change between children's pre- and post-intervention social communication skills, and children's adherence to the intervention. Meanwhile, the collected qualitative data afforded an exploration of the

perceptions of dance movement therapists, parents, and teachers to understand and provide richer insights into the quantitative data, especially around the feasibility of the intervention and acceptability of the recruitment and training phases. Further, the observational data provided an additional measure of children's social skills pre- and post-intervention and enjoyment during the intervention, which was not subject to parental retest bias in the home-based feasibility study, complimenting the quantitative data. This mixture of methods (quantitative and qualitative) afforded triangulation of the data and a greater comprehensive understanding of the feasibility of the intervention than what would have been achieved if only one methodology had been employed (Bryman, 2006)

A final major strength of the current thesis is the positive message it offers and the contribution it makes to the small, but exciting body of research surrounding the use of movement as a vehicle to enhance autistic children's social development. The series of chapters presented suggests that many autistic children enjoy moving and have a love for music and dance, corroborating much of the existing literature (Amos, 2013; Molnar-Szakacs & Heaton, 2012; Reinders et al., 2019; Simpson & Keen, 2011). Furthermore, the successful inclusion of mirroring and rhythm during an accessible video game-based exercise activity may positively influence children's social communication skills in a naturalistic and enjoyable manner. Whilst the message presented here needs to be mindful of the research limitations, the dance-based exergaming activity affords the practice of imitation, attendance to external rhythmic, and facilitating interpersonal motor synchrony, which are all skills attributed to social development. Furthermore, video gaming activities are often intrinsically motivating for the autistic population – drawing on many autistic children's interests and providing an activity that mostly brings happiness and enjoyment (Finke et al., 2015; Finke et al., 2018). Additionally, four research articles have been published from this thesis and subsequently cited within the academic field, suggesting it is

already contributing to the scientific literature base and informing prospective research. Similarly, due its explorative and theory-building nature, much of the work presented here provides scope for future research to build upon.

5.4 Limitations of the studies and directions for further research

Whilst the work presented here successfully attempts to gain a better understanding regarding the feasibility of a dance-based exergame in the home and school environments for enhancing autistic children's social communication skills, it is not without its limitations. These limitations should be recognised and further addressed. The first limitation refers to the initial empirical study of the thesis – the survey of dance movement therapists to explore the most common features of music and rhythm used when working with autistic children. Although the use of a survey allows access to a wide range of dance movement therapists from geographically dispersed locations across the world, it restricts the quality of data that may be collected. It is well noted in the realms of qualitative research that the outputs of verbal interviews contain more quality-rich data than written responses from questionnaires (Seale, 2012). Furthermore, it is observed that interviews often gain a higher response rate in comparison to questionnaires (Bowling, 2005). To overcome this limitation and expand on the 'theory-building' stance assumed during this study, future research may wish to conduct telephonic or videoconferencing interviews with dance movement therapists to further explore the outputs of this study. Prospective research may also wish to confirm the outputs of this study and ensure that music of a 4/4 time signature, moderato tempo, and age-appropriate pop lyrics is the most preferential style of rhythm and music for the autistic community by also conducting interviews with said individuals. Ensuring interviews can be completed via phone or videoconferencing software will still afford access to a wide range of geographically dispersed participants.

Overarching and recognisable limitations of the home and school-based studies include the limited sample sizes and absence of control groups. Recruitment ran for approximately two months for the home-based study and gave access to only four consenting families who completed the project. It was not feasible to implement a control group as the small sample size would not generate meaningful results from which to draw comparisons. Whilst the four families offered a great insight into the feasibility of implementing *Just Dance* into the home environment, limited conclusions can be drawn regarding the effectiveness of the dance-based exergame for enhancing autistic children's social communication skills. Similarly, the generalisability of the observed results is restricted by the small sample size and subsequent lack of diversity. All parents involved in the home-based study were married, inferring additional support or help in the household compared to a single parent living alone. Some research indicates a higher prevalence of autistic children in single-parent households (Delobel-Ayoub et al., 2015); however, other work challenges this association (Freedman et al., 2012; Montes & Halterman, 2007). Nonetheless, it is important to ensure that the proposed intervention is feasible and accessible for all families to ensure inclusivity. Future research should strive to recruit and include a wide variety of families, including single parents, to ensure the generalisability of the intervention. As previously discussed, financial incentives may bolster recruitment (Keller et al., 2020; Treweek et al., 2018). Furthermore, longer recruitment times and rolling recruitment (i.e., starting the project as soon as consent is given) may allow access to more families and increase retention from sign-up to participation.

A final limitation of the research presented here is the single measure of autistic children's social communication skills recorded within the school environment at pre- and post-intervention. Whilst the home-based feasibility study incorporated behavioural observations into its methodology, it was not feasible to introduce this into the school-based

feasibility work due to ethical concerns raised by the schools' project liaisons during the planning phase. As a result, only one measure of children's social communication skills was gained through the ERSSQ-T. It was highlighted during the semi-structured exit interviews with staff members that completion of the ERSSQ-T may have required a more "abstract view" to make it more appropriate for pupils in the school. Although the results from the home- and school-based studies indicated an average 4-point improvement on the ERSSQ in each environment, it would have been beneficial for both teachers and parents to complete the ERSSQ in each setting to provide greater insight into children's social communications from a variety of informants. Furthermore, future research may wish to include additional standardised questionnaires to overcome some of the challenges of the ERSSQ highlighted by staff members. Such questionnaires may be considered within a consultation with the autistic community to ensure they meet autistic-prioritised outcomes.

5.5 Broader research directions and implications for practice

The results from the feasibility studies indicate that *Just Dance* is an enjoyable physical activity for parents, teachers, and children to complete. Further research is required to confirm the true effectiveness of the intervention for enhancing autistic children's social development using a similar methodology presented within this thesis and the addition of a control group. Nonetheless, the multi-environment approach suggests that *Just Dance* could be used as a low-cost medium to support physical activity engagement and potentially aid social communication skills, whilst overcoming many of the challenges associated with the more 'traditional' social skill interventions. For example, the intervention is accessible to geographically dispersed participants in multiple settings and does not rely on continuous input from researchers or the attendance of a trained professional to implement it. Moreover, children can partake in the intervention both at home and school, overcoming the challenges

of single-setting interventions and enabling children to become more aware of the exergame and its expectations, leading to greater familiarity and a sense of comfort within it (Bernardini et al., 2014; O'Connor et al., 2009).

Notably, the exergaming intervention is flexible and can be tailored to each child's desires; what songs they would like to complete, the environment they would like to complete it in, how many songs they would like to do, and the time they would like to complete it. Such factors present the opportunity for children to have ownership over their intervention and afford a person-centred approach. This flexibility and person-centred approach should be more widely adopted within autism research. Moreover, the work presented here demonstrates that a standardised protocol (i.e., completing 60 songs of *Just Dance* within six weeks) can be adjusted to suit the individual's needs and preferences. This provides a precedent for future interventions to be more attentive to individual participants' requirements.

Whilst the research predominately focused on autistic children, due to the notion that early and naturalistic interventions are most beneficial for social development, further populations may warrant exploration (Corsello, 2005). For example, staff members suggested that the intervention would be beneficial for the older pupils within their school. Currently, the most prominent interventions used to support autistic adolescents and adults are psychosocial interventions (e.g., individualised interventions; group therapy; support groups). However, few autistic adults report the use or knowledge of interventions that aim to improve speech and language skills, physical activity, or leisure experiences (Micai et al., 2022). Future research may wish to explore the use of a dance-based exergame within older populations of autistic individuals to further understand the intervention's implication for practice. The exergame may provide an opportunity for autistic adolescents within the school environment to engage in a physical activity with their peers, which is a fun and

enjoyable experience, whilst positively influencing social skills and connection between individuals. Such factors may subsequently limit drop-out rates or the observed reduction in exercise and physical activity for autistic adolescents (Crane & Temple, 2015; Gardner et al., 2017).

Finally, the work presented within this thesis was conducted either during the height or the tail-end of the coronavirus pandemic. The global situation stressed the importance of developing evidence-based interventions that can still occur even when conventional facilities are closed and traditional therapies are inaccessible, emphasising the need for more innovative ways to deliver such interventions. For example, telehealth interventions for the autistic population have been fast growing in popularity, with the outbreak of the coronavirus pandemic strengthening this evolution (Chen et al., 2022). In response to the pandemic, the studies presented within this thesis contribute to the expanding body of work regarding remote research, asynchronous interventions, and the training of parents or teachers to deliver interventions via telehealth (Cleffi et al., 2022). The work suggests that both parents and teachers can be effectively trained via videoconferencing software and telephone conversations to deliver a standardised protocol and trusted to adapt the intervention (within reason) to best suit the child or children they are caring for. This subsequently reduces the continuous input needed from researchers or practitioners enhancing the longevity of an intervention.

5.6 Conclusion

The overarching theme of this thesis was to '*investigate the use of a dance-based exergame in the home and school environments as a vehicle to enhance autistic children's social communication skills*'. The current research provides initial evidence that *Just Dance* is an enjoyable activity that can be integrated into the home and school environment by

parents and teachers, respectively. Furthermore, the work suggests participation in six weeks of *Just Dance* may positively influence children's social communication skills as measured by the ERSSQ, a standardised questionnaire curated for use within the autistic population, and by behavioural observations coded by independent coders.

Throughout the body of research presented here, several gaps in the literature were addressed. First, the research sought to corroborate that mirroring and rhythm interventions were beneficial for autistic children's social communication skills, even when used outside the practice of DMT. Secondly, the research explored the most common elements of music and rhythm used by dance movement therapists to recommend their use in the intervention phases. Thirdly, the final feasibility studies demonstrated that the dance-based exergame could be viably incorporated into multiple environments, specifically the home and school environments, which had not yet been explored in the literature. Similarly, the evidence base regarding exergames for autistic children's social communication skills was scarce and inconclusive. Therefore, the work presented here attempted to respond to this disparity by providing suggestive evidence that a dance-based exergame, incorporating rhythm and mirroring, may be beneficial for autistic children's social communication skills. As a result, the work contributes to the small body of literature and calls for further research to be completed to confirm the true effectiveness of *Just Dance* for autistic children's social communication skills using a similar methodology proposed within this thesis. Despite the considerable work still required, the findings presented are promising and suggest additional research within this area will prove worthwhile and be meaningful for the autistic population, whilst still celebrating neurodiversity and encouraging movement through the medium of dance.

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7 Appendices

7.1.1 Appendix I: Outcome document produced following consultation with autistic and autism community

Outcomes from the 'Dancing out for a Voice: ASD' consultation

Introduction

The overarching aim of the proposed study is to assess the feasibility and potential efficacy of a dance-based exergaming intervention for autistic children.

Previous research has indicated that participating in physical activity and dance movement therapy (DMT) can act as viable vehicles to enhance social communication skills in young autistic individuals. Yet, it is observed that many autistic children lead sedentary lifestyles and partake in more online, virtual gaming activities.

We believe that an intervention, which draws upon the interests of many young autistic individuals (i.e., video gaming technology) and incorporates successful elements of DMT into a physical activity may be more intrinsically motivating than traditional styles of therapies and could produce beneficial effects for social skills for autistic individuals.

Consultation

This consultation was initiated by the Research Team as current guidelines suggest that autistic individuals, their families, and relevant professionals or service providers should be involved in the design process of research studies for autistic children; thus, involving both the autistic and autism community in the design process of upcoming projects.

Furthermore, we believe holding a consultation and discussing the planned project with the autistic/autism community and academics outside the Research Team will enable us to understand whether any part of the protocol could be improved.

Therefore, a consultation was held via videoconferencing on Zoom, due to COVD-19 restrictions in the United Kingdom, with 8 members from the autistic, autism, and wider research communities. The consultation focused on key elements of the project that the Research Team had highlighted as important to understand before submitting the ethics application. Key questions regarding each element were put forward to the panel members to discuss.

Key Discussions

The Intervention

In our proposal, the intervention was scheduled to last six weeks, consisting of child-parent dyads completing two *Just Dance* sessions per week. Each session was scheduled to last 5 songs - approximately 20 minutes.

"Will parents and children be able to commit to six weeks of Just Dance sessions?"

During the consultation, it was emphasised that if you meet one autistic child, you haven't met *every* autistic child. This is due to the immense heterogeneity and variability of the condition. Therefore, it is difficult to confirm that *all* parents of autistic children will be able to commit to the six-week scheduling of the intervention. However, owing to the short length of the sessions (~20 minutes) and only occurring twice per week, almost all panel members agreed that the scheduling should be feasible for parents and children to complete. As a result, the proposed scheduling will be maintained: two Just Dance sessions per week, each lasting 5 songs long (~20 minutes), for six weeks.

Outcome measure 1: Behavioural Observation

In our proposal, we stated that we would like to draw on some of the successful elements of the Naturalistic Observation Diagnostic Assessment (NODA) and implement them into our study. This would give rise to our first outcome measure, where recorded in-home "play-based" scenarios could be stored and forwarded to the Research Team for subsequent behavioural coding.

"How do we make the behavioural observation outcome measure as simple as possible to complete for parents?"

During the consultation, we discussed what is meant by the word "play" and what activities parents and children may engage in together. We have since formulated the definition for parents to adhere to; "*Any activity that your child enjoys and will engage with for at least 10 minutes. This could be an arts and crafts activity, free-play, a puzzle, or the use of dolls/cars/trains/etc…*".

It was also stressed that parents should be made aware of how the behavioural observation recordings will be used. Thus, we have since tried to emphasise in our interest webinar, training session, and training manual that the behavioural observations will be coded and the recordings will subsequently be destroyed. Furthermore, the coded data will be stored under pseudonyms so no identifiable information will be stored.

Outcome measure 2: ERSSQ

In our proposal we had planned to use the Emotional Regulation and Social Skills Questionnaire parent version (ERSSQ; Beaumont & Sofronoff, 2008) as our second measure. We believed the ERSSQ will provide a valid measure of overall social performance in participants. It is a standardised measure, consisting of 27 items in the format of a five-point Likert Scale, from 0; never to 4; always.

"Is one rating scale sufficient to cover changes in emotional regulation and social development?"

During the consultation, it was discussed that the standardised questionnaire did not allow parents to express or rate social skills that they or their child may find particularly relevant to themselves. Therefore, we have since introduced a free-text response at the end of the questionnaire for parents to elaborate on their responses made during the questionnaire, or comment on social skills that may not be recognised within the ERSSQ.

We were also reminded in the consultation that parents may be autistic, dyslexic, or simply find online questionnaire difficult to navigate. As a result, we will also now allow parents to complete the questionnaire over the phone with a member of our Research Team.

Outcome measure 3: Calendar-style Grid

In our proposal we specified that whilst completing the intervention, child-parent dyads will be required to complete the calendar-style grid after each session. We had planned for this to be sent to parents via email for them to download and then complete with their child.

"Will parents be able to download the calendar-style grid to fill out or complete on their computer (is there a more simplistic way)?"

During the consultation, we discussed three potential options for how we may deliver or administer the calendar-style grid. The most popular option was to post a printed version of our calendar-style grid to the home addresses of participants. Many of the consultation panel members liked the idea of having something visual and tactile for children to see and hold.

Following on from our discussions with the panel, we have now also planned to distribute a set of stickers to use on the calendar-style grid for children to mark what days they completed each session and reflecting how much they enjoyed each session.

Other comments

Alongside the key questions discussed during the consultation, our panel made some interesting comments and raised important questions that have helped steer the way our project will be conducted.

"Can you focus on social skills not observed during "play", perhaps during the actual intervention?"

This question was raised by a panel member during our consultation. As discussed by the research team and panel members, it would be useful to understand if skills that may relate to social capabilities, connection, and empathy are also improved during the intervention, such as interpersonal motor synchrony, and not necessarily focusing on "typical" social skills. We have since introduced a new outcome measure into a project proposal, which will ask parents to record the first, middle, and last *Just Dance* sessions of the intervention that they complete with their child. We will then code the "intervention-based behavioural observations" for interpersonal motor synchrony, enjoyability, and confidence.

"What is the parent/caregivers knowledge of autism?"

Again, this was another valued question raised by a panel board member. We believe most parents and caregivers, especially those who are likely to volunteer for a research project, will have a basic understanding and awareness of autism. However, we believe it is important for us to emphasise to parents that we do not wish to impart or enforce neurotypical social functions onto autistic individuals, rather we aspire to enhance social abilities already upheld by autistic individuals and increase feelings of empathy and connection between social partners. Therefore, we will ensure that all parents have a level understanding of autism and are aware of the aims of the research project during the interest webinar and training session.

"Import to know how the intervention makes the child feel"

This was a useful comment made during the consultation by a panel member. We agreed with the panel members and believe it is important to understand if the child is enjoying the intervention. We hope that our 'intervention-based behavioural observation' outcome measure should reflect the child enjoying the intervention and that each child will mostly mark each session with a 'happy face'; symbolising that they enjoyed the session. We will also host a semi-structured interview with parents at the end of the intervention to find out more about how their child enjoyed or engaged with the intervention. Altogether, we hope that these outcome

measures should reflect how the intervention made each child feel.

"THE AGE RANGE IS QUITE LARGE AND THERE MAY BE SOME VARIABILITY"

We had previously planned to recruit child-parent dyads, where children were aged between 6 and 12-years-old. Following on from our consultation and the helpful comment made by a panel member, we have decided to reduce the age from 6 – 12-years-old to 8 – 12-years-old. We hope that this age range will still allow us to recruit our required number of participants, whilst providing results for young autistic individuals. We also believe this age range may be better suited for the intervention and outcome measures we plan to use.

CONCLUSIONS

We have since adapted the project proposal and ethics application in line with the discussions made during the consultation. We hope that our planned project and intervention will be enjoyed by both parents and children, creating a vehicle to strengthen connection and empathy between social partners and enhance social communication in young autistic individuals.

WITH THANKS

This statement was developed through consultation via Zoom on the 27th of May 2021. Team Research Lab would like to give thanks to the parents, teachers, researchers, and autistic individuals who attended the consultation; contributing to the way autism research is carried out in the UK.

7.1.2 Appendix II: Pre-registered report on the 'As Predicted' platform

ASPREDICTED

Wharton CREDIBILITY LAB
UNIVERSITY of PENNSYLVANIA

"Dancing for a 'voice' –Autism Project, UK, 2021 (#75433)

Created: 09/24/2021 05:22 AM (PT)
Public: 07/28/2022 01:27 AM (PT)

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1) Have any data been collected for this study already?
No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?
We hypothesise that participating in frequent sessions of Just Dance will enhance the social-communicative skills of autistic children as measured by the Emotional Regulation and Social Skills Questionnaire (ERSSQ) and behavioural observations. Furthermore, we hypothesise that the majority of children will enjoy the intervention and parents will find it easy to implement in the home environment as measured by our calendar-style grid and parental interviews.

3) Describe the key dependent variable(s) specifying how they will be measured.
We have four primary outcome measures that we will use in our feasibility study. To understand the feasibility of implementing Just Dance in the home environment, parents and children will complete our pre-distributed calendar-style grid after each session. We will also hold a semi-structured interview with parents following our Just Dance intervention to understand how easy they found the intervention to implement.

To understand the potential/initial effectiveness of Just Dance for enhancing the social-communication skills of autistic children, parents will complete the ERSSQ pre–and post-intervention. They will also video-record their child in a naturalistic setting at home (pre–and post-intervention) and forward these recordings to the research team. We will then code the video recordings for proximal and distal social behaviours.

4) How many and which conditions will participants be assigned to?
There is only one condition for this feasibility study. All child-parent dyads enrolled in the study will be assigned to the intervention group; participating in weekly Just Dance sessions at home.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
As we will only have a relatively small sample size, we will use a Shapiro-Wilk test to test for normality. We will then perform a paired, parametric (normality score-dependent), two-tailed t-test where the mean of the post-intervention dataset will be compared to the mean of the pre-intervention dataset for observational and ERSSQ scores. Confidence levels will be set to 95% and the definition of statistical significance will be $P < 0.05$ for all analyses. We will report the t value (t), the degrees of freedom (df), and the p-value (p) for analyses. These quantitative analyses will help to explore the effectiveness of Just Dance.

We will record and then later transcribe our semi-structured interviews held with parents. We will analyse the transcripts using inductive thematic analysis on the NVivo software. These qualitative analyses will help to explore the feasibility of Just Dance.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
We will exclude participants who do not complete at least 40% of the Just Dance sessions from our analyses that focus on the effectiveness of Just Dance for enhancing social-communication skills. However, it is important that we still analyse their data and input regarding the feasibility of the intervention to understand why their completion rate was below 40%.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.
Based on previous research, we aim to recruit between 5 and 12 participants for the study; however, participants should be enrolled in the study by 25/10/21 to meet our anticipated project timeline. Therefore the ultimate sample size is determined by how many participants have enrolled in the study by this date.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)
Our secondary outcome measure includes an intervention-based observation, where we are asking parents to video-record the first, middle, and last Just Dance sessions they do with their child. We will then code these video recordings for indicators of enjoyment, confidence, and time spent moving in motor synchrony as this has been associated with positive changes in social-communication skills. It is also important for us to understand whether children are enjoying the intervention.

7.1.3 Appendix III: Follow up document that was distributed to parents after hosting the mid-intervention check-ins with each family

Mid-Intervention Update

Introduction

Hello everyone,

It's been great to speak to all of you over the past couple of weeks and find out how you and your child are finding the intervention. It's great to hear that many of you and your children are enjoying the *Just Dance* sessions.

After some feedback and discussions from each of you, I've decided to compile a document that may help you to overcome some of the barriers you may be experiencing.

Importantly we'd like to emphasise that we want this to project be an enjoyable experience for you and your child. Please don't worry if you miss a session or if your child really does not want to do a session that week. Just mark it down on the calendar-style grid and we'll be able to report this in our findings.

Adjustments

A lot of the feedback we've received centres around children initially not wanting to take part in the sessions but enjoying the sessions once they get started. Therefore, we've come up with some suggestions, which may help children to feel as though they have more autonomy over the sessions.

Allow your child to pick the day(s) they'd like to do the session

We understand most children are very busy with school, therapy, and/or extra-curricular activities. Therefore, the *Just Dance* sessions may be eating into 'their time'. It may be beneficial at the start of the week to sit down with your child and let them pick the days you would like to do the *Just Dance* sessions. You could mark this on the calendar so they know they have decided to do the sessions

that day and then once they have completed the session, mark it again with how much they enjoyed the session.

Allow your child to pick the songs they'd like to dance to during the session

Motivating your child by allowing them to pick the songs they'd like to dance to might help them to feel as though they have control over the session. It also helps to create an element of conversation and discussion during each of the dances.

Allow your child to pick how they'd like to do the session

What we mean by this is, some children may prefer YouTube, others may prefer the *Just Dance* platform on *Just Dance* Now, Wii, Nintendo Switch, or XBOB. Allowing your child to choose how they would like to do the *Just Dance,* will again allow them to feel like they have more autonomy over the sessions. You/they may choose to do a mixture of both; i.e YouTube one session, gaming platform the next session. This is fine and can be completely individual to each child-parent dyad in the project.

Pick Just Dance Kids

If you think your child may be finding the actual movements of the *Just Dance* clips hard and this is impacting on their enjoyment, *Just Dance* offers a 'kid's' version; where the dances have been specifically choregraphed for children. These can be found on many of the *Just Dance* games and playlists are available on YouTube for *Just Dance* Kids dances, here is one example: https://youtube.com/playlist?list=PLPEBrJfw2peLxNFEOrYaC2khP-QfrXsP7

With Thanks

After speaking with most of you, I'd just like to thank you again for your continued participation and support within this project. We really believe the elements included in *Just Dance* (mirroring and rhythm), the physical activity of *Just Dance*, and engaging with parents in the comfort of one's own home will help to impact and strengthen children's social communication skills. Thank you for helping us to research this important topic.

If you have any questions or queries in the meantime, please do not hesitate to get in contact with me.

7.1.4 Appendix IV: Training manual that was distributed to parents prior to embarking on the intervention

DANCING OUT FOR A VOICE

PROJECT: TRAINING MANUAL

Table of Contents

❖ Introduction

Firstly, I'd like to start by thanking you for participating in this important and exciting research project. We really hope that you and your child find it an enjoyable experience that leads to a positive outcome. This project has been given full ethic approval and all aspects of the project were discussed with members of the autism and autistic community before submitting the ethics application. However, if you feel uncomfortable with any aspect of the research project, please contact a member of the research team.

We hope this manual will provide you with all the relevant information needed to successfully carry out the project's protocol.

As you're hopefully aware by now, the project will last approximately 8 weeks. In the first and last weeks, you will be required to complete several outcome measures. Between these weeks (week 2 – 7), you will be expected to complete two *Just Dance* sessions a week; each lasting 5 songs, with your child. You should attempt to limit distractions during these sessions and also during the recorded behavioural observations.

We have provided a summary of each of the outcome measures below and a timeline of when we would like these outcome measures to be completed.

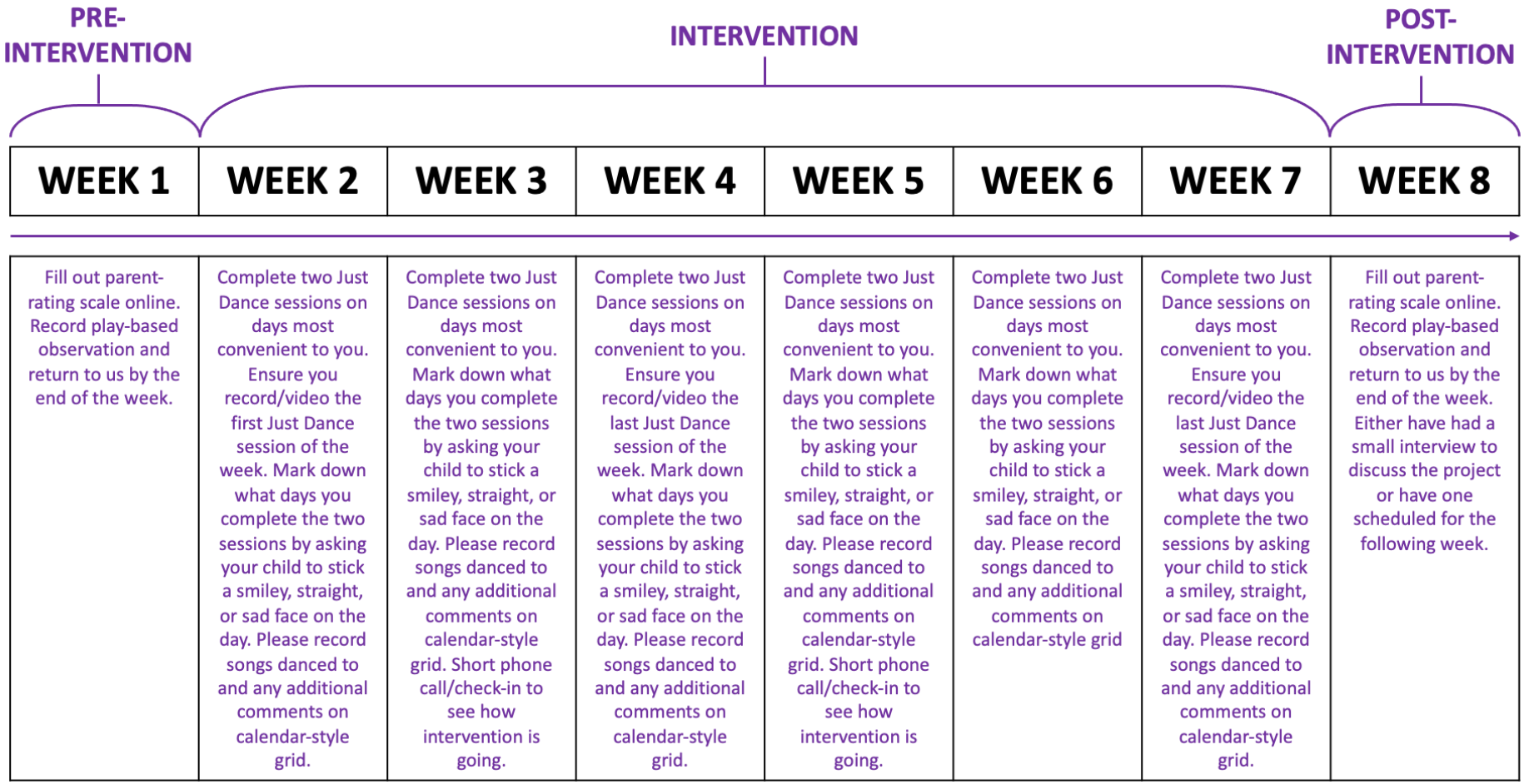
- ***Summary of outcome measures***

It is important for us to gain as much information as possible to see if the intervention has a beneficial effect, if you and your child are enjoying the intervention, and how easy it is for you to follow the protocol. Therefore, we have to collect lots of different 'bits' that may help to answer these questions. These 'bits' are called outcome measures and are listed below. We have attempted to explain each outcome measure; the reason why we need it, when it should be delivered/completed, and also when we need it back by/returned to us.

Outcome measure	Reason	Delivery	Return
Store and forward play-based behavioural observation	To judge the usefulness of store and forward observations. To observe and code children's social skills in a naturalistic setting.	Parents to complete with their child one week before intervention starts (Week 1) and one week after intervention stops (Week 8).	By the end of Week 1 and then again by the end of Week 8. These should be emailed, will most likely need compressing into a Zip file or via google drive link.
Emotional Regulation Social Skills Questionnaire	To measure ease of parent's completing ERSSQ and to have a numerical measure of social skills assessed by a validated and standardised tool.	Parents to complete one week before intervention starts (Week 1) and one week after intervention stops (Week 8).	Complete on the Qualtrics platform by the end of Week 1 and by the end of Week 8. Will automatically be returned to us after saving results.
Calendar style grid	To measure ease of sticking to the intervention and to determine how enjoyable to intervention was for each child	Parents to complete with their child each week of intervention following each Just Dance Session (Weeks 2 – 7)	At the end of Week 8, either scan or take a photo of the calendar style grid and send to our team lab's Whatsapp number; number to follow, or via email
Store and forward intervention-based behavioural observation	To judge the usefulness of store and forward observations. To observe and code behaviours, including confidence and enjoyment during the intervention.	Parents to record the first, middle and last intervention sessions with their child (Weeks 2, 4, and 7)	These should be returned via email within one week of recording. They will most likely need compressing into a Zip file or sending via google drive link.
Short phone calls/check-ins	To understand the practicality of the study	We will call you in weeks 3 and 5 at a	All phone calls will be recorded so that they

	and limit any potential barriers that parent-child dyads may face during the intervention.	time that is most convenient for you	can later be transcribed.
Long Semi-structured interview	To discuss the overall practicality of the intervention from start to finish, including the pre- and post-intervention phases and understand the overall achievability of the project from the parent's perspective.	We will call you either in Week 8 or in Week 9, at a time that is most convenient for you .	All phone calls/zoom calls will be recorded so that they can later be transcribed.

- ***Timeline of when to complete outcome measures***



❖ Complete the parent-rating scale

The Emotional Regulation Social Skills Questionnaire is a parent-rated scale that consists of 27 questions. Responses are designed to measure how often your child displays certain skills and behaviours. Items (questions) on the scale were developed based on extensive clinical experience and existing literature by Beaumont and Sofronoff (2008). We believe it should offer a reliable insight into your child's social skills when answered honestly and accurately.

It is a standardised questionnaire, where responses are formatted by a five-point Likert Scale (numbered scale), from 0 to 4: 0 = never does this behaviour, 1 = rarely does this behaviour, 2 = sometimes does this behaviour, 3 = often does this behaviour, and 4 = always does this behaviour.

Five-point Likert Scale:

0	1	2	3	4
Never does this behaviour	Rarely does this behaviour	Sometimes does this behaviour	Often does this behaviour	Always does this behaviour

The questionnaire should take no longer than 10 minutes to complete and can be answered via the Qualtrics platform:

- You must complete the pre-intervention questionnaire in the first week of the study's programme **BEFORE** you start the intervention in Week 1.
- You must then complete the post-intervention questionnaire the last week of the study's programme **AFTER** you finish the intervention in Week 8.

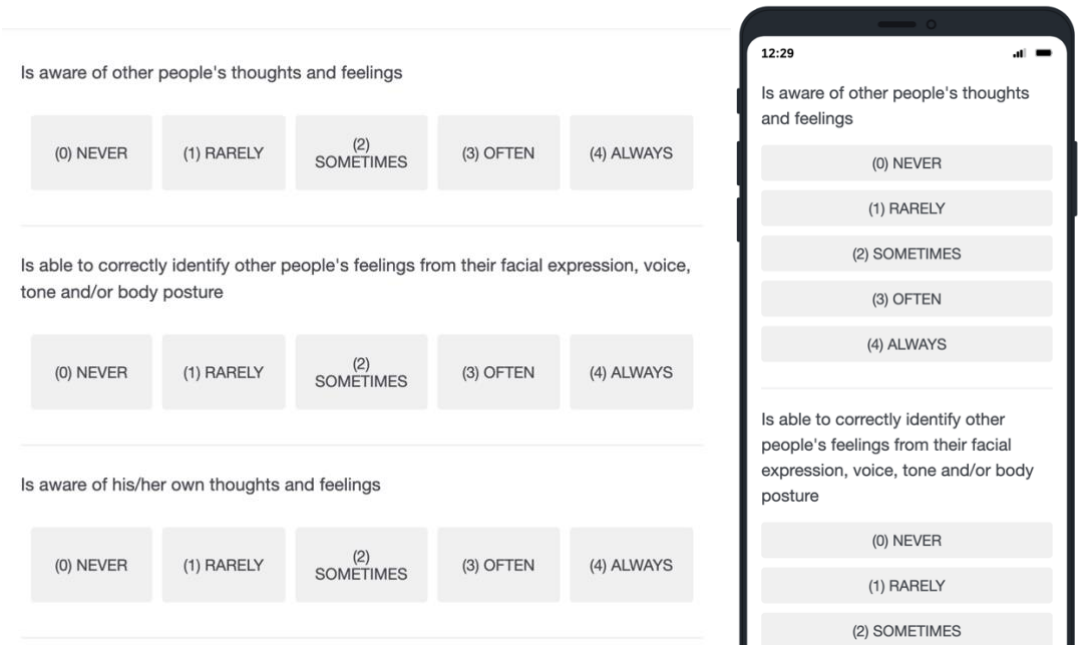
PRE-INTERVENTION QUESTIONNAIRE:

You can click the link here to answer the **pre-intervention** questionnaire: https://essex.eu.qualtrics.com/jfe/form/SV_bCuCcxHyksEvGyq. Alternatively, you can click the link we have sent you via email.

POST-INTERVENTION QUESTIONNAIRE:

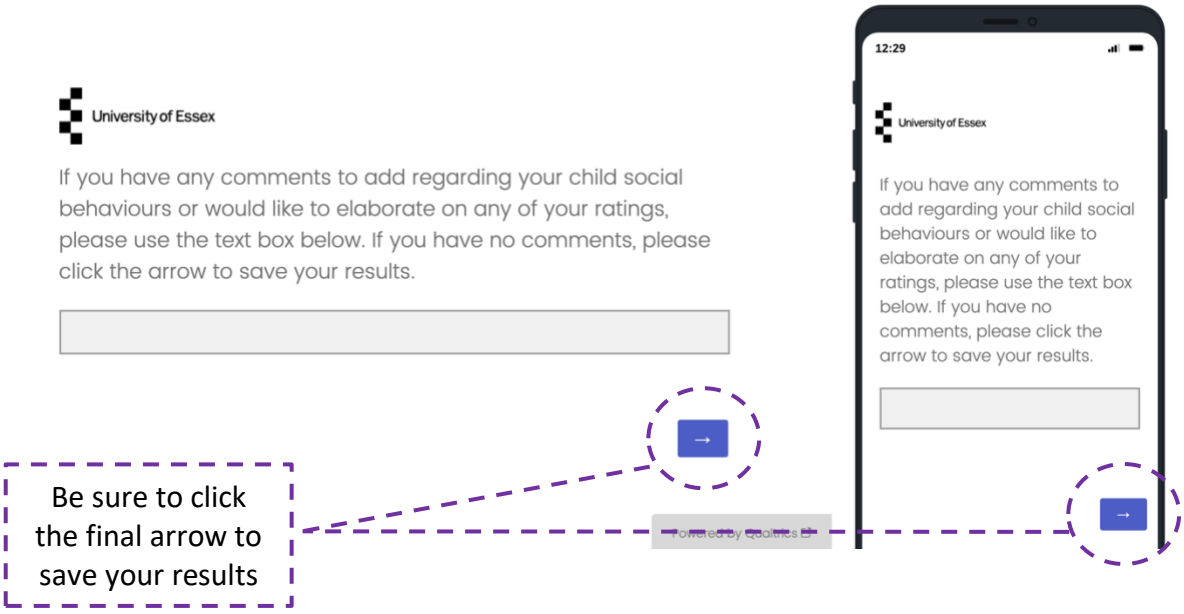
You can click the link here to answer the **post-intervention** questionnaire: https://essex.eu.qualtrics.com/jfe/form/SV_9RXZBjyGPy4e86y. Alternatively, you can click the link we have sent you via email.

Below are some screenshots of how the questionnaire will look on desktop or mobile.



- ***Returning the parent-rating scale to us***

Once you complete the questionnaire on the Qualtrics platform make sure you click the final arrow and it will automatically be returned to us. You must ensure you click the final arrow on the both the pre- and post-intervention questionnaires.



❖ Completing the play-based observations

The play-based observations will allow us to see your child's social skills in one of the most natural settings to them – their home! We would like you to record 10-minutes of play with your child in your home setting. Pick an activity that you know your child will enjoy; for example, arts and craft or playing with trains, cars, or dolls. You can use a phone, camera, or web camera on a computer or laptop to record the play-based scenario. You may wish to prop the recording equipment up and out of reach of your child.

We have based this outcome measure on the successful NODA app.

Tips for creating a play-based scenario:

- ✓ We want this to feel as authentic as possible for your child, so try not to "force" any interactions
- ✓ Invite them to play with you and maybe have some of their favourite toys or games they like available
- ✓ Talk to your child and engage with them, but try not to "force" conversation – let your child lead
- ✓ Attempt to limit distractions in the room
- ✓ Ensure the same parent/caregiver completes both the pre-intervention in-home observation recording and post-intervention in-home observation recording.

You must record at least 10 minutes of play between you and your child. If the clip ends up being 12 minutes long, that is okay as we will trim it to 10 minutes.

Tips for taking a good in-home recording:

- ✓ Ensure there is enough space between yourselves and the recording equipment, this will guarantee that you and your child are in the frame
- ✓ Ensure the room is well lit and avoid using dim lighting
- ✓ Try to ensure the child is facing the camera
- ✓ Try to ignore the camera and interact with your child how you would normally
- ✓ Set up the recording equipment before starting the play-based scenario

To view a video demonstration on how to set up your in-home play-based observation recording please click this link: https://youtu.be/2_Ltvj0pq2U

➢ *Returning the in-home observations to us*

Once you have recorded your in-home play-based observation you will need to return it to us by the end of Week 1 (before commencing Week 2). You can do this by emailing the file to us in a secure email (you may need to compressed the file first or email via google drive link) or via Whatsapp (encrypted messaging service).

You will then need to repeat this outcome measure in Week 8 and return to us by the end of Week 8.

❖ Completing the Just Dance session recordings

The in-home Just Dance recordings will allow us to see how you and your child complete the Just Dance sessions and if there are any changes from the first session to the middle session and then again to the last session. These behavioural observations allow us to not reduce behaviour to number or scale; thus, enriching the data we collect.

We would like you to record the first, middle, and last Just session with your child.

You can use a phone, camera, or web camera on a computer or laptop to record. Again, you may wish to prop the recording equipment up and out of reach of your child, perhaps on a piece of furniture.

Tips for taking a good in-home recording:

- ✓ Ensure there is enough space between yourselves and the recording equipment, this will guarantee that you and your child are in the frame
- ✓ Ensure the room is well lit and avoid using dim lighting
- ✓ Try to ensure the child is facing the camera
- ✓ Try to ignore the camera and interact with your child how you would normally
- ✓ Set up the recording equipment before starting the first, middle and last just dance sessions
- ✓ Enjoy each of the sessions

Here's a video on YouTube, which is very similar to the video recordings we would like you to complete and return to us for the Just Dance session recordings:
https://www.youtube.com/watch?v=uX3qryJ_SII&t=110s

➢ *Returning Just Dance observations*

Once you have recorded your first in-home Just Dance observation you will need to return it to us as soon as possible, preferably within a week of completing the recording. You can do this by emailing the file to us in a secure email (you may need to compress the file first or email via google drive link).

You will then need to repeat this outcome measure in Weeks 4 and 7, for the middle and last Just Dance sessions respectively. Please return both of these recordings to us as soon as possible – preferably within a week of completing the recording.

❖ Completing the calendar

The calendar will help us to understand how many sessions you and your child completed (i.e., ease of following the schedule and completing two Just Dance sessions a week). It should also give us an insight into whether your child enjoyed the sessions and what songs they liked.

At the end of each session, we would like you to ask your child three questions:

1. *How much did you enjoy the session?*
2. *What was your most favourite song that we danced to today?*
3. *What was your least favourite song that we danced to today?*

You can ask the questions in a format or via a communication channel that is most suited to your child. For example, if your child is verbal you may verbally ask them or if they prefer communicating via a tablet or Voice Output Communication Aid, you may ask them using this.

We would like your child to record how much they enjoyed the session by using a 'face'. A smiley face would represent enjoyment, a straight face would represent neither liking or disliking the session, and a sad face would indicate that your child did not enjoy the session.

The blank calendar document will be posted to you, along with stickers prior to the intervention starting, if that is the option you have chosen. Alternatively, you can download it from here: https://www.teamresearchlab.org/feasibility-study/. The calendar should be completed after each session including what day you completed each session, what 5 songs you danced to, your child's enjoyment feedback, answer to the questions and any additional comments you believe are necessary.

Below is an example of the calendar being completed for weeks 2 and 3:

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	COMMENTS
WEEK 1								
WEEK 2								*X enjoyed both sessions and was excited to play on the game. They really liked the song baby shark so we did it twice* Favourite song = + Least favourite song = - shown on the song list.
		1. Katy Perry Roar 2. Time Warp - 3. Baby Shark + 4. Baby Shark 5. Dance Monkey			1. Ghost Busters - 2.Let it go 3. I like to move it 4. I got a feeling + 5. Into the unknown			
WEEK 3								X was having a bad week and said they didn't enjoy the first session. They started to
		1. Ghost Busters 2. Old town road 3. I like to move it - 4. Baby Shark + 5. Dance Monkey			1. Shape of you - 2. I'm still standing 3. Let it go + 4. Waka Waka 5. Baby shark			feel better toward the tail end of the week but still said they didn't really enjoy the session. Favourite song = + Least favourite song = - shown on the song list.

- ***Returning the calendar to us***

Please take a photo of the completed calendar style grids and either email the photo to a member of the research team or send the photos to our Team Labs Whatsapp Number.

❖ Completing the intervention

The intervention consists of six weeks of *Just Dance.* You are asked to complete two *Just Dance* sessions a week with your child. Each session should include 5 songs and therefore should last approximately 20 minutes. We have attempted to be as flexible as possible to meet with your schedules so that you can choose the days you would like to complete the sessions. However, it is important that you limit each session to 5 songs to ensure 'sameness' across participants.

We have compiled a list of songs at the end of this manual for each game, that you and your child might like to dance to, based on previous research. However, if your child wants to dance to a song that is not on the list that is also okay.

During the sessions we would like you to engage with your child using their name, praising them for completing the songs and encouraging movement. You may ask them what song they would like to dance to and then respond to their answers.

Praises and engages may include:

- Good job!
- Keep going!
- Excellent work!
- Wow!
- You're doing so well!
- Yes, we can dance to that song!
- How about 'x' song?
- Would you like to dance to 'x' song?
- You can pick a song!
- Keep moving!
- Let's dance!
- That was good!

Tips for completing the intervention

- ✓ Minimise distractions
- ✓ Ensure there is enough space in the room
- ✓ Set up the game for your child
- ✓ Actively engage with your child
- ✓ Praise them when they do well
- ✓ Try to focus on enjoying the game rather than scoring points
- ✓ Keep a positive attitude

❖ Project Checklist

From the 25th of October:

- ☐ Complete pre-intervention ERSSQ by the 31st of October
- ☐ Complete pre-intervention play-based behavioural observations and forward to research team by 31st of October

From the 1st of November

- ☐ Complete first week of Just Dance sessions
- ☐ Record first Just Dance session and forward to research team by the 7th of November

- ☐ Complete second week of Just Dance sessions
- ☐ Have short "check-in" with research team

- ☐ Complete third week of Just Dance sessions
- ☐ Record middle Just Dance session (last session of the third week) and forward to research team by 21st of November

- ☐ Complete fourth week of Just Dance sessions

- ☐ Complete fifth week of Just Dance sessions
- ☐ Have short "check-in" with research team

- ☐ Complete sixth week of Just Dance sessions
- ☐ Record last Just Dance session and forward to research team by 12th of December

From the 13th of December:

- ☐ Complete post-intervention ERSSQ by the 19st of October
- ☐ Complete pre-intervention play-based behavioural observations and forward to research team by 19st of October
- ☐ Complete post-intervention interview by the 19th of October (contingency till the 23rd of October)

Ways to return outcome measures:

- Via email: phoebe.morris@essex.ac.uk
- Via google drive link in email
- Via Whatsapp: +44 7835 962332

❖ Research Team Contact Information

Please return all outcome measures to the project lead, Phoebe Morris, at phoebe.morris@essex.ac.uk

If you have any questions please contact a member of the research team and they will try their best to answer any questions or queries.

Contact details:

- ✉ Project lead: Ms. Phoebe Morris; phoebe.morris@essex.ac.uk
- ✉ Lead supervisor: Dr. John Mills; john.mills@essex.ac.uk
- ✉ Supervisory team: Dr. Edward Hope; e.hope@essex.ac.uk
- ✉ Supervisory team: Dr. Tom Foulsham; foulsham@essex.ac.uk

If you have any pressing issues that need resolving immediately you may also contact the project lead on the Team lab's Whatsapp number between the hours of 5pm – 7pm Monday to Tuesday, 9am – 5pm Wednesday – Friday, and 10am – 3pm Saturday to Sunday.

Team lab's Whatsapp number: +44 7835 962332

❖ Potential Song Choices for each Just Dance Game

Just Dance (2009)

- Hot N Cold - Katy Perry
- Cotton Eye Joe – Rednex
- Eye Of The Tiger – Survivor
- I Get Around – The Beach Boys
- I Like To Move It – Reel 2 Real
- Wannabe – Spice Girls
- Who Let The Dogs Out? – Baha Men

Just Dance 2 (2010)

- A-Punk – Vampire Weekend
- It's Raining Men – The Weather Girls
- I Got You – James Brown
- Move Your Feet – Junior Senior
- D.A.N.C.E – Justice
- Monster Mash – Boris Picket
- Funkytown – Lipps Inc
- I Gotta Feeling – The Black Eyed Peas
- Firework – Katy Perry
- Professor Pumplestickle – Nick Phoneix And Tomas J Bergersen

Just Dance 3 (2011)

- Take On Me – A-Ha
- Lollipop – Mika
- Price Tag – Jessie J
- Forget You – Cee Lo Green
- I Don't Feel Like Dancing – Scissor Sisters
- Dynamite – Taio Cruz
- Teenage Dream – Katy Perry
- Land Of 1000 Dances – Wilson Picket
- Tightrope – Janelle Monae

Just Dance 4 (2012)

- Call Me Maybe – Carly Rae Jepson
- Good Feeling – Flo Rida
- What Makes You Beautiful – One Direction
- Super Bass – Nicki Minaj
- Never Gonna Give You Up – Rick Astley
- Moves Like Jagger – Maroon 5
- Time Warp – The Rocky Horror Picture Show Cast

Just Dance 2014

- Kiss You – One Direction
- C'mon – Ke$Ha
- Ghost Buster – Ray Parker Jr
- I Will Survive – Gloria Gaynor
- Troublemaker – Olly Murs
- Blame It On The Boogie – Mick Jackson
- Gimme! Gimme! Gimme! – Abba
- Ymca – Village People
- Candy – Robbie Williams
- Waking Up In Vegas – Katy Perry

Just Dance 2015:

- Happy – Pharrell Williams
- The Fox – Ylvis
- Let It Go – Iidina Menzel
- Birthday – Katy Perry
- She Looks So Perfect – 5sos
- Best Song Ever – One Direction
- I Love It – Icona Pop

Just Dance 2016:

- All About That Bass – Meghan Trainer
- I Gotta Feeling – Black Eyed Peas
- Uptown Funk – Mark Ronson And Bruno Mars
- Balkan Blast Remix – Angry Birds
- Teacher – Nick Jonas
- Copacabana – Barry Manilow
- Under The Sea – Samuel E Wright

Just Dance 2017:

- Cake By The Ocean – Dnce
- Don't Stop Me Now – Queen
- Can't Feel My Face – The Weekend
- Don't Wanna Know – Maroon 5
- Oishii Oishii – Wanko Ni Mero Mero

Just Dance 2018:

- How Far I'll Go – Auli'i Cravaho (Moana)
- Shape Of You – Ed Sheeran
- In The Hall Of The Pixel King – Dancing Bros
- All You Gotta Do – The Just Dance Band
- Beep Beep I'm A Sheep – Lil Deucedeuce
- Blue Da Ba Dee – Eiffel 65
- Funky Robot – Dancing Bros
- **Any from Kids Mode**

Just Dance (2019)

- Shaky Shaky – Daddy Yankee
- Mimimi – Serebro
- Rhythm Of The Night – Corona
- I'm Still Standing – Elton John
- Pac-Man – Soshio Kai
- Water Me – Lizzo
- Un Poco Loco – Disney's Coco
- **Any from Kids Mode**

Just Dance (2020)

- Old Town Road – Lil Nas X
- Baby Shark – Pinkfong
- Into The Unknown – Disney's Frozen 2
- Sushi – Merk And Kremont
- Jungle Dances – The Sunlight Shakers
- Magical Morning – The Just Dance Orchestra
- **Any from Kids Mode**

Just Dance (2021)

- Blinding Lights- The Weekend
- Dance Monkey – Tones And I
- Don't Start No – Dua Lipa
- Kulikitaka – Tono Rosaria
- You've Got A Friend In Me – Disney's Toy Story

Just Dance Kids Or Disney:

- Any Songs

Just Dance Now

- Any 'Kids Mode' Songs
- Or songs from previously mentioned games

Playlists on YouTube:

- Disney Songs: https://youtube.com/playlist?list=PLzkyFTVU_5WKLPio05qSRYr1OtYyvhBN_
- School Appropriate Songs: https://youtube.com/playlist?list=PL_ebO2e2plEFkgE-p313uMwC7ru6InFDi
- Just Dance Kids: https://youtube.com/playlist?list=PLgTbj1HQDw7Bx9ONhdUGMyWi7OLj2Oda1
- Mix of Songs: https://youtube.com/playlist?list=PL-bPni9tSxfUkOwxkNtJ69RECk0F422Qm

7.1.5 Appendix V: Domain summaries, themes, and sub-themes extracted from thematically analysing the transcribed parental exit interviews. Exact quotes and frequencies at which themes sub-themes were referenced are also provided.

Domain Summary Theme Sub-theme	Quotes	Frequency of References
1. Appreciation for the organisation and the information provided throughout the project.		
Parents appreciated the information provided	"There wasn't really any point where I was like struggling to understand what I was meant to do" – Parent B	18
Parents appreciated the hybrid approach to training	"Oh, the webinar was awesome yeah and also super helpful, so was the training manual like I think it was very detailed. I mean, there was a lot of information conveyed" – Parent C	2
Parents liked the	"I mean it looked very, very nice, as well as. The way it was put together, very easy to navigate… It's definitely something I found useful" – Parent A	12

training manual		
Parents enjoyed the training webinar	“I think the webinar was nice because it was interactive and you could ask questions, you can see, you know, like the individuals and stakeholders of the project face to face, so to speak. That was very good” – Parent C	7
Attendance of recruitment webinar	“That's the first one...? Yeah. Yep. Yeah, I did come to that one... I think it was useful, yeah” – Parent D	8
Parents valued the organisation of the project	“But I mean speaking specifically to how the project was organized and presented and so on, I think you did a spectacular job like, and I mean I've seen quite a few, you know research projects because I've worked in a University in research for a while, so I’ve seen you know a lot of you know, research projects put together and like just like the care for the visual and visual presentation, like everything from typography to the general design of all the material that you put together, I think, was impeccable” - Parent C	14

	"I say it was pretty straightforward to the instructions and the fact that there was a bit of a build-up so you were gently introducing us to give us as an idea of what would be happening, and that was useful too because you kind of had an idea, about what you were doing at the next stage, like 'right, this is what we're going to be doing'" – Parent B	
Keeping in touch and the researcher being available	"You kept in touch with us and on a regular basis and we knew, well I knew, that I could contact you if there was any problem at any time" – Parent B	6
2. Importance of preparing children and offering options before and during the intervention		
Giving children options or control of the intervention	"Having a sense that he can actually choose amongst several options is really important to him, and then knowing what's going to come in, in advance, is also really soothing and comforting to him" – Parent C "Yeah, for her to be more in control of the tasks that she's doing; she thrives off that, if she's in control…When we changed it round and got her to do be more in control that definitely had an effect because she was more willing to take part" – Parent B	16

Praise and feedback are important for children	"You're getting the feedback as well from it it's giving you the stars; as I say, she's very motivated by praise and everything, so that keeps her going" – Parent B	4
Children appreciate feeling prepared	"Only thing with him is. If you try to do that something for the first time or even second time, it's difficult. After that he enjoys starts enjoying it" – Parent D "I tried to prepare her and to say, "look we're going to do thing, we're going to do some dancing before it even started, so I was trying to get her prepared" – Parent B	14
3. Personal circumstances affecting the delivery of intervention		
Family commitments affecting delivery of the intervention	"For me, because I had that big holiday booked in, I was like Okay, I signed up for this but now I'm not sure I can do it because we are away for such a long time, but yeah it did work eventually yeah" – Parent A	9
Scheduling of intervention was	"I think so. They were okay. I believe it's two sessions again, you know, it depends on the time" – Parent D	4

	perceived as feasible	"I think two days a week, it is more now - it should be feasible, it should really yeah I think it's okay, the two a week" – Parent A	
	Creating structure was important for children	"Right. So, I mean, I'm just talking about myself more generally. It's better to have things with him every day, or like repetitive, you know, then he starts enjoying it… I mean, for them, an autistic child, it's that kind of like the routine, right. If you do something out of routine, they don't generally like it, but then slowly and gradually, when things you do more consistently every day, they may start liking it" – Participant D	3
	Doing the intervention on a weekend	"We started off on the weekend and then yeah it's just our schedule really"– Parent A "Again, it's really weekend-based that we did the work for the project" – Parent C	5

4. Feasibility of outcome measures used within the project

	Outcome measures were easy to use	"I mean, the activities were okay to record, and the questionnaire, I think so in terms of completion, yeah it was fine" – Parent D "As far as I remember, the questionnaire that was very easy" – Parent A	13
	Parents and children liked the calendar style-grid	"Yeah, but it was easy to fill in and all that was straightforward, it's quite good as well to have the visual side of things; you know, having the red, amber, green faces" – Parent B	2
	Consent forms were easy to complete	"Well yeah that was fine, that was easy, I've done it many times with other project and it was very similar to everything else" – Parent A	3
	Importance of individualised responses to questionnaire	"The questionnaire, some of them might not be kind of relevant for my son. So, I just kind of, you know, did not answer or maybe. answered. It wasn't very accurate, but of course, you know, everyone has a different way, right" – Parent D	2

Losing calendar	“I think I've been, to be honest, I lost it actually pretty early in when we started. So. Yeah. I was not able to follow that one. What I was doing was just, I was writing the songs or something on a piece of papers or a diary or something” – Parent D	2
5. Positives to take away from the project		
Parents and children enjoyed the intervention and wish to continue	“She just wanted to carry on and she wasn't really interested in the dancing and practicing the dancing, she was just more interested having a carry on with me. But that's still a positive thing you know, she was still having a play around with me” – Parent B “Yeah, so I’m very happy to continue yes. Okay, so we got the game, we can do it any day” – Parent A	24
Parents found the intervention easy to use	“Once you get into the process everything you know becomes pretty easy and it's not too onerous and so” – Parent C	4

Parents valued the importance of physical activity and end goal of the intervention	"I mean your idea of movement and the physicality is, I think it is, it is very, very important." – Parent A "Have a craving for communicating and sometime they don't have the tools or the knowledge to do so and expressing themselves bodily through dancing I think is a great outlet and it's a great idea" – Parent C	7
Parents wanted to do something with their child	"So, I thought, you know, it probably helps me as well to learn something and may be an enjoyable experience with my son" – Parent D	3
6. Challenges to the intervention		
There were negative aspects of the intervention	"They [the dances] are way too fast. Even when I was trying to do it, they were too fast….so that was a kind of challenging thing for me and Child D" – Parent D	12
Children were already tired or	"She's getting to just get overworked or overloaded… She's like 'I just want to do this; I don't want other people telling me what to do'" – Parent B	7

potentially burnt-out	"Yeah, because he shattered, he is tired mentally". – Parent A	
Associating home time with down time	"The problem that I've kind of had with it with her, is that Child B associates home time with her kind of down time, when she can kind of do what she wants" – Parent B	2
7. Potential improvements and changes for future studies		
Being there (virtually) for the first session	"If you have a one or two sessions, you know, where you can guide the parent and child, you know, like either even virtually on a zoom meeting or something like that for the first session if they get stuck on what is expected" – Parent D	3
Creating a social story	"You could create social story to try to explain what is happening and why you know there's a change in a routine and so on" – Parent C	3
Differing from five songs	"She didn't want to do the five songs. Three songs were enough for her" – Parent B "Five song is quite a lot, even for me. I'm very unfit so yeah, I think, so I think it's quite a lot because yeah normally, as I said that we do three or four song that's well over 10 minutes, for example. Yeah, I think five is about five was a bit too much" – Parent A	6

	Doing things differently and suggestions for improvement	"Because like, how do I say this, the selection… some of the work and time was spent selecting the songs before the actual session started. You could have some kind of tool to help the children select the songs ahead of time" – Parent C "Suggest to parents that you could make the video slower so that they're easier to follow as some steps are quite complex" – Parent D	10
	Providing more information	"The only thing it was it wasn't really emphasized, but maybe you didn't want to emphasize it was that it was quite a short time do quite a lot of sessions" – Parent B	10
	Providing an incentive	"But if you could give the kids like a five-pound voucher… a little bit of reward at the end for them" – Parent A	5
	Small time-scale was challenging	"I honestly, I don't think that such a small-time window will generate measurable differences, I know we got there but it might vary, but what I mean is, like, I think, for an intervention to like you know make noticeable differences…Like you know six weeks is, you know, maybe not sufficient for children" – Parent C	2

7.1.6 Appendix VI: Domain summaries, themes, and sub-themes extracted from thematically analysing the transcribed parental exit interviews. Exact quotes and frequencies at which themes sub-themes were referenced are also provided.

Domain Summary **Themes** **Subthemes**	**Quotes**	**Frequency of references**
1. Appreciation of collaborative planning, organisation, and information provided throughout the project.		
Staff appreciated the research teams' quick responses	"I know that as soon as something was passed your way it was dealt with very quickly and sent back and any concerns or queries were answered very quickly so. You know, I think it worked well in that sense, there was no like waiting for anything, it was just done ASAP"	2
Staff felt they were provided with sufficient information and prepared to start the project	"Yeah, I did, I definitely feel like I had enough information provided" "I think we had everything, you know I mean, it was all explained, and we had a list of songs to choose from" "And yeah, I did feel prepared to go ahead with the project"	10

Collaborative planning to ensure success of project in school environment	"Because obviously you came to us with an idea of you know engagement with parents and we said all let's try and do it with in school and it worked really well, so I feel like it was nice to feel like our students got accommodated"	3
Staff felt that project was well organized and streamlined	"No, I wouldn't say from your point of view of how you've organized at all, there weren't any bad points" "Yeah, I mean, it was pretty straightforward"	6
Project liaisons were able to train other members of staff in delivery of the intervention and completion of outcome measures using information provided	"Yeah, I just briefly wrote down, I think I bullet pointed basically what you'd sort of relayed to us and, like the reasons behind it and, like sort of what you expected or not expected, but what the research project was and then just gave them the information I think they needed" "Once I got the time to sit down and almost like kind of train the staff into what we wanted the sessions to be like and how we wanted it to go ahead, then it seemed to flow quite easily then"	7

2. Importance of creating structure and routine both within the sessions and throughout the intervention.		
Doing the intervention daily helped to create structure and routine	"It was just a case of getting ahead of ourselves and building it into the day, every day, you know what I mean, the two songs" Yeah, I mean definitely doing it daily is something that students from our school would need and so it's incorporated into a routine	3
Children's expectations should be managed to help limit any anxieties	"Yeah, so we have a visual timetable, so I knew that, well I always use to put it in where I planned to have it [the two songs] for that day. So, yeah, they always knew it was coming in general and when to expect so that was how we tried to create structure"	2
Using the same songs every day to help manage expectations	"I also had some comments from some teachers who wanted to be involved and that they feel like the same two songs every day would be better for their class obviously that's on an individual basis"	1
Staff created structure within the sessions using different songs	"When the first one [song] was a little bit higher and then the second [song] is a little bit lower, that cued the children in that it was going to finish"	8

	“We queued in, like, we always sing with them just a simple song ‘it's finished it's finished’, so they know that it's done and that kind of cued them into know that it was done”	
3. Emphasizing the individual-ness of each child within the classroom.		
Staff adapted the protocol to be more individual to each child	“Because everyone's on such an individualized timetable if it was appropriate to be a little bit later in the day, then that’s just how we played it out and it and it did work well” “Sometimes it'd be just a case of lowering the lights or pulling the blinds down and they engage with just the music and a bit of the visual and so yeah, we it was easy to adjust to it was it was a successful project in that sense” “So yes, sometimes it was, we would do it more when it slotted in really so we may do it to breakup English and math sometimes. Other times we would do it at the start of the day or the start of the afternoon and do two songs together. We didn't particularly always do it at the same time every day, we just built in whenever it worked for that day and the children if you see what I mean”	12

Staff supported individual participation; not forcing participation and allowing each child in to join in how they would like	"We did sort of go for one child – one chance for everyone to join in if you see what I mean so no one felt pressured. You know I mean, with that sort of activity, if they couldn't access it at the time or they didn't want to then we didn't come back to it, and if they could you know I mean we worked with it and then moment" "One of the young men, some days he would sit in and be involved in his own way, but other days he'd just keep going in and out and in and out of the classroom to the music and well that was his way of participating"	9
Staff highlighted the 'individual-ness' of each child	"Some of them, you know, some of them, the dancing sort of was a way of getting them active but didn't suit some of them. But then again, for most of them it was perfect. I suppose, in any activity, you have some it works for some and it doesn't work for" "Yeah, we had the enthusiastic, bubbly, confident ones at the front and then just more quiet ones that joined in as and when they wanted to and just did bits and pieces with us at the back of the classroom"	8

Working to the children's schedules	"Definitely its beneficial to have that kind of flexibility, I think, to fit it in and say 'we must do it now' or 'we must do it at such and such at time' that doesn't always feel right, I mean like some, for example, sometimes they're down and tired and needed calm time and then other times we had to appreciate that they were down and tired and we needed to pick them up, so we would use it then and work with the children"	5
4. Benefits of participating in the intervention and positives of the project, including ease of implementation and flexibility.		
Highlighting the benefits of movement and being active	"Yeah, I thought it was really interesting and I think it made me more aware of how you should keep children active" "Movement can try to help self-regulate so I definitely think there is potential benefits" "Some of them it suited some of them it didn't, I mean the activeness, as such, suited all of them or I feel being active is really important to build into the day"	8
Continuing with intervention after the project finishes and	"Yeah, I think we definitely will continue to use it, especially on those less active days. It's in your head now. The kids know it and they know what to expect and they're familiar with it, so we can just drop back in to it when it is beneficial for the"	4

recommending to other schools or classes	"Yeah, yeah, definitely, I'd recommend it to other schools"	
Children enjoy music and music facilitated group cohesion	"They all they all love music, so it, you know, is something that all that, even if they struggle in other activities, through shared music seems to always bring them together in some way so" "Music seems to always bring them together in some way so"	6
Children enjoyed the intervention	"Yes, so I think the children enjoyed a lot of it"	8
Intervention may aid learning	"Yeah, I think, so I just definitely think it is beneficial for children, and I think, and it can definitely help with their learning and stuff"	2
Staff participating in the intervention to increase children's participation	"Just yeah that I think would be the main thing, just us getting involved rather than sitting back, we also sort of made ourselves look silly in front of the"	13

and supported children to take part	"No not particularly, other than sort of support those, I mean, those that found it harder or were less motivated to join in, staff tended to support those children more during the sessions" "I think just us [staff] getting involved with them, we did it with them each session"	
Staff wanted to increase awareness of ASD in research	"What we are trying to do as a trust is say that, well, our students are really complex and really you know, have got loads of different things going on in their lives, and we need to show that also these questions can't always be used because they're not always applicable for our young people and it's important for them" "So next time something like this is done, someone will think well actually there's a better way of doing this and that's hopefully what we're hoping will come out of it"	3
Teachers appreciated that the structuring of sessions was not concrete	"And I think it worked really well because you were so flexible with us… as long as we did the two songs we could be as flexible as when and, you know, how we did it"	3

The intervention allowed for flexibility of the sessions and choice; length, time, songs choices, and environment	"Yeah, I think everything we do has to be so fluid to fit with the children. And so I think, yeah, you have to make sure everything is fluid and I think we do it dependent on what would work that day" "I think, so I think there's obviously so many different songs and different styles of music on there, I think… I mean I would hope most children would find at least a couple songs that they sort of would take too. I think you can adapt it quite a lot of depending on like the age group and sort of their ability like the age they're working at, that sort of think" "In terms of things that went well, I think were choosing their own songs, obviously that worked really well and I think for us, just giving them the freedom to do as they wished" "Yeah, so it's that's why it's so good, because it is so flexible, so they still get the same songs as their peers but just in a different environment better suited to them"	21
Two songs were an appropriate duration for	"Yeah, they did the two songs every day"	13

each session and was easy to implement	"From the teachers I have spoken to the two song I think the two songs was absolutely fine" "I think the two songs I think that's good because it sort of gives me and them time to sort of get into it"	
The outcome measures were easy to complete	"I think the questionnaire was good, I think that how it was made and the formatting of it was easy to use and yeah, I think that will have made the process easier for some people"	4
Answering questions on the questionnaire as honestly as possible	"I just took the questions of the questionnaire at face value and sort of answered them as honestly, as I could, at that moment, you know what you mean"	3
5. Challenges to the intervention and drawbacks of the project.		
Dancing was not some children's "thing"	"Some of the students did struggle with staying in the room, with all of their peers doing it at once" And I think what didn't work is purely for some of them dancing was just not their style of activity, you know, it just perhaps wasn't suited to them	6

Songs were too fast or overwhelming for some children	"I mean for a couple of them, the music was sometimes a bit loud but that was something that we could adjust"	3
Items on the questionnaire need to be responded to on an individual basis and limit the literal interpretation of the items	"I have quite, like, an abstract view of stuff… So, when I might read the questions and it was like…One of them was "Does the student start conversations with other students" from the position I'm in I might take that quite differently, as to what a TA might think, or some of the teams may have taken that in quite a literal sense" "We need to show that also that these questions can't always be used because they're not always applicable for our young people and it's important for them"	3
Difficulties completing the questionnaire and parental concerns	"One parent, who's child was involved, wanted me to go through the questions and was a bit like 'oh I don't really understand how you're going to get feedback from this', so it just took a conversation from me, for them to think right, we need to think of this in a broader sense…"	4

	raised regarding the validity of the questionnaire items	"The questions were quite hard and I think, and they would have to be tweaked for if you did it further, or you know the study went on further, and in that sense"	
	Staffing issues (limited staffing) affecting completion of outcome measures	"Obviously due to staffing issues which is out of everyone's control, we couldn't go ahead with it as soon as we would have liked competing the questionnaires" "Yeah, but I think that's been the hardest thing for me is getting the teachers to complete them"	9
	Time constraints affecting delivery of intervention	"I think, so I think possibly not always twice a day or every day, as you know sometimes if we're out like for half the morning and have to try and fit it in, I mean if we've already been doing something active"	3
6. Adaptations to the protocol during delivery and suggestions for future studies.			

Enhancing motivation to take part	"Well, what seemed to be working well in there, they said they'd pick their first song, and then they do like a 'just dance champion' so then whoever sort of was participating the most then got to choose the next song" "I suppose, them [the teachers] modelling it themselves and joining in probably helped children to actually join in and, I'm trying to think of what else, like letting the children pick the songs so it was all songs they were interested in"	5
Children took ownership of the sessions	"So, they really enjoyed that freedom of choosing that one, you know the songs that they liked and I think that was a real key in keeping them focused, you know" "Yeah, I think, so yeah, definitely having ownership, so it did become very much their sort of sessions that we helped to manage or run it and were like here you go"	5
Staff were able to overcome any challenges	"I say if it was that it was too many, with the six students, in the room in the one class, we would split it up into different groups and that worked quite well"	4
Creating visuals for sessions	"I would probably make symbol work lists or meet visuals to go along with it"	3

Selecting staff members who have the capacity to complete the outcome measures	"So maybe if you have to do with another school, maybe the school could pick teachers, that they would maybe know that it would be more streamline"	1
Targeting older students	"It'd be interesting if we could do it, maybe with it is difficult, but with the post-16 students…because there's quite a lot of students, the older students who would, I think, really benefit from it quite a lot"	1
Targeting other students	"I think, maybe, maybe like in the future if you ever thought about doing it with different groups of people, obviously, we have like PMLD students and we have an MSI students too who may benefit"	1