Examining the Nature of Communication Difficulties between Autistic and Non-Autistic Individuals

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Abstract

Up until recently, psychological literature surrounding the topic of Autism Spectrum Disorder (hereafter 'autism') has used the medical model, treating autism as a disadvantageous medical condition, resulting in social communication deficits and restricted and repetitive interests. The neurodiversity movement shifts focus away from the medical model, reframing neurodiversity in a more positive light. An example of this is Milton's Double Empathy Hypothesis which suggests that communication deficits are not an autistic trait, but instead the outcome of mixed neurotype interaction. Based on this hypothesis, Crompton and colleagues used a diffusion chain methodology and determined that autistic-to-autistic communication was as effective as allistic-to-allistic and that miscommunications only occurred in mixed-neurotype interactions. In the present study, we repeated the diffusion chain methodology, followed by a Minecraft-based task which aimed to examine these effects in a more natural setting. We found a significant effect of pair type on time taken to complete the map, with autistic pairs completing the map fastest. This suggests that communication deficits are not an autistic trait but instead the outcome of mixed-neurotype interaction. Future studies should focus on adapting lab procedures further to suit the needs of the neurodivergent community and further our understanding of autism as a neurodifference.

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Literature Review

Traditionally, under the medical model, Autism Spectrum Disorder (ASD, hereafter ‘autism’) is defined as a neurodevelopmental disorder, affecting how one interacts with others, communicates and behaves (National Institute of Mental Health (NIMH), 2024). This view of autism demonises the disorder, viewing it as a disadvantageous medical condition (Waltz, 2008) with some early papers going as far as to call autistic individuals ‘dehumanised’ (Bettelheim, 1967) and ‘monsters’ (Tustin, 1992).

Under the medical model, Wing and Gould (1979) defined a ‘triad of impairments’ present in autistic individuals; impairments in social interaction, communication and restricted and repetitive behaviour. Social interaction impairments include challenges understanding verbal and non-verbal cues, difficulty holding conversations, understanding social norms and lead autistic individuals struggling to maintain social relationships and eventually social isolation. Communication impairments in autistic individuals, as outlined by Wing and Gould (1979), include a possible speech or language delay and limited vocabulary, repetitive language patterns, difficulty understanding and using body gestures. Finally, Wing and Gould outlined restricted and repetitive behaviours exhibited by autistic individuals, such as repetitive body movements (often known in the autistic community as ‘stimming’), adherence to strict routines/rituals, intense focus on topics/subjects (often known as ‘special interests’ colloquially), resistance to change and sensory sensitivities.

Baron-Cohen et al (1985) suggested that a theory of mind deficit was present in autistic individuals, underpinning the social impairments identified as a core diagnostic criteria. Theory of mind is defined as one's ability to understand others' mental states and that these are different from our own (Premack and Woodruff, 1978). A deficit in or lack of theory of mind theory of mind could present as a difficulty understanding others thought processes, misunderstanding social norms or rules or a lack of empathy, all of which are identified as social communication 'symptoms' of autism. To identify this deficit in autists, Baron-Cohen used the false belief task, in which one doll (Sally) puts a marble in a basket, then leaves and the marble is moved. Children are then asked where Sally will look for the marble, with participants responding with either Sally's basket (correct) or the box (incorrect). Non-autistic and participants with Down's syndrome answered correctly, whereas autistic participants consistently identified where the marble was, as opposed to where she believes it is. Baron-Cohen, Leslie and Frith believed this showed a theory of mind deficit in the autistic individuals, resulting in an inability to understand and predict others' behaviour and feelings.

Historically, autism and autistic individuals have been misrepresented and under-researched resulting in feelings of mistrust between autistic individuals and those who are supposed to support them (Cascio et al, 2020), leading to misunderstandings of autism as a disorder, rather than a neurodifference, and further marginalisation of autistic individuals. A 'neurodifference' is anything which makes somebody's brain function in a way that is different to average (Singer, 1999), such as autism, Attention Deficit Hyperactive Disorder (ADHD) and Tourette's syndrome. Due to the relative novelty of neurodiversity as a concept and research field, many of the core terms relating to the subject are under defined and therefore commonly misunderstood.

In 2013, the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V; American Psychological Association) updated the way that autism is classified, moving from a triad of impairments to a dyad. This update defines autism as a neurodevelopmental disorder, characterised by impairments in social communication and restricted and repetitive behaviours and interests. This change, while an improvement from the aforementioned theories, lead to a higher prevalence of the disorder but not a better understanding (Richards, 2016). The growing neurodiversity movement (Singer 1999), however, provided an alternative to the medical model which is more neurodiversity-affirming and has resulted in an increase in the quantity and variety seen in autism research (Cascio et al, 2020).

The term neurodiversity, although often attributed to Singer (1999) was created by an online autistic community in the 1990's (Botha et al, 2024). Neurodiversity can be defined as the natural emergence of different brain types within the human race, as natural and valued as other human differences, rather than something to be fixed or cured (Happe and Frith, 2020). In addition to redefining autism, the neurodiversity movement demands neuroequality (Fenton and Krahn, 2007), recognition and acceptance (Jaarsma and Welin, 2012).

While the neurodiversity movement shows promise for greater understanding and acceptance of neurodivergent individuals, there are still issues that need addressing by future research. The first issue surrounding the neurodiversity movement surrounds the notion of self-identification. A key component of the neurodiversity movement is the idea that self-identification is just as valid as formal diagnosis when it comes to being a part of the neurodivergent community, acknowledging that diagnosis is a privilege many do not have access to and the term ‘neurodivergent’ has broad, undefined limits as to what is and isn’t included (Russell, 2020). While this is generally viewed as a positive by the neurodivergent community, it is important also to note that this view can be as harmful as it is helpful, over normalising neurodivergent ‘traits’ and undermining the experiences of neurodivergent and disabled individuals. For example, phrases such as ‘a little bit autistic’ and ‘on the spectrum’ have been commandeered by neurotypical individuals, diluting the meanings of neurodivergent identities. Self-identification is, as mentioned above, a key component of the neurodiversity movement and should therefore be further investigated to determine how individuals come to the decision that they are neurodivergent, and why one might self-identify as opposed to seeking formal diagnosis. In addition to this, it’s possible that the neurodiversity movement is not inclusive or representative of those with more severe difficulties, such as those who are completely non-verbal or require full time care. In order to strengthen and better understand the neurodiversity approach, it’s important to investigate how this view can apply to all neurodivergent individuals, not just those who are able to participate in lab research.

Milton’s ‘Double Empathy Hypothesis’ (2012; also known as the ‘Double Empathy Problem’) challenges the idea that communication deficits are an autistic trait, suggesting that, instead, they are an outcome of misunderstandings between autistic and allistic individuals. ‘Allistic’ is a neuro-affirming term referring to non-autistic individuals (Monk, Whitehouse and Waddington, 2022). One would, assume that if communication is truly defective in autistic individuals, autistic-to-autistic communication would be doubly ineffective. Milton suggested that two people, of vastly different backgrounds, experiences and world views, will struggle to understand and empathise with one another, resulting in miscommunications. When applying this concept to autism, this provides a much more neurodiversity-affirming view on autistic communication styles. The Double Empathy Hypothesis (DEH) suggests that autistic and allistic individuals have such different experiences and world views that they are unable to empathise with each other, which results in miscommunications. This perspective suggests that, rather than being a deficit in autism, these miscommunications are as much due to allistic people not understanding autistic thoughts, behaviour and language as they are due to misunderstandings from the autistic individual. This suggests that miscommunications are as much the responsibility of the allistic individual as they are the autistic, and that learning is required by both parties. Since the creation of this theory, many neurodiversity-affirming researchers have provided evidence to suggest that autistic-to-autistic communication is just as efficient as non-autistic to non-autistic (Crompton et al, 2020; Heasman and Gillespie, 2017; Williams et al, 2021; DeBrander et al, 2019; Morrison et al, 2020).

Since its initial publication, the Double Empathy Hypothesis (Milton, 2012) has received an overwhelmingly positive response from researchers, clinicians and educators alike, generating much more neuro-affirming research into autism, such as those described above. It has been argued that there is an interpretation bias in regard to the DEH, an argument which is only strengthened by the fact that it has never been formalised as per the usual scientific standards (Livingston, Hargital and Shah, 2024). As a result of this, there is a tendency for studies to be interpreted with regard to the double empathy hypothesis, despite there being no clearly agreed conception of the theory. As such, as well as additional empirical investigation, the theory requires further conceptual clarification in terms of specific predictions that it makes on cross neurotype interaction (Livingston et al., 2024).

Heasman and Gillespie (2017) used the Interpersonal Perception Method (IPM), which involves an open-ended discussion combined with participants rating different aspects of the interaction. This allows comparison of direct perspectives (how one sees oneself or others) with meta-perspective (how one thinks one is seen by others). They presented 12 topics in a random order to autistic-family member dyads, who then rated using three different dimensions: self ('how good do you think you are at handling criticism?'), other ('how good do you think your relative is at handling criticism?') and Meta ('how do you think your partner rated you for handling criticism?'). Results provided support for the double empathy hypothesis, revealing that close friends and family of autistic participants also struggled to understand their autistic loved one. In addition to this, dyads expected significant misunderstandings (based on participants' perceived rating), however significant misunderstandings were not present. Family members often overstated the difficulties faced by their autistic loved one and were generally more dismissive of their loved one's perspective taking abilities. Heasman and Gillespie suggested that research focusses too heavily on the autistic individuals where it should focus more on social relations and how autists interact with their allistic loved ones.

DeBrander and colleagues (2019) investigated how people perceive individuals of the same or different neurotype. They showed autistic and allistic participants a brief video of an autistic or allistic person, either with or without their diagnostic status. Participants were then asked to rate character traits of the person in the video, as well as their interest in interacting with them in future. In this experiment, autistic subjects received more unfavourable first impressions from allistic raters. Autistic raters also rated autistic subjects less favourably, but in this case this didn't reduce social interest. The researchers also found that the unfavourable first impressions of autistic subjects from allistic raters was reduced when the rater was informed of the subject's neurotype. This may suggest that these unfavourable first impressions are simply the outcome of not understanding the person in the video, recognising that they are different to themselves but not knowing why may trigger the 'us vs them' response. When raters are informed of the subjects' neurotype, they have an explanation as to why this persons behaviours are different to theirs and feelings of hostility and otherness are reduced. Finally, they found that informing autistic raters of the subjects diagnostic status didn't impact first impression ratings, which DeBrander and colleagues suggested meant that they already inferred diagnostic status or that autistic impression formation is less affected by diagnostic status. The fact that knowledge of the subject's diagnostic status impacted the raters' first impressions only in allistic raters suggests that unconscious judgements of neurotype differences specifically relate to allistic judgments of autistic people. These implicit biases could account for miscommunications in mixed-neurotype interactions, particularly in autists who can infer neurotype without being informed. The clear own-neurotype bias in socialisation suggests that social interaction issues are a mixed-neurotype exclusive concern, with same-neurotype interactions being easier and more successful. As such, this provides evidence against the idea that miscommunication is caused by communication deficits in autism and points to other potential mechanisms.

Morrison and colleagues (2020) tested the double empathy hypothesis by assigning autistic and allistic participants to one of three dyads; autistic-autistic, allistic-allistic or mixed neurotype. These dyads had a five minute, unstructured conversation before rating the quality of the interaction and first impressions of their partner. Morrison identified a gap in the existing literature surrounding mixed-neurotype real world social interactions which we have also identified and attempted to address with the current study. In Morrison's experiment, autistic adults were rated significantly more awkward than allistic, as well as less attractive and socially warm by both autistic and allistic participants. Both neurotypes expressed a preference towards future interactions with their own neurotype, and autistic adults disclosed more about themselves to other autists.

Williams and colleagues (2021) had autistic participants have a conversation with various partners about loneliness. The experiment took place over three days and included autistic participants having conversations with various partners, including a chosen partner, an autistic stranger and a non-autistic stranger. Contrary to common belief, high mutual understanding was reported across all interactions, with autistic to autistic conversations having significantly increased flow, rapport and intersubjective attunement (such as shared emotion). While all interactions were successful, the increased rapport reported in autistic-autistic interactions provides strong evidence for the Double Empathy Hypothesis (DEH; Milton, 2012), using a procedure which better matches a real life situation one might find themselves in. However, the study used a total of only eight core autistic participants, meaning only these eight participants took part in each condition. In addition to this, the procedure of five conversations a day for three days is still unnatural, possibly resulting in participants behaving unnaturally.

Gowen et al (2020) worked with focus groups of autistic individuals to identify and address issues faced by the autistic community regarding autism research. Throughout these focus groups, several concerns were raised which, combined, have resulted in the majority of the research being conducted about autism not representing the needs of the autistic community. Generally, autistic individuals expressed a sense of dissatisfaction with the level of engagement received from academics conducting research on autism, with a particular focus on poor communication of both research opportunities and the dissemination of results. The groups then worked together to group these into four categories: pre-study considerations, recruitment of participants, study visit considerations and post-study considerations; and then generated several recommendations for future research. An overarching theme was identified of a need for more information to be provided to participants, an issue which can be easily addressed through the use of participatory research methods, which involve the autistic community from beginning to end. The use of participatory research methods also means that researchers must be clear and upfront about their goals, with outcomes being transparent and focussing on advancing the scientific, social and physical representation of autism. Gowen and colleagues suggested that making these adjustments when researching autism will allow not only for the autistic community to be better represented but also for autistic individuals to feel more comfortable and willing to participate in laboratory based research, increasing the validity of the research field. Based on this, we will seek consistent and detailed feedback from participants about the methodology and research process, as well as hosting focus groups to discuss the findings and plan future experiments with the autistic community.

Based on the Double Empathy Hypothesis (Milton, 2012), Crompton and colleagues (2020) used a diffusion chain method to investigate mixed-neurotype communication. This involved chains of eight participants, made up of either completely autistic, completely allistic a mixture of neurotype participants, passing a 30-point story from person to person. Using this method, Crompton and colleagues found that the loss of information was greatest in mixed-neurotype chains, and no difference was found between autistic and allistic chains. As Milton (2012) theorised, this suggests that communication deficits are not an autistic trait, but instead the outcome of mixed-neurotype interaction. In addition to having the least information transferred, mixed chains had the lowest self-rated rapport. While this provides good evidence for the DEH, diffusion chains like these are rarely seen in real life, so these findings should be interpreted with some caution. More often, people have to work together in groups and communicate to reach a common goal, such as in a co-operative game.

Mutually enjoyed activity focussed on shared interests can help autistic individuals connect with others, suggesting that activity based over instruction based interventions may be preferable for autistic individuals (Bottema-Beutel et al, 2016). Games, in particular video games, are a popular interest among the autistic community, likely due to the consistent and immediate feedback they provide to players (Moore and Calvert, 2016), suggesting video games could be a useful tool not only for interventions, but as a research tool to better understand autism and autistic traits. Based on this, Terlouw and colleagues (2021) worked with a group of autistic and special educational needs (SEN) students to develop 'AScapeD', an escape-room style game with the aim of serving as an activity based intervention. The creators of AScapeD hoped to develop the game as an activity-based intervention to help autistic children with socialising, since the concept of an escape room results in a natural emergence of communication and teamwork. Although the aim of AScapeD was to develop a game which would 'teach' social skills to autistic people, which doesn't align with the neurodiversity movement in autism, AScapeD was shown to enact equal cooperation and communication between autistic and allistic children, showing the benefit of video games for autistic individuals. At the end of game development, Terlouw and colleagues found that all players, irrespective of neurotype, were able to complete the game successfully. This provides further support for the argument that communication is not defective in autistic individuals, as this would mean autistic individuals would struggle more than their non-autistic counterparts, which did not occur. Although this doesn't support the DEH, as this would predict deficits in cross-neurotype interaction, it also does not support the idea that there is a communication deficit in autism.

Social play allows players to practice roles and test social boundaries in a safe environment (Ringland, 2016), possibly explaining why autistic individuals enjoy video games. In particular, Minecraft (Mojang, 2009) is a sandbox video game popular within the autistic community (Khan, 2022). Minecraft is a 'sandbox game', meaning the players have infinite creativity and can complete goals and discover game elements at their own pace. A sandbox video game has no set ending, allowing for many gameplay opportunities (Rouse, 2024). In 'Minecraft', players can choose one of nine default 'skins' (aka 'avatar') or create their own unique 'skin'. Virtual worlds, such as Minecraft, allow those with disabilities to experiment and explore different identities (Stendal, Balandin and Molka-Danielsen, 2011), which can help players overcome social phobias.

In addition to this, some players have set up dedicated Minecraft servers for neurodivergent individuals, which can act as a virtual safe space. 'Autcraft', a multiplayer Minecraft server, is designed for young autistic people and their friends/family (Ringland et al, 2016). This server is adapted to prevent bullying or abuse and acts as a safe space which is accessible to more than an in person intervention may be. Cadieux and Keenan (2020) established a framework known as 'Social Craft', which rehearses key social communication skills in game, to aid autistic children with developing social skills. Servers and interventions like these provide support in a format that is more accessible and fun.

Heasman and Gillespie (2019) provided support for the use of video games to investigate communication with autistic participants. They argued that autistic sociality is too often investigated using neurotypical definitions of being social, resulting in functional communication styles being regarded as dysfunctional by the majority. Heasman and Gillespie, among others, began to investigate why it is that cross-neurotype communication is less effective than same-neurotype, identifying a gap in the existing literature regarding how autistic individuals relate to each other socially outside of neurotypical norms. One possibility, proposed by research such as Chown (2014) is that autistic individuals find it easier to socialise with other autists, due to a lack of social protocol which is present when socialising with non-autistic individuals. Heasman and Gillespie (2019) followed up on this suggestion by investigating within-interaction variability in autistic individuals, examining the features of these interactions. To do this, autistic adults were given the option of several activities such as music, strategy games, Lego, art and video games while the researchers observed their conversations. These observations found that autistic communication contained several features which were typically viewed as dysfunctional by neurotypical standards (Heasman and Gillespie, 2019), but despite this still contained opportunities for rich intersubjectivity. These conversational features included a generous assumption of common ground, meaning that individuals assumed that the other knew as much about the activity as they themselves did, and low demand for coordination, meaning autistic individuals may discuss multiple topics at a time or experience misunderstandings without it impacting how much they enjoyed the interaction. ‘Misunderstandings’ were described by Heasman and Gillespie as small scale and resulting from ignored turns, parallel dialogue and misreading pragmatic/emotional context. Autists showed a 'low coordination threshold' which allowed them to move on faster from these misunderstandings, therefore limiting their impact on enjoyment. To further understand potential differences in communication within neurotype versus between neurotypes, this method should be recreated using also cross-neurotype and allistic to allistic interactions to see how this effect applies more generally. We aim to address this by examining participants in either cross or same neurotype interactions.

Research Gaps and Motivations

Although studies such as Crompton et al (2020) and Williams et al (2021) provide compelling evidence for the Double Empathy Hypothesis (Milton, 2012), the methodology used in these experiments is not reflective of a real life situation one would find themselves in, and therefore may not be ideal for measuring communication. For example, one could argue that the diffusion chain method, in addition to being extremely unnatural, is more a measure of memory than communication. In order to generalise these findings and show the double empathy hypothesis in action, we must use lab procedures which are more lifelike and accessible for neurodivergent participants. Williams et al (2021), whilst an improvement on the diffusion chain methodology, also uses procedures unlike any situation one would encounter in everyday life, having participants take part in structured conversations with different partners over several days. While the procedure uses a conversational structure, the order and timing of the conversations is very unnatural and likely disrupts the natural flow of conversation. To combat this issue, we decided to use a co-operative joint task (such as a video game) to measure communication between different neurotypes.

In addition to this, Crompton and colleagues informed participants of the neurotype of their partner, however they were not told what this means for their interaction, how an autistic person may communicate differently, why this might cause issues communicating or anything about the double empathy hypothesis. Crompton and colleagues (2020) established that information loss was greatest in mixed-neurotype pairs, and the DEH suggests this is due to misunderstandings from both parties. To prevent these miscommunications, one could educate both parties involved in the interaction on different communication styles and the DEH, hypothetically resulting in fewer miscommunications and a smoother, more successful interaction. None of the existing studies discussed have educated participants on this theory, so we plan on informing some of our mixed-neurotype chains on the DEH and communication styles, with the aim of reducing miscommunications.

With the exception of newer, more neurodiversity affirming research, a vast majority of existing autism literature focusses on children (Nicolaidis et al, 2019), despite acknowledging that autism is a neurodevelopmental disorder and therefore persists throughout adulthood. Social differences and hierarchies are present throughout one's whole life, not just childhood, and therefore it is important to understand how autism impacts somebody from birth through to adulthood and how we can support autists of all different ages. For example, autistic adults have been shown to have difficulties with decision making (Luke et al, 2011), mental health (Moss et al, 2015) and often report a lack of social support (Camm-Crosbie et al, 2018). In addition to this, social communication difficulties and repetitive behaviours identified as a core diagnostic feature of autism have been identified as key predictors of anxiety in autistic adults (Kuzminskaite et al, 2020), clearly showing how difficulties faced by autistic children persist into adulthood. In order to add more valuable insight to the existing literature, this study focusses on young adults, mainly university students, to investigate communication difficulties beyond childhood and how these can be prevented.

Despite the recent neurodiversity movement in research, a lot of the existing autism literature focusses on either 'treating' autism, for example 'Teaching social skills to people with autism' (Weiss and Harris, 2001), or focusses heavily on the parents/friends/family of autistic individuals, such as 'The relationship between autism and parenting stress' (Schieve et al, 2007). Research like this perpetuates the idea that autism is something 'wrong' to be fixed and increases to the already overwhelming stigma faced by autistic people. Instead of focussing on fixing autistic people, the neurodiversity approach suggest that research should focus on identifying why autistic people struggle and what can be done to support, rather than change, them. Participatory research methods help to combat this issue by involving members of the autistic community in the generation and follow through of research. Fletcher and colleagues (2019) generated a framework for participatory autism research comprised of five concepts essential for the facilitation of meaningful autism research. These concepts are as follows: (i) respect, emphasising the importance of respectfully representing the autistic lived experience (ii) authenticity, outlining how autistic non-researchers should be involved in the generation of research questions (iii) assumptions, which describes the necessity of autistic leadership and advocacy (iv) infrastructure, which explains how to support and encourage autistic academics and activists, such as through participatory research methods and (v) empathy, building effective working partnerships.(. Fletcher-Watson suggested that work which uses this framework, conducted by and with partnership from autistic individuals to a high standard is likely to lead to greater impact and support for the community.

Research Questions and Hypotheses – Study One (Diffusion Chain)

With this study, we aim to answer two key questions, first, we aim to examine if increasing awareness of autistic communication styles and potential differences will improve the efficiency and quality of cross-neurotype interactions. This is because Milton's (2012) Double Empathy Hypothesis suggests miscommunications in mixed-neurotype interactions are due to mutual misunderstanding from both parties, so informing both parties of communication styles and where miscommunications could occur may increase the efficiency of mixed-neurotype communication.

Based on the findings of Crompton et al (2020), we hypothesise that mixed-neurotype chains will transfer the least points of the story. We additionally manipulated the information provided to participants in mixed-neurotype chains, and predict that (i) participants who are informed about the double empathy hypothesis will transfer more points of the story than those who are not and (ii) the difference between same- and mixed-neurotype chains will be reduced when participants are informed.

In addition to the number of story points recalled, we collected participants'' self-reported rapport scores for their partners, and we hypothesise that (i) rapport will be lowest in mixed-informed chains but (ii) rapport in mixed-informed chains will be higher than in mixed-uninformed.

Research Questions and Hypotheses – Study Two (Minecraft)

In addition to examining communication using the diffusion chain method, we hope to answer the question: How do previous findings using diffusion chain method transfer to more natural communication and collaboration, such as in a joint problem solving task? Although Crompton et al (2020) provides strong support for Milton's double empathy hypothesis, the diffusion chain methodology used is unnatural and time consuming to organise, limiting the generalisability of their findings. To improve on this, we will use the game Minecraft as the experimental task to better reflect real-life information transfer.

Based on concerns surrounding the realism of the diffusion chain methodology, we chose to use a second, more realistic video game based task for the second study, in which we also predicted that mixed-neurotype pairs would take longest to complete the task due to having the least efficient communication. Again, we additionally expect that mixed-informed pairs will be faster than uninformed pairs. As with the diffusion chain study, we expect rapport to be lowest in mixed-neurotype chains but that this difference will be less in mixed-informed pairs.

Methods

A Note on Ethics

Both experiments were carried out in accordance with the British Psychological Society (BPS) code on human research ethics. All procedures were reviewed and approved by the University of Essex research ethics committee.

All participants provided written informed consent before participating and were informed they could withdraw at any point (The information sheet and consent form given to participants can be seen in the appendix (Figure A1; A2)). Before participating, participants were asked if they would like to be reimbursed with £5, 1 SONA credit (SONA is a research participation website where individuals can view and sign up for studies that are looking for participants, students in the Department of Psychology at the University of Essex are required to obtain 5 SONA credits per year, one SONA credit is equivalent to an hour of participating in research) or just for fun.

Study 1 – Diffusion Chain Task

Participants

This study was based on methods developed by Crompton and colleagues (2020), which required 8 participants at a time to be completed. As a result of this, recruitment for this study was restricted and difficult, resulting in a very small sample.

As part of the neurodiversity movement in research, formal diagnosis was not necessary for autistic participants. This decision was not made lightly, as recent studies have shown self-identification in autism is as reliable as formal diagnosis, showing no significant difference in traits of self-identified and formally diagnosed autistic participants (Bloem et al, 2024). Instead, all participants completed a pre-screening test to check their eligibility, within which they were asked whether they identified as autistic or not. Autistic participants completed the Ritvo Autism Asperger Diagnostic Scale – Revised (RAADS-R, Ritvo et al, 2011), and were required to obtain a minimum score of 70, as was specified in Crompton and colleagues original paper. Allistic participants completed the Autism Spectrum Quotient (ASQ, Baron-Cohen et al, 2001) and were required to score less than 30, again, as outlined by Crompton and colleagues. In total, 16 participants completed the diffusion chain task, 12 of which identified as autistic (M = 151.61, SD = 39.85) and 4 allistic (M = 19.65, SD = 7.38). These made two complete diffusion chains, one fully autistic and one mixed-informed neurotype.

Autistic participants were primarily recruited through the AuDHD Neurodivergent Society at the University of Essex. Allistic and other autistic participants were recruited using SONA and posters around campus.

Design

For this experiment, we used a 3 (interaction type: same-autistic, same-allistic, mixed) x 2 (informed vs uninformed) between subjects design. For our primary analysis, we measured the number of points successfully communicated by both the chain and individual participant. In addition to this, participants' rapport ratings for both partners were measured. Rapport ratings were made across five 100-point scales (ease, enjoyment, success, friendliness, awkwardness) which were averaged together to create a rapport score, where 1 reflected the lowest and 100 the maximum rating.

The independent variables in this study were interaction type (same-autistic, same-allistic, mixed) and 'informed' vs 'uninformed'. Interaction type was determined based on availability of participants, whereas the informed/uninformed condition was randomly assigned.

Materials and Apparatus

The first materials presented to participants were the pre-screening surveys, completed online via Qualtrics. These surveys were versions of the Autism Spectrum Quotient (ASQ, Baron-Cohen et al, 2001) for allistic participants, and the RAADS-R (Ritvo et al, 2011) for autistic participants. Within this survey, participants were asked to tell us their availability and based on this information we formed groups of 10 participants to come and complete experiment, meaning not everybody who completed the pre-screening survey completed the experiment. Before completing the diffusion chain task, but after completing the consent form, participants in the ‘informed’ condition were presented with a brief summary of the Double Empathy Problem (Milton, 2012), written by myself, which can be found in the appendix (Figure A3). This summary was 141 words, presented on an A4 printout in size 18 font. During the task, participants pass a story along the chain. This was a 30-point story about a bear (Crompton and Fletcher-Watson, 2019), the story was designed to be difficult to predict and can also be found in the appendix (Figure A4). Throughout the task, participants were audio recorded using a Dell laptop for scoring.

After completing the diffusion chain task, participants completed an online survey via Qualtrics, comprised of 20 questions. The first two questions ask the participant to rate the interaction with their first, then second partner. These ratings are recorded through five 100-point Likert scales, asking participants to rate how easy, enjoyable, successful, awkward the interaction was as well as how friendly their partner appeared. After completing the rapport ratings, participants have a chance to leave a comment about their partner.

Question five asks participants to rate how well they felt they communicated the story to their first, then second partner, mistakenly on a 100-point Likert scale, rather than the five point Likert scale used in the following questions. The following two questions ask the participant how enjoyable they believed their partners found their interactions, on a 5 point Likert scale (1 = Definitely not, 5 = Definitely yes), followed by two questions asking if they believed they appeared friendly in these interactions, also on a 5-point Likert scale. Finally, the survey ends with a question asking participants how much they enjoyed the diffusion chain task (5 point Likert scale, hated it = 1, loved it = 5) and a chance to leave anymore comments about this task.

Procedure

For the first study, we used a diffusion chain method, based on methodology used by Crompton and colleagues (2020) in their original study. These diffusion chains were made up of either completely autistic (same-autistic), completely allistic (same-allistic) or mixed neurotype participants. Mixed-neurotype chains always began with an allistic participant and then alternated, allistic-autistic-allistic and so on. However, the original experiments all began with an allistic researcher. In this study, I was the researcher and therefore all mixed and allistic chains started with an autistic researcher. Before completing the diffusion chain task, participants were informed which condition they were in, as was the procedure in the original experiment.

Due to the nature of the task, each session of data collection involved eight participants. To avoid interacting prior to the task, participants were taken to separate booths after arriving to complete consent forms. Once all eight participants had arrived, the experiment could begin. Participants' position in the chain was randomised, however this still adhered to the allistic-autistic pattern in the mixed chains. The first participant in the chain is taken from their booth into a room with the researcher and a laptop (for audio recording). The researcher then read the story to the first participant, participants are told to remember the points of the story, as opposed to the actual words to avoid the task becoming too memory-reliant. Once the first participant (P1) has heard the story, the researcher leaves and the second participant (P1) enters. P1 repeats the story to P2, then leaves and the third participant (P3) enters. This is repeated until the final participant in the chain (P8) has heard the story. P8 repeats the story aloud for the researcher, and is then taken back to their booth. Once a participant had completed the diffusion chain task, they were asked to complete a short online survey via Qualtrics. This survey first asked participants to rate their rapport with their first, then second partner as well as other questions (outlined in the 'materials and apparatus' section above).

Data Preparation

Throughout the diffusion chain task, participants are being audio recorded using a laptop. These audio recordings were then scored using the scoring template provided by Crompton and colleagues (2020). Scores are collected for the chain, as well as for individual participants. The planned analyses was to run a between-subjects Analysis of Variance (ANOVA) to identify which group successfully transferred the most information. However, due to issues with recruitment and lost data as a result of a broken USB stick we didn't collect enough data to analyse. Descriptive data was still obtained and analysed, as will be outlined in the results section, below.

Post-study survey responses, however, were still collected able to be analysed for rapport and self-communication scores. Rapport ratings were taken across 5 100-point scales, most of which could be analysed as raw data. The awkwardness ratings however, needed to be reverse scored before analysis. Awkwardness scores were reverse scored using the formula '100 – X' in Microsoft Excel. The ease, enjoyment, success, friendliness and reverse scored awkwardness scores were averaged to find a mean rapport score for each partner. Self-communication scores were able to be inputted directly into SPSS, needing no pre-processing.

Study 2 – Minecraft

Participants

Participants who completed the Minecraft experiment were from the same participant pool as the pre-screening survey, meaning recruitment and average pre-screening scores are the same as outlined in study 1, above. All participants who completed the diffusion chain task completed the Minecraft task directly after the diffusion chain task ended. Unfortunately, due to misinterpreting ethics guidelines, I did not allow any way for a participants pre-screening data to link to their performance in the experiments, meaning all pre-screening data was analysed, not just those who participated. The full breakdown of number of participants in each stage of the experiment and condition can be seen in Figure 1, below.

Figure 1*A Flow Chart Representing the Number of Participants in Each Stage of Stage of Study*

In addition to filling out an autism pre-screening test (ASQ or RAADS-R), participants were asked to rate their Minecraft skill and experience, which were both measured on a 100-point Likert scale and then averaged to find a participant's 'Minecraft Score'. This survey collected a total of 158 responses (105 unique responses, 35 autistic and 70 allistic).

However, not every participant who filled in the pre-screening survey participated in the Minecraft experiment. Of these survey responses, autistic participants had an average Minecraft score of 46.87 (N = 27, SD = 29.93), whereas allistic participants had an average score of 40.05 (N = 60, SD = 32.19). Due to Minecraft being a common interest in autistic people (Khan, 2022), we expected that autistic participants would score significantly higher on Minecraft skill. However, an independent samples t-test was run on the pre-screening data and revealed no significant effect of neurotype on self-reported Minecraft skill: $t(86) = .936$, $p = .352$.To further ensure that Minecraft skill or experience had little impact on participants' performance, pairs were paired based on their scores, matching less experienced players with those who were more confident. For the Minecraft experiment, we had a total of 50 participants, 22 of which identified as autistic and were assigned to either the 'same' or 'mixed' conditions; 14 (63.6%) of autistic participants were assigned to the 'same-autistic' condition, four (18.2%) were assigned to the mixed-uninformed condition and the final four (18.2%) to the mixed-informed condition. A total of 28 allistic participants were obtained, with 20 (71.4%) of these participating in the same-allistic condition, four (14.3%) in the mixed-uninformed and mixed-informed conditions. Due to uneven sample sizes, we combined the two mixed-neurotype conditions, resulting in this new 'mixed-neurotype' condition being made up of 16 total participants; 8 (36.4%) autistic and 8 (28.6%) allistic participants.

Design

This study used a one factor between-subjects design with four levels (mixed-informed, mixed-uninformed, same-autistic and same-allistic) in which we measured the time it took pairs to complete the Minecraft map, as well as rapport ratings for each partner. Participants were randomly assigned to one of three interaction type conditions depending on if their partner was autistic or allistic, and those in the mixed-neurotype condition were then assigned to either an informed or uninformed condition. In total, we had 7 (20.3%) same-autistic, 20 same-allistic (29%), 8 mixed-uninformed (11.6%) and 8 mixed-informed (11.6%) pairs complete the Minecraft experiment.

Materials

As discussed in Study 1, above, all participants completed pre-screening surveys to check their eligibility. Full details in the 'materials and apparatus' section of study 1. In addition to the autism pre-screening surveys, participants were asked to rate their Minecraft skill and experience. As in study 1, participants in the informed condition read a brief summary of the double empathy problem (Milton, 2012).

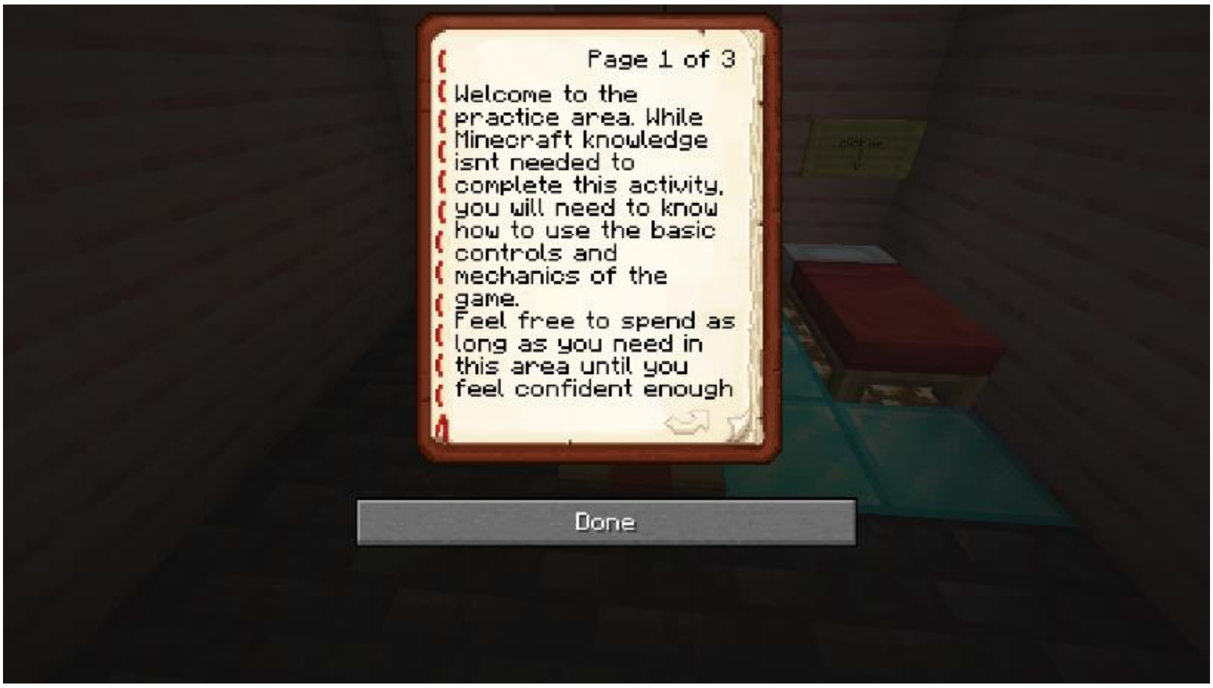
The task was an escape room style Minecraft map, in which pairs worked together to complete puzzles and progress throughout the map. The task was designed to be cooperative, using mechanics such as redstone and-gates to prevent players from progressing the map without their partner. Redstone (Mojang, 2009) is a built-in electrical wiring type system in Minecraft, used to move objects and create circuits. Utilising redstone circuits, I built 'and-gates' which prevented players form progressing without their partner. 'And-gates' use a two-switch design to open doors, meaning both players must have switched their levers for the doors to open. This map was made by inspired by similar examples displayed in YouTube videos and my own experience with the game Minecraft. The puzzles were designed to be based on information transfer, as opposed to Minecraft skill, to avoid the task becoming too skill-dependant instead of measuring communication.

Before completing the Minecraft task, participants had the chance to complete a practice area, which contained instructions and examples of everything they needed to know how to do in Minecraft to complete the task. The practice area contained nine rooms which the participants could progress through at their own pace, containing both written

text instructions and examples. Participants each had their own practice area but could work with their partner to get through it. The first room in the practice area contained a bed and a lectern with a book on it (Figure 2). When participants arrived, the first book was already open for them with the basic controls.

Figure 2

Instructions provided to Participants' in the First Practice Room



To progress from this room to the next, participants opened four doors, giving them a chance to practice the basic controls of interacting with objects and moving their avatar. The following room explained to the participant that they were in 'adventure mode', meaning their avatar could die in game. They're then instructed to go through a door which leads them into lava, providing an example of how they can die in game, since this will be relevant in the main task. At this point, they're also advised to use any beds they may see as these act as 'respawn points', where they will start again should their avatar die during the task. The third room contained four doors, showing the different ways that doors can be opened in Minecraft. Room four explained how 'redstone' works, showing the participant that doors can be opened from further away. Continuing from this, the fifth room showed how redstone can be used to move blocks, and the sixth room tells participants how to jump, and how to use 'water elevators'. The following room contains only a lectern with a book, telling them that they can avoid lava death by getting into water fast. The penultimate room contains just a lectern with a book and a chest. This room provides step by step instructions on how to take items out of chests, and how to read books this way. This is explained to them as books are primarily presented in chests throughout the task. The final room (Figure 3) contains a chest with a book and an anvil. The book provides instructions on how to use the anvil to rename it, as well as a second book titled 'Finished?' with instructions for the participants when they have finished the practice area.

The puzzle map was made up of 11 unique (12 total) rooms, completed side by side but separate from their partner. Participants completed the map in 'adventure mode', meaning they could interact with objects and take damage but couldn't break blocks or leave the test area. In addition to this, the world was set to 'peaceful mode' to prevent monsters from spawning.

Figure 3

Participant View of the Final Practice Room

Room One of the puzzle area (Figure 4) contains a bed, a door, and a glass wall allowing participants to see each other in game. To progress through this room, they each need to press the levers in their room, which opens their partner's door.

Figure 4

Participant view of the 'Spawn Room'

The following room, named the ‘Lava Border’ room (Figure 5) presents the participants with three pits of lava. Each room had a coloured border (red or orange), which corresponded with the coloured border of one of their partners lava pits. The lava pits have water hidden beneath it, preventing participants’ avatar from dying. Participants were advised to tell their partners everything they saw, ideally resulting in them discovering the lava pit which matches the border of their room is safe. In addition to the lava pits, this room has a glass wall which allows the players to see into each other’s rooms.

Figure 5

'Lava Border' room

The next room, named the 'Garden Room' (Figure 6) provides each player a unique clue to find a lever to open the door in their room. These clues, when combined, will allow players to find their levers and once both players have done so, the doors will open (Image 10). Player 1's hint reads 'follow the falling petals to find your lever. Your partner could use this same advice…', whereas Player 2's hint says 'While your lever is nearby, your partner will need to look a bit further out'. Once again, this room has a glass wall allowing players to look into each other's rooms.

Figure 6

The Garden Room

The next room, named the 'Maze Room', contains three labelled routes which seem to go to the exit (Figure 7). However, only one of these routes will take them to the door, the others are blocked with invisible barrier blocks. Each player is given instructions on a sign saying 'go left', 'go middle' or 'go right', which tells them which route their partner must take. Each player has a different solution, meaning they had to share their instructions to solve the puzzle. In this room, participants were blocked from seeing into each other's rooms.

Figure 7

Participants' View of the Maze Room

After the Maze room, participants entered the 'Buttons room'. The walls, ceiling and floor of this room were covered in different methods of opening doors, except for a glass window allowing them to look into their partner's room (Figure 8). In order to solve this puzzle, each player is provided with a clue to help their partner. These clues were 'your switches are both on the same-coloured block' and 'you are both looking for a lever', with the purpose of encouraging sharing information.

Figure 8

The 'Buttons' Room

The following puzzle – the 'secret staircase' – is across a few rooms. The beginning of this puzzle puts player one in an empty room, with nothing but a sign that reads 'looks like you could use a way UP' on a yellow block (Figure 9). Player two, on the other hand, is presented with three levers on different coloured blocks, one of which is on a yellow block and reveals the staircase, and a sign that reads 'looks like your partner could use a hand. But which lever should you pull?' Once they've pressed the correct lever, a staircase appears in player one's room which takes them up to another room with a lever to let their partner up.

Figure 9

The Secret Staircase Rooms

The first of four ‘Colour rooms’, presented players with six colours and informed if these colours are safe or unsafe (Figure 10). There is no puzzle to be solved in this room, however both players must be present to move onto the next room with the first ‘colour room’ puzzle. This room (Figure 11) works the same as the lava border room, one of the lava pits has water beneath it to allow players to pass through safely, participants had to use information provided to their partner in the previous room.

Figure 10

The First Colour Room

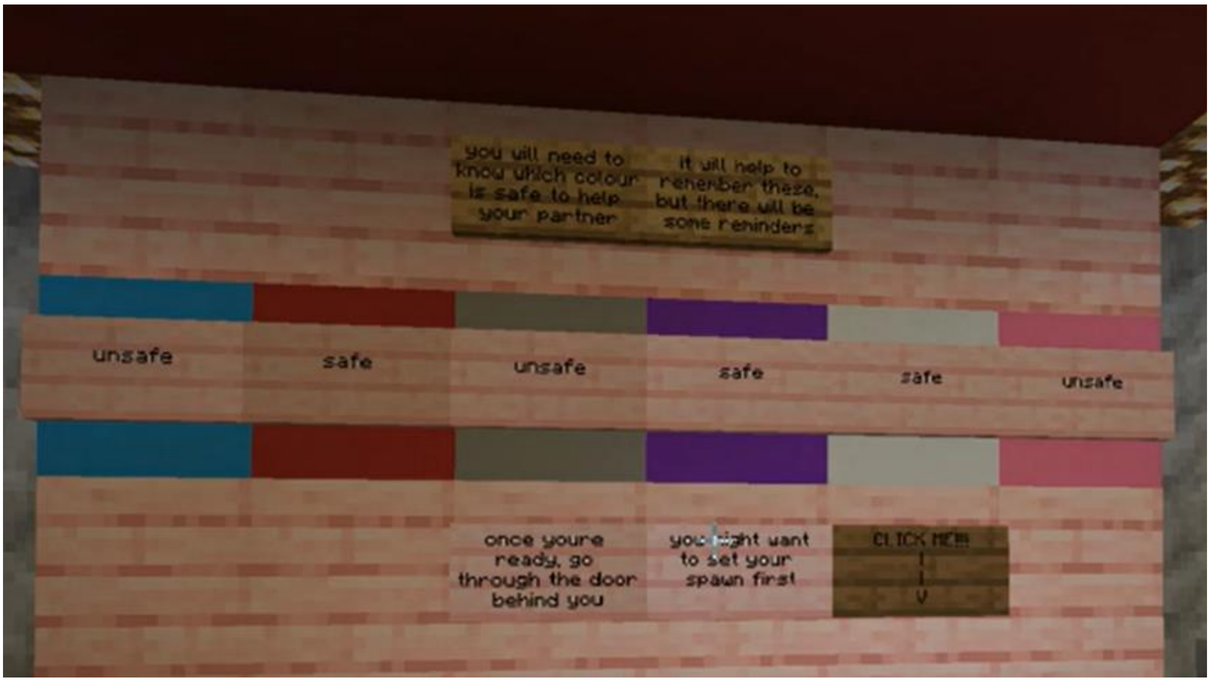


Figure 11

The First Colours Puzzle

The final two colour rooms are identical, but duplicated so that each participant completes each side of the interaction. First, Player one is brought into a room with three doors with different coloured paths leading to them (Figure 12). Player 2 is brought into a room with six coloured blocks above them (Figure 13), these are the same as the colours they saw in the previous room (Figure 10, above).

Figure 12

One of Two Colour Room Puzzles

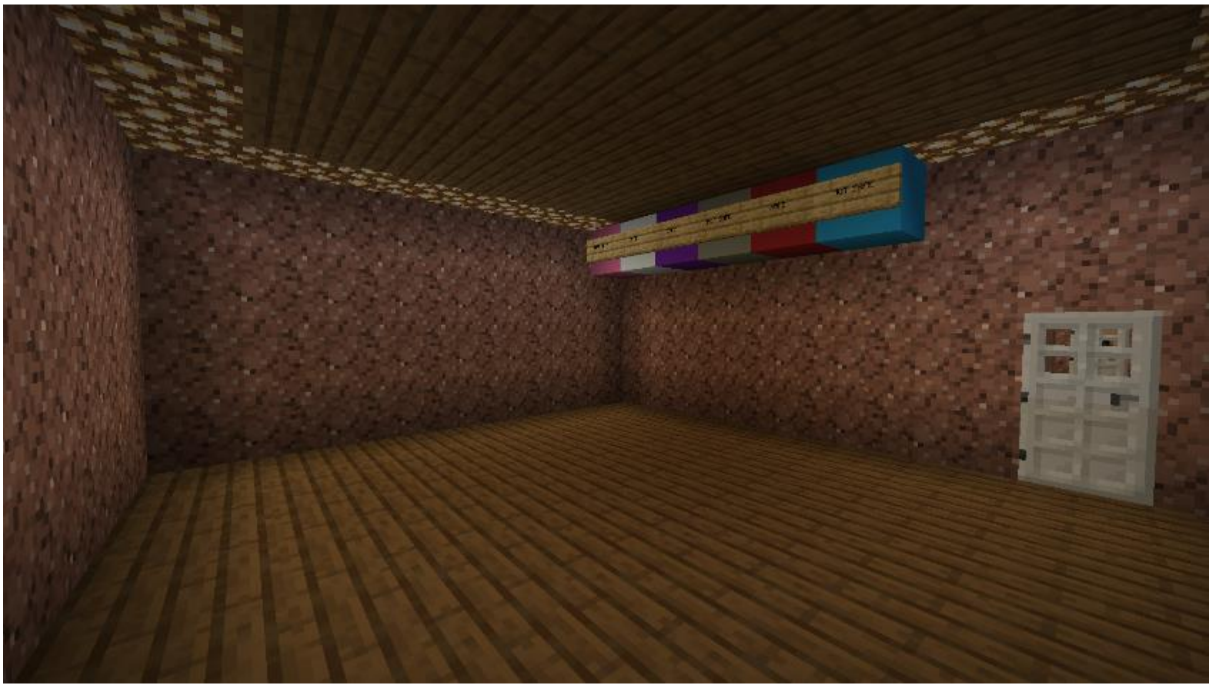


Figure 13

Information Provided to Participants in the Final Colour Rooms

To choose the correct door, player 1 must tell their partner what they see, allowing player 2 to tell them which door is safe. If they are successful, P1 will be taken into a room similar to the room their partner is room, but with a lever to let their partner through. The previous rooms are repeated, but this time with P2 having to choose a door and P1 with six coloured blocks. If they go through the incorrect door, they walk into lava and die.

After completing the colour rooms, participants are taken into the Lava Wall room (Figure 14). This room is similar to the lava border room, presenting participants with three pits of lava with different coloured borders, one of which has water beneath it making it safe to pass through. However, in this rendition of the puzzle, participants are not able to look into each other's rooms and the correct pit is the one that corresponds with the wall in their partner's room.

Figure 14

The 'Lava Border' Room

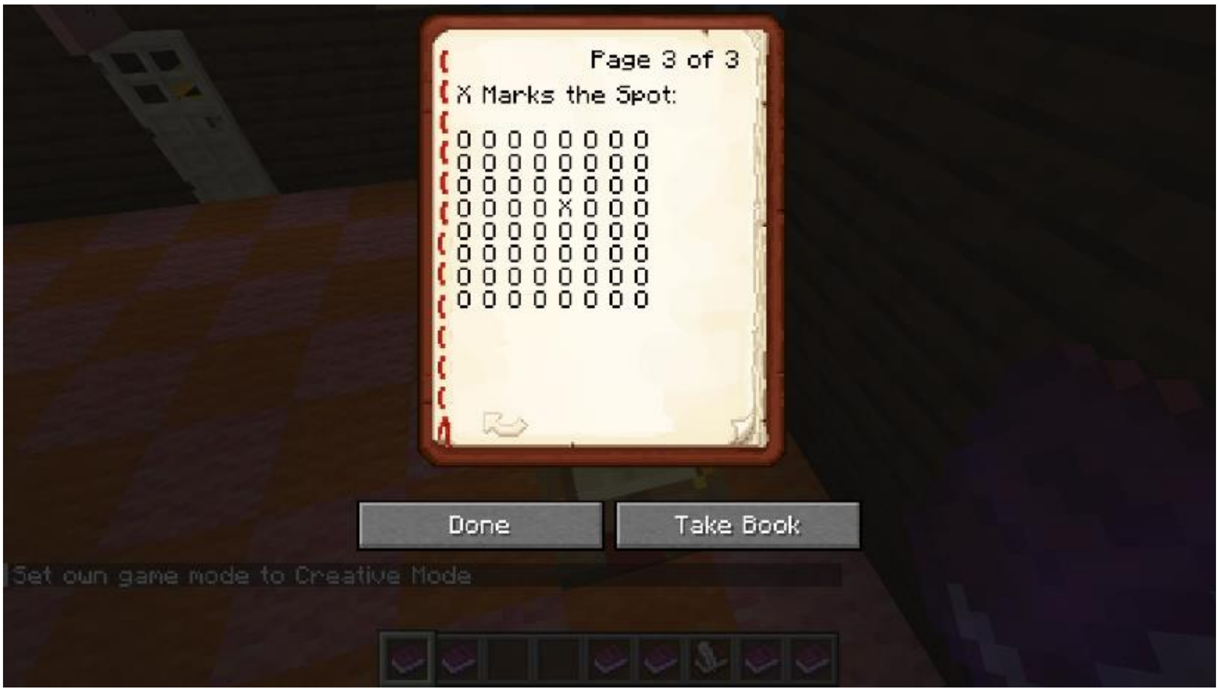
The final two puzzles, named the 'password rooms' are similar, with the second of the two requiring more information transfer. The first password room presents the participants with a lectern, a double chest containing many pieces of paper and an exit (Figure 15). In the book, participants are told their partner's password and given a map showing where to place the password (Figure 16).

Figure 15

The First Password Room

Figure 16

An Example of the Map Provided to Participants



The second puzzle room is very similar, however in this room there is also an anvil (Figure 17). In their books, participants are again told what their partner's password is and where to put it. This time, however, they are instructed to rename a piece of paper with the correct password, rather than being given the password. Once they've completed the final password room, they have completed the task and are taken into a congratulations room (Figure 18).

Figure 17

The Second Password Room

Figure 18

The Final Room

After completing the Minecraft task, participants are asked to fill in a short online survey via Qualtrics. First, the survey asks them to rate their rapport with their partner, as was outlined in the 'materials and apparatus' section in Study 1 (above), followed by a chance to leave a comment about their partner. Autistic participants were also asked if they preferred person first or identity first language.

Apparatus

All participants completed the task using identical computers (PCs) and Minecraft Java Edition, version 1.20.4. The computers used were Dell OptiPlex 5490 All-in-one, with a 23.8" screen, Intel 11th gen i5 processor. They had 16GB RAM, 512GB NVMe SSD and a GTX 1650 Graphics card.

The resolution in Minecraft was 1920x1080 @60 (24bit), and the render distance was set to 15 chunks. Participants played on an internal server which runs through 11 computers (computers described above). NVidia Experience was used to record gameplay and audio in the room.

Procedure

When they arrived, participants were taken into a booth with two computers, chairs, information sheets and consent forms. This is where they, and their partner completed the whole experiment. Participants began by reading the information sheet and filling in a consent form. They then were able to begin working through the practice area, which included text instructions and a chance to practice controls that they would need to know for the task. Each participant had their own practice area, however, partners were able to talk, help each other out and work together to get through the areas. Those who rated themselves particularly low on Minecraft skill were recommended to work closely with their partner in the practice area. Once participants reached the end of the practice area, and both members of the pair were confident to move on, they sent a message in the in-game chat to let the researcher know.

The researcher then teleported the players to the starting positions, however they were instructed not to begin the task until the researcher had returned. Before beginning the task, all participants were given the same instructions, along the lines of ‘This map is designed to be cooperative so work together, share information, say what you see. It is built to be impossible to complete alone so if you find yourself stuck at any point it’s probably something you need to do with your partner. It’s been test run a bunch of times so I promise it does all work, again, if you’re stuck maybe you’ve missed something you need to do together. If you see a bed please use it, you will die throughout the game and if you don’t use the beds you’ll be stuck. When you’re done let me know but I will be in game spectating too, have fun!' The map was made up of 12 rooms completed as pairs, side by side but separated by a wall. Depending on skill and effectiveness of communication, the map took between 15 to 45 minutes to complete. After finishing the map, participants were asked to fill in a short online survey via Qualtrics which asked them to rate their rapport with their partner.

Data Preparation

Throughout the task, data was collected using screen recording software which captures gameplay as well as the audio in the room. These recordings have been used to work out how long each pair took to complete each individual room, as well as the whole map. Two of the pairs didn't finish the map, so for these pairs their times are listed as 'DNF' (Did not finish).

Post study survey responses were collected by Qualtrics and analysed in SPSS for rapport ratings. Rapport ratings were taken across 5 100-point Likert scales, these scales were ease, enjoyment, success, friendliness and awkwardness. The final scale, awkwardness, was reverse scored, and therefore the scores had to be reversed before analysis. Each awkwardness scored was reversed using the formula '100 – X', which was then used in combination with the other 4 scales to find an average rapport score for their partner.

Results

Study 1 – Diffusion Chain Task

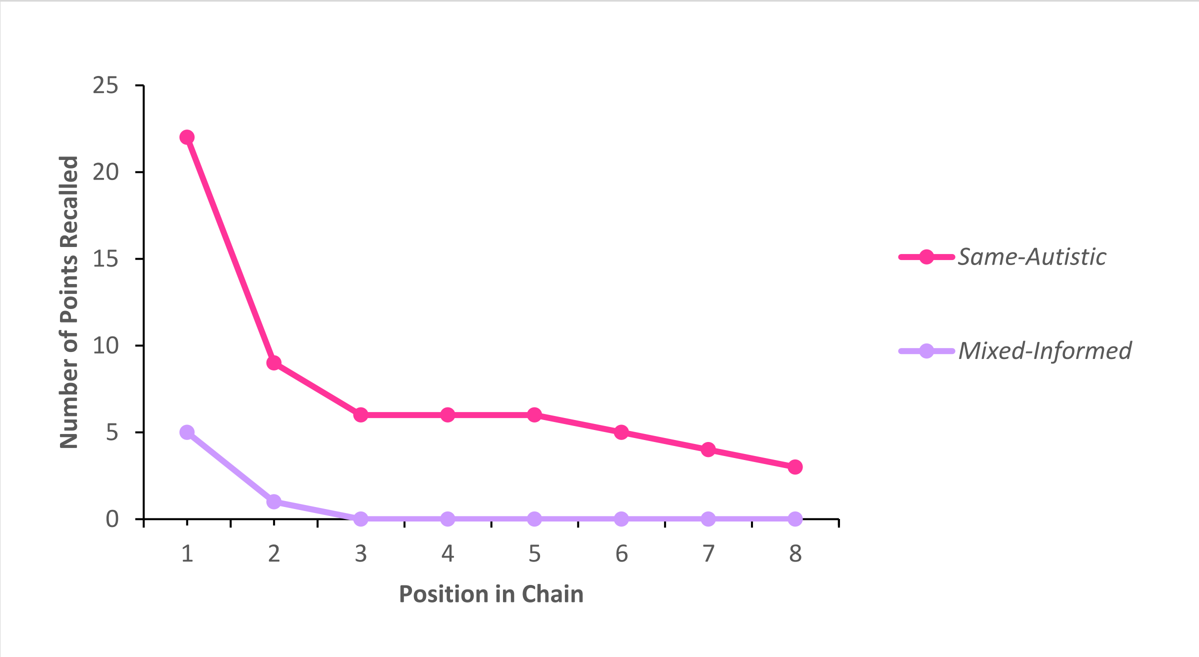
Diffusion Chain Data

Unfortunately, due to issues with recruitment, we weren't able to gather enough data to conduct a meaningful analysis of this task, with only two 'chains' of usable data. The first group (same-autistic) recalled 3 points (10%) of the story, with the first participant in the chain recalling just 17 points (56%). The second chain (mixed-informed) recalled 0 points in total, with the first person in the chain recalling only 5 of the story points (16.6%). Figure 18, below shows the number of points recalled by each participant

On average, the chains recalled 1.5 points (*SD* = 2.12) points, and each participant recalled an average 3.81 points (*SD* = 4.51). Based on previous findings (such as those by Crompton and colleagues) we predicted that there would be no significant difference between same-autistic and same-allistic chains. However, given that we only had one chain of each type we did not conduct any inferential statistics on our data. Further, it is evident from Figure 19 that the one mixed chain had significant loss of recalled points already on the first participant, suggesting a potential problem with the data from this chain.

Figure 19

Number of Points Recalled by Position in Chain



Rapport Data

Two additional groups participated in the diffusion chain task, however this data was lost. Their rapport ratings, on the other hand, were stored safely, meaning we have more rapport data for this first study than for the diffusion chain task. This meant we had a total of 32 participants for the analysis of rapport ratings. In addition to recording the number of points recalled, participants' rapport ratings with each of their partners was collected and analysed. We expected that rapport ratings would be lowest in mixed-uninformed chains, and highest in same-autistic chains. As mentioned above, we didn't collect enough data to conduct meaningful analyses. Descriptive data for participants' partner rapport ratings are summarised in Table 1, below.

Table 1

Descriptive Statistics for Rapport Ratings in the Diffusion Chain Task

Variable	Minimum Score	Maximum Score	Mean (Standard Deviation)
Ease	17.5	100	67.02 (22.2)
Enjoyment	0	100	65.6 (23.6)
Success	13	100	65.1 (23.7)
Friendliness	50	100	78.0 (15.4)
Awkwardness, reverse	0	100	54.8 (25.6)
Average	44	100	69.5 (17.0)

In addition to rating rapport with their partners, participants ranked how well they believed they communicated with their partners, and how they believe they appeared during these interactions these scores are summarised in Table 2, below.

Table 2

Descriptive Statistics for Self-Communication Ratings in the Diffusion Chain Task

Variable	Minimum Score	Maximum Score	Mean (Standard Deviation)
Self-Communication	3	52	22.6 (14)
Self-Enjoyment	2.5	5	3.7 (0.64)
Self-Friendliness	2.5	5	3.7 (0.6)

Written Responses. In the post-study survey, participants were given the opportunity to leave a comment about their partner and the diffusion chain task, as part of the participatory research methodology. These comments can be seen summarised below, by chain type.

Same-Autistic:

'It was comedic. Although I was confused if communication or memory was being tested. Like I'm a forgetful person sometimes'

'Try different order variations with different stories'

Mixed-Neurotype:

'It made me anxious'

'It was interesting to see how differently I conveyed the story and what points I could remember'

Study 2 – Minecraft

Minecraft Data

Screen recording was used to work out how long participants spent not only to complete the whole map, but also on individual rooms. On average, participants spent 29.4 minutes completing the Minecraft map, spending the most time in rooms 10 (M = 6.1 minutes) and 11 (*M* = 5.3 minutes). Full descriptive statistics for time spent in the map can be seen in Table 3, below.

Table 3

Descriptive Statistics of Time Taken in the Minecraft Map

Area	Minimum Time to Complete (minutes)	Maximum Time to Complete (minutes)	Mean (Standard Deviation)
Whole map	12	60 (Did Not Finish)	29.4 (14.9)
Room 1	0.05	3.9	1.03 (1.1)
Room 2	0.07	12	2.9 (3.1)
Room 3	0.63	7.8	2.9 (2.2)
Room 4	0.58	4.7	1.8 (1.03)
Room 5	0.75	5.1	2.2 (1.4)
Room 6	0.35	6	1.6 (1.4)
Room 7	0.15	1.8	0.65 (0.5)
Room 8	0.9	5.4	2.1 (1.2)
Room 9	0.27	3.1	1.1 9(0.7)
Room 10	0.95	20.9	6.1 (4.8)
Room 11	1.78	16.35	5.3 (4.5)

In addition to this, the average time taken per pair type can be seen outlined below in Table 4.

Table 4

Average Time Taken to Complete the Map (by Pair Type)

Pair Type	Mean	Standard Error	Lower Bound	Upper Bound
Same-Autistic	17.3	3.4	10.4	24.2
Same-Allistic	37.5	2.9	31.6	43.4
Mixed-Uninformed	24.6	4.1	16.3	32.9
Mixed-Informed	36.3	4.4	27.5	45.1

Due to the complexity of recruiting participants for the aforementioned diffusion chain task, we had only four pairs in the mixed-informed condition, resulting in a very uneven sample. To combat this, statistical analysis was only conducted with the two mixed-neurotype conditions combined, resulting in a more evenly distributed sample. Updated descriptive statistics can be seen in Table 5, below, showing that same-autistic pairs still completed the Minecraft map fastest on average.

Table 5

Descriptive Statistics for Time Taken to Complete the Minecraft Task (Combined Mixed Chains)

Pair Type	N	Minimum	Maximum	Mean (Standard Deviation)
Same-Autistic	14	12	30	17.8 (6.44)
Same-Allistic	18	16.17	60	37.5 (15.74)
Mixed Neurotype	16	12	60	29.43 (13.01)

In addition to this, a few participants found the final two rooms more difficult than the others, potentially due to it being more reliant on Minecraft skill, rather than communication. As seen in Table 3 (above) the maximum time to complete these rooms was much greater than all other rooms, while the standard deviation was also 3 times higher than any other room. For this reason, we have chosen to re-run the analysis, omitting the data from the final two rooms to see if this changes the results. Updated descriptive statistics can be seen in Table 6, below.

Table 6

Descriptive Statistics for Time Taken to Complete the Minecraft Task (Combined Mixed Chains and Omitting Final Two Rooms)

Pair Type	N	Minimum	Maximum	Mean (Standard Deviation)
Same-Autistic	14	12	18.13	14.66 (2.02)
Same-Allistic	18	9.68	29.02	18.84 (6.43)
Mixed Neurotype	14	9.35	29.6	19.52 (7.43)

As outlined in the Introduction, we expected that participants in the mixed condition would take the longest to complete the map, whereas same-autistic pairs would complete the map fastest. To investigate if there was an effect of pair type on time taken to complete the task, a one way analysis of variance (ANOVA) with three levels was conducted which revealed a significant effect of pair type on time taken to complete the map: $F(2, 45) = 9.51$, $p < .001$, $\eta^2 = .297$. A follow up independent samples t-test revealed that same-autistic pairs completed the map significantly faster than same-allistic pairs ($p < .001$). Same-autistic and mixed-neurotype pairs were not found to differ significantly ($p = .141$), nor were same-allistic pairs (*p* = .064), full details of follow up t-tests can be seen in Table 7, below. However, after omitting the final two rooms, this effect becomes no longer significant: *F* (2, 43) = 2.9, *p* = .066, η^2 = 0.297. As no significant effect was determined, no further post-hoc tests were conducted.

Table 7

Summary of Post-Hoc Independent Samples T-Tests on Times Taken to Complete the Map

Pair Type 1	Pair Type 2	Mean Difference	Significance
Same-Autistic	Same-Allistic	19.7	<.001
Same-Autistic	Mixed-Neurotype	12.67	.141
Same-Allistic	Mixed-Neurotype	7	.169

Rapport Data

In addition to completing the Minecraft task, participants were asked to rate their rapport with their partner. Descriptive statistics for rapport ratings can be seen in Table 8, below.

Table 8

Descriptive Statistics for Participants' Self-Reported Rapport Ratings (Broken Down by Pair Type)

Group	Same-Autistic	Same-Allistic	Mixed
Variable	*M (SD)*	*M (SD)*	*M (SD)*
Ease	68.85 (25.10)	72.06 (23.25)	67.36 (32.66)
Enjoyment	73.89 (20.20)	76.61 (22.84)	71.94 (26.44)
Success	83 (13.42)	80.06 (22.6)	77.8 (22.96)
Friendliness	84.3 (12.84)	88.67 (16.74)	80.6 (24.41
Awkwardness (Reversed)	89.16 (11.18)	88.69 (18.04)	74.26 (19.55)
Rapport Average	64.4 (24.21)	86.73 (22.51)	57.38 (23.72)

A one-way ANOVA with three levels (same-autistic, same-allistic and mixed-neurotype) was conducted on all rapport scores to determine if pair type had an impact on rapport ratings. A one-way ANOVA performed on participants' ease scores revealed no significant effect of pair type on ease of interaction; F (2, 42) = 0.128, p = .88, η^2 = 0.006. Next, a one-way ANOVA conducted on the enjoyment rapport scores also revealed no significant effect: F (3, 40) = 1.25, p = .305, η^2 = .008.After this, a third ANOVA on participants' friendliness scores was conducted which revealed no significant effect of pair type on perceived friendliness: F (2, 40) = 0.735, p = .486, η^2 = .035. Next, an ANOVA on participants' perceived success scores revealed no significant effect of pair type on success of interaction: F (2, 41) = .197, p = .822, η^2 = .01.

Next, another one-way ANOVA was run on the awkwardness scores, revealing a significant effect of pair type on awkwardness of interaction: F (2, 47) = 4.04 p = .024, η^2 = .147. Post-hoc t-tests were conducted revealing this effect was significant only at multiple levels, with same-allistic pairs rating their interaction significantly less awkward than mixed-neurotype pairs (p = .028) as well as mixed-neurotype pairs rated their interactions as significantly more awkward than same-autistic pairs (p = .018), full details of post-hoc analyses on awkwardness scores can be seen in Table 9, below.

Table 9

Summary of Post-Hoc T-Tests on Awkwardness Scores

Pair Type 1	Pair Type 2	Mean Difference	Significance (T-Test)
Same-Autistic	Same-Allistic	0.47	.932
Same-Autistic	Mixed	14.89	.018
Same-Allistic	Mixed	14.43	.028

Finally, a significant effect of pair type on average rapport scores was found: F (2, 35) = 6.0, p = .006, SS = 6557.3, MS = 3278.65. Post-hoc t-tests revealed this effect to be significant at two levels, with same-allistic pairs rating rapport significantly higher than both mixed-neurotype (p = .002) and same-autistic pairs (p = .027). Full details of post-hoc t-tests can be seen in Table 10.

Table 10

Summary of Post-Hoc Tukey HSD, LSD and T-Tests on Average Rapport Scores

Pair Type 1	Pair Type 2	Mean Difference	Significance (T-Test)
Same-Autistic	Same-Allistic	22.33	.027
Same-Autistic	Mixed	7.02	.493
Same-Allistic	Mixed	29.35	.002

Written Responses. As with the diffusion chain task, participants were given the chance to leave a comment about their partner and the Minecraft task in the post-study survey. These responses will be used to inform future research directions.

We asked: *'Any further comments about your partner for Minecraft?'*

Same-Autistic:

'Great teammate'

'Other than eating food during study, seemed alright'

Same-Allistic:

'It was easy to get through the puzzle with the help of my partner, he tried very hard to help out and we worked well as a team'

'It was cool and fast'

'She was very nice and friendly ☺'

'Very helpful at Minecraft tasks'

'Very helpful and willing to listen to my suggestions'

'Just needed to familiarise with controls'

'We did very well'

'Beautiful map'

Mixed-Neurotype:

'Never played before, very eager to listen to me knowing I've played before'

'I found myself getting frustrated quite easily as they did not understand the instructions I was giving them'

'They were very good even when I didn't explain myself very well in a more difficult task'

Next, we asked participants if they had any further comments about the experiment as a whole.

Same-Autistic:

'Minecraft world was cool. Would've maybe liked to see bigger groups to see how communication works in a more complex escape room, and also mix up partners by making people carry out similar tasks in different order with different people, this could provide some more data but maybe too much. And also would require making multiple different escape rooms and tasks.'

Same-Allistic:

'Was quite difficult at some points but overall managed it'

'Cool and fun experiment'

Mixed-Neurotype:

No further comments from participants in the mixed-neurotype condition.

Discussion

Study 1 – Diffusion Chain

Based on Crompton and colleagues' (2020) diffusion chain findings, we expected mixed-neurotype chains to transfer the least information, with there being no significant difference between same-allistic and same-autistic chains. In addition to this, we expected that informing participants in the mixed-neurotype chains of the Double Empathy Hypothesis (DEH; Milton, 2012) would decrease miscommunications in mixed-neurotype, resulting in more information transferred and higher rapport ratings. Due to several issues, we did not yield any significant findings based on these hypotheses.

Unfortunately, due to issues with recruitment and data storage, we weren't able to collect enough diffusion chain data to conduct any statistical analysis. Due to the structure of a diffusion chain, each session of data collection required eight participants at the same time, of a specific ratio of neurotypes. This was very difficult and if even one participant cancelled we weren't able to carry out the experiment, this resulted in only a total of four diffusion chains completing the task (two mixed-uninformed chains, one mixed-informed and one same-autistic chain). Unfortunately, the USB stick which had the diffusion chain data saved was broken and we lost two chains of data (both mixed-uninformed chains data were lost), leaving us only with a mixed-informed chain and a same-autistic chain to analyse.

In addition to the data quantity issues, issues with methodology resulted in poor quality data from the chains we didn't lose. The first methodological problem we encountered was the task being too memory reliant. From the beginning, I was sceptical about the use of diffusion chains to measure communication, worrying that it is more a measure of memory than communication. Unfortunately, this was the case for many participants, as can be seen in the written responses, in the results section above. In both diffusion chains with data, the first participant in the chain recalled half or less of the story, meaning each person in the chain would never be able to transfer any more than half of the story. In addition to these issues with memory, we encountered similar issues regarding accents and English language fluency. In the mixed-informed chain, the first person did not speak English as their first language and therefore struggled to understand the researcher telling the story. This, combined with their strong accent led to only 1 point in the story being transferred through the chain, with most participants in this chain recalling 0 points.

Finally, no significant effect of chain type on rapport ratings was able to be determined due to the small number of chains we collected. Although we didn't lose any rapport data, we only had 4 chains total for the diffusion chain and none of these were same-allistic, resulting in no reliable analysis being possible.

Based on Milton's hypothesis, Crompton et al. (2020) used a diffusion chain method to measure communication between same- and mixed-neurotype participants. They found no significant difference between same-autistic and same-allistic chains, with miscommunications only arising in the mixed-neurotype chains. As discussed earlier, several methodological and other issues arose resulting in no significant findings from our diffusion chain experiment, despite these issues not being present in Crompton et al.'s (2020) original study. Firstly, they were able to recruit many more participants for the diffusion chain than we were, and the 72 participants recruited were evenly distributed among the three conditions, assigned to groups matched by age, gender, education and IQ. All participants spoke English to a native fluency and had no clinical diagnosis of social anxiety disorder. All participants signed up, and then once enough were recruited Crompton and colleagues assigned participants to one of nine research days based on the above mentioned demographics. Unfortunately, we were unable to reach the same sample size, giving our study less power than the initial study. In addition to this, the addition of a fourth condition (mixed-informed) would have required an even larger sample to achieve similar power.

As with Crompton and colleague's original 2020 study, participants provided self-reported rapport ratings for their partner after completing the tasks. The first issue with rapport ratings applies only to the diffusion chain task and concerns the amount of time between completing the task and giving the ratings. Participants who completed the diffusion chain task did so immediately before completing the Minecraft task, and then gave their rapport ratings at the same time in the post-study survey after completing the Minecraft task. This meant up to an hour between completing the diffusion chain task and giving their rapport ratings, with a task in the middle which could act as a distractor. This likely meant that these rapport ratings were less accurate, given the time passed and the fact that they'd completed a new task with a new partner impacting their recall. In future studies, rapport ratings will be reported right after completing the task, rather than doing another task first.

Study 2 – Minecraft

Based on the predicted methodological issues with the diffusion chain methodology, we chose to test participants a second time, but this time using a co-operative Minecraft task, since this required participants to communicate information to one another to solve a task together. This is more likely closer to a real-world encounter, than having to recount details of a story along a chain. It is also not reliant on memory for successful completion. We predicted that same-autistic pairs would complete the map fastest, a hypothesis which our findings partially support, with same-autistic pairs finishing faster than other pair types however this effect was only significant between the two same-neurotype pairs. While no significant difference was found between same- and mixed-neurotype pairs, the fact that same-autistic pairs completing the map fastest directly contrasts the idea that communication is defected in autistic individuals, as they performed better at a task requiring communication. One potential explanation for the superior performance may be the popularity of Minecraft within the autistic community, resulting in autists having more experience with the game. However, no difference in Minecraft skill or experience was identified between autistic and allistic participants in our pre-screening. Instead, we propose that, at least in this specific context, autistic-to-autistic communication may be more effective than allistic-to-allistic.

Our next hypothesis predicted that mixed-uninformed pairs would complete the map significantly slower than mixed-informed pairs. As mentioned earlier, we recruited very few (four) mixed-informed pairs, and as such, we were not able to conduct meaningful statistical analysis to explore this potential difference.

Finally, we expected that rapport ratings would be lower in mixed-neurotype pairs than in same-neurotype pairs. However, this effect was only significant on participants' awkwardness scores. Pair type was not found to impact ease of interaction based on self-reported scores, one explanation for this is that ease of interaction only differed between mixed-informed and mixed-uninformed pairs, meaning informing participants of the double empathy hypothesis made mixed–neurotype interactions easier. In future studies, full samples should be recruited before being assigned to conditions, to ensure that an even distribution of participant types is obtained and investigate if this effect persists. Enjoyment was not found to differ between pair types, a potential explanation for this is that the use of a cooperative game task allows for a more enjoyable interaction, despite type of interaction (same- or mixed-neurotype). Despite this, our findings do not support our hypothesis, since all pair types found the task equally enjoyable.

No significant effect of pair type was present on friendliness, suggesting all pair types rated their partners equally friendly. This could potentially be due to the fact that we had to combine the two mixed-neurotype conditions together. Once again, future research should use an evenly distributed sample, with equal amounts of participants in the mixed-uninformed and –informed conditions, to investigate whether this effect is still purely present in mixed-neurotype conditions. A second potential explanation for this pertains to the task itself, using a video game task as opposed to a more typical lab procedure. The use of a video game shifts focus from the interaction itself onto a shared goal, possibly increasing cooperation and therefore perceived friendliness. To further examine the nature of this effect, future research should use a traditional interaction and compare this to performance on a shared goal task, it would also likely be beneficial to examine the difference in performance on a 'boring' versus 'fun' shared goal task, for example, working together to solve maths problems vs to play Minecraft.

No effect was found of pair type on perceived success of interaction, despite a significant effect being found of pair type on time taken to complete the map (actual success of interaction). A potential explanation for this could be that miscommunications and issues with communicating between different neurotypes may be unconscious, impacting participants' performance without them realising. While no significant effect was found of pair type on perceived success ratings, these ratings may not be accurate due to the conditions under which rapport ratings were given, rapport ratings for the Minecraft task were given while in the same room with the person you completed the task with. This meant that, theoretically, participants could see their partner's screen while they were being rated which could have influenced the ratings. Being in the same room as the person they're rating likely influenced the scores that they gave since they may not want to give a low rating with their partner watching. Next time, rapport ratings will be given in separate rooms from their partner or with their screen blocked from their partner's view to obtain the most accurate results possible.

The final rapport measure used was awkwardness, which was shown to be significantly higher in mixed-neurotype than same-neurotype pairs. This provides strong support for our hypothesis, suggesting that mixed-neurotype interactions are more awkward / difficult than same-neurotype interactions, which would not be true if communication deficits were solely the responsibility of the autistic party. This is significant for the neurodiversity movement as it clearly shows no difference between same-autistic and same-allistic pairs, with mild issues arising in mixed-neurotype conditions. To further build on this evidence, the experiment should be repeated with an evenly distributed sample to examine if this effect persists.

Finally, all five rapport measures were averaged to determine an overarching effect of pair type on rapport. Based on these average scores, same-allistic pairs rated rapport significantly higher than any other pairs. A likely explanation for this is that same-allistic pairs found they enjoyed their interactions more, regardless of actual success (total time taken to complete the map), where same-autistic pairs performed best.

The idea of communication deficits being a central diagnostic feature of autism has led to the impression that miscommunications are solely due to the autistic individual. However, as Milton (2012) suggested, one would expect doubly inefficient communication between autistic individuals if a communication deficit really was an autistic trait, which was not the case with our current study. All pairs, except from two which were both same-allistic, were able to complete all puzzles and complete the map, suggesting they were able to successfully transfer information regardless of neurotype. In fact, communication difficulties were only reported in the comment boxes by participants in the mixed-neurotype condition, suggesting mixed-neurotype interaction is the issue, not the autistic individual.

Baron-Cohen, Leslie and Frith (1985) suggested that autists may have a deficit or lack of theory of mind, meaning they have difficulty understanding other people's mental states and knowing that they are different from their own (Premack and Woodruff, 1978). As a result of this, Baron-Cohen theorised, autistic individuals experience communication deficits as a central 'symptom' and would fail to form normal social relationships. However, in the present study almost all participants completed the map, suggesting that participants of all neurotypes were able to communicate and transfer information successfully. In order to complete the task, participants had to be aware what information was available to them and their partner, showing presence of theory of mind. In addition to this, same-autistic pairs completed the map fastest, which suggests they found communicating easiest, opposing Baron-Cohen's theories surrounding autistic communication. Despite theory of mind not being a central focus of the present study, our findings show autistic participants forming social relationships and working cooperatively to reach a shared goal and argues against the suggestion that communication deficit should be a central diagnostic feature of autism. Milton's Double Empathy Hypothesis (2012) suggests that allistic individuals don't understand autistic thought processes as much as autists don't understand allistic thought processes, which could be misinterpreted as a theory of mind deficit when placing responsibility solely on the autistic party. While this may be true, it can also be argued that the neurodiversity movement is not inclusive of all autistic individuals, and that some autists may present with a theory of mind deficit, as Baron-Cohen and colleagues suggested. The neurodiversity movement, and Milton's (2012) Double Empathy Hypothesis, while hopeful in normalising neurodiversity and neurodivergent traits, fails to acknowledge those who do have significant developmental delays, such as those who may be completely non-verbal or reliant on a full-time carer. Baron-Cohen et al. (1985) looked at a more diverse representative sample of autistic individuals which included those with more severe difficulties which are often left out of research, meaning that there conclusions may be more generalizable and realistic to the autistic community. To further investigate this and support the neurodiversity movement, future research should aim to involve those who are have more significant developmental delays and difficulties to see how these effects apply to the whole autistic population.

Milton's 'Double Empathy Hypothesis' (2012) suggested that communication difficulties are not an autistic trait, but instead the outcome of mixed-neurotype interaction. As discussed earlier, same-autistic pairs completed the map fastest, with same-autistic pairs completing the map faster than both same-allistic and mixed-neurotype pairs. In line with the Double Empathy Hypothesis (DEH), this suggests that communication deficits are not an autistic trait, since this would result in double ineffective communicating. Instead, our results suggest that autistic participants communicated the most efficiently. In addition to investigating where miscommunications occur, we wanted to see if informing participants of the DEH and communication styles would change the outcome. We expected miscommunications to be less and rapport to be higher in mixed-informed pairs compared with mixed-uninformed, but due to small numbers in these two groups, we ended up having two combine the mixed-dyads into a single mixed group. Future research should look to investigate this possibility further, to see if informing participants of differences in communication style might reduce biases and ultimately also miscommunications.

In addition to the completion times, the written comments from mixed- and same-neurotype participants provides further evidence for Milton's Double Empathy Hypothesis. In one participant comment from the mixed-neurotype condition, there was some expression of frustration and difficulty communicating, writing 'I found myself getting frustrated quite easily as they didn't understand the instructions I was giving them.' On the contrary, written comments from participants in same-neurotype conditions express better cooperation and more successful interactions. In the same-autistic condition, one participant wrote 'Great teammate', and in the same-allistic condition another wrote 'very helpful and willing to listen to my suggestions'. Although this provides hopeful evidence for the neurodiversity movement and Milton's Double Empathy Hypothesis (2012), these are only very few comments on a fairly small sample. Therefore, these conclusions should be taken with caution and further investigated with future stages of study.

Using Minecraft as a research tool has proven very useful for both the recruitment and comfort of autistic participants. Over a short period of time, we gained 36 total sign ups from autistic individuals, with 27 of those participating, a vast improvement from studies such as Williams et al (2021). Though 27 still isn't a huge sample size, for over half of the data collection period participants were recruited to participate in both the diffusion chain task, meaning we encountered the same recruitment and scheduling issues discussed above. In addition to aiding with recruitment of autistic participants, the use of Minecraft yielded positive feedback from participants, expressing it was enjoyable and they were interested about the outcomes, for example, 'cool and fun experiment' and 'Minecraft world was cool'.

Ringland (2016) suggested that social play allows autistic individuals to practice roles and test social boundaries in a safe space. In this experiment, we found that social play, in this case Minecraft, also acts as a mediator, allowing autistic participants to initiate conversation easier. Preliminary observations of screen recording data of Minecraft gameplay and audio recordings from the diffusion chain task, suggest that conversations flow easier and more naturally in the former. This data will be further explored in future.

Participant feedback clearly shows promise for the use of Minecraft as a research tool, particularly in the context of neurodiversity and disability. Historically, researchers have expressed a difficulty with recruiting autistic participants, due to issues such as access and autistic individuals mistrust of researchers, however this shows that, with the right connections and adapting research methods, collecting data from autistic participants is far from impossible. Many autistic participants signed up for free, asking for no reimbursement, due to the use of Minecraft and close involvement of the autistic community in the generation of research. By developing our methodology and remaining transparent and thorough in our explanations, we made a study which enabled autistic participants to not only participate but enjoy the experience and help us produce meaningful results. Many autistic participants expressed a keen interest in both the outcomes and next steps of the experiment, asking to hear more about the results when we have them and asking to be involved in future studies, despite not being reimbursed (all participants were offered reimbursement, many did not take us up on

As discussed above, this study clearly adds to the growing literature supporting Milton's Double Empathy Hypothesis (2012), suggesting that communication deficits aren't an autistic trait, but instead an outcome of mixed-neurotype interaction.

As discussed above, this study as with all studies isn't without its faults. Issues with recruitment resulted in an uneven sample size, meaning some of our findings should be taken with some caution. Future experiments should make sure to have even sample sizes, especially in a study as complex as this with four levels. One way we could improve on this next time draws from the methodology of Crompton and colleagues (2020), who recruited 72 participants, equal amounts of autistic and allistic, who were each then assigned to one of nine chains. This method of recruitment and assigning participants to conditions ensured that they would have equal amounts of participants in each condition. We were not able to adhere to this strict recruitment issues due to time constraints, and because we were largely reliant on student volunteers, but going forward more time will be allocated for recruitment.

Another issue faced concerned the tracking of participants' data. As an autistic Master's student handling ethics for the first time, I was overcautious regarding anonymity and took some of the ethics guidelines too literally. This meant that I did not give myself any way to know which pre-screening result goes with which diffusion chain score, rapport score, Minecraft performance and post study survey responses. In future experiments and under rephrased guidance we will keep track of participants from the beginning to end while maintaining anonymity by assigning participants a number as soon as they arrive to participate, and having this number recorded on any relevant materials (screen recordings, survey responses, etc.).

Next, the practice areas used in the experiment need improvement going forward. Two pairs were unable to complete the Minecraft map and one of these expressed that this was due to not understanding the practical applications of the Minecraft task, despite having completed the practice area. The practice area used in the present Minecraft experiment gave participants a chance to try all the controls and skills required to complete the task, to allow inexperienced Minecraft players to practice these skills without it affecting their performance. However, due to the variety of puzzles throughout the Minecraft task, the participants were not given the opportunity to practice the puzzles themselves before beginning the experiment. This resulted in some participants not making the link between the controls and what they learnt in the practice area to the practical applications in the experiment task. For example, while many participants found it easy renaming a book in the practice area, they didn't see how this skill was applied practically in the final room of the test area. If I were to use Minecraft as a research tool going forward in a similar way, I would still use this initial skill-learning area, however I would keep the test area to fewer puzzles to allow for practice trials in a more traditional sense. Participants would have a chance to try out the puzzle alone in the practice area and then complete the task with a partner for data collection, ideally reducing these confusions and producing better results.

The second pair not to complete the task made it to the penultimate puzzle, however they were not able to finish this or complete the following puzzle. When asked why they couldn't solve the puzzle, the pair revealed that they had solved it but when they were trying to 'drop the item' nothing was happening. We then realised that they had misread the instructions provided to them, thinking that a 'Q' was a '0'. The font used on the participants' in game instructions was the default Minecraft font which can be tricky to read, in this case causing a pair to be unable to complete the task. In future, we will download a game modification (colloquially known as and hereafter a 'mod') which changes the font of the text presented to participants in game.

It is important to note that, as mentioned earlier, some participants took significantly longer to complete the final two rooms of the experiment more than the rest, which we assumed was due to these tasks being more reliant on Minecraft/video game skill rather than communication, resulting in a re-analysis of the data omitting these rooms. However, it is possible that these rooms actually took longer to complete due to the high levels of communication required to complete these tasks. These rooms required participants to tell their partner a password, which their partner then had to write on a piece of paper and put in the correct place to open the exit. It is also possible that the multi-step nature of the communication needed to complete this task resulted in it taking longer, but also being a more accurate reflection of how individuals communicate when completing a task together. Therefore, when developing future studies and Minecraft map we will focus on multi-step communication where multiple pieces of information must be transferred to complete the task.

In addition to the aforementioned issues with the methodology, there are issues concerning participants' rapport scores. Firstly, participants completed the post-study survey while still in the same room as their Minecraft partner, including while giving rapport ratings. This could have impacted participants' ratings as they wouldn't want to give a negative rating of their partner if they could look over and see, resulting in inaccurate scores. To combat this, future experiments should block participants from seeing their partner's screen, or take them into separate rooms while completing the survey. Similarly, participants' rapport ratings may have been influenced by the process of matching pairs based on Minecraft score. Participants who reported themselves as inexperienced in Minecraft may have higher ratings of their experienced partner due to the support they provided, as opposed to their neurotype alignment. Going forward, participants will be randomly assigned to pairs, regardless of Minecraft scores, to ensure that effects persist regardless of skill level differences.

Finally, going forward I would ask more demographic questions to participants. Due to the nature of the study, participants were asked if they were autistic or not, however no demographic variables were collected besides this. Autism is a complex disorder and therefore expression of traits can be very influenced by variables such as age (Stewart, 2024) and biological sex (Cardon et al, 2023). For this reason, it is imperative that demographic variables are recorded in autism studies as its likely these variables will impact performance. For example, Crompton and colleagues matched participants in each chain based on biological sex, Intelligence Quotient (IQ) score and other variables to ensure that communication was the only contributing factor to their results. As discussed earlier in this section, in future we will use a more thorough recruitment and assignment process to ensure that only communication is being measured and sex differences or other individual differences don't impact the validity of the findings.

These findings clearly show the benefit of adapting research methods for neurodivergent participants. As mentioned earlier, the decision to use Minecraft as a research tool was based a combination of factors, one of which being its popularity among autists. As we expected, the use of Minecraft was very popular with autistic participants, resulting in many autistic participants taking part in the study for fun, rather than for cash payment or SONA credit. This suggests that they were more inclined to take part in the experiment knowing that it was in this more accessible format, showing the importance of adapting laboratory procedures for neurodivergent participants. Future research concerning neurodiversity should adapt their methodology to recruit the most neurodiverse participant pool possible and reduce demand characteristics in these participants. Minecraft works well for the purpose of measuring behaviours such as communication but may not be ideal for all experiments, so it's important to not only use novel research methods like Minecraft but adapt traditional procedures to help neurodivergent individuals participate. For example, the diffusion chain method is extremely unnatural and was a source of anxiety for some autistic participants, but using a more structured recruitment process as Crompton and colleagues did could reduce some of this anxiety.

Despite these established issues, the current study shows the merit of using Minecraft to measure communication and, for most pairs, the map was successful as a shared goal-oriented task and acted as a mediator in uncomfortable pairs. The feedback received from participants and existing literature shows that Minecraft can be incredibly useful for autism and other studies. It is for this reason that I suggest the experiment is repeated as a lone task, as opposed to having participants complete the diffusion chain task first. I believe that this will enable us to recruit a more even sample and hinder more valuable insights, allowing the Minecraft task to standalone free of order effects with some minor changes, such as a better practice area and a more accessible font (as discussed in the above section).

In addition to examining which type of pair would transfer information most efficiently, we aimed to test if informing participants on the double empathy hypothesis and different communication styles would decrease miscommunications in mixed-neurotype pairs/chains, but did not analyse these differences due to our limited sample. Future research should aim to examine the effect of informing participants on the double empathy hypothesis and different communication styles as Milton's theory suggests this would reduce miscommunications.

In Crompton's original 2020 study and our current experiment, participants were told if their partner was autistic or allistic before participating. Based on the double empathy hypothesis, informing participants on their partner's neurotype could trigger implicit biases, likely resulting in them changing the way they interact with their partner. For example, an allistic participant may assume their autistic partner will struggle to understand them and result in them putting in less effort or speaking to their partner in a more condescending way. In this experiment, many autistic participants expressed a disappointment or upset when being told they would be in a mixed-neurotype condition, suggesting biases can occur on both sides of the interaction. Future studies should change whether participants are aware of their partner's diagnostic status to see how this impacts their ability to transfer information successfully.

To summarise, our findings provide support for Milton's (2012) Double Empathy Hypothesis (DEH), suggesting that communication deficits are not an autistic trait but instead the outcome of mixed-neurotype interaction. Through replication of Crompton et al's (2020) diffusion chain methodology we discovered some issues such as the method being too reliant on memory and English language fluency. Based on these issues, a second experiment using Minecraft was conducted which also provided support for the DEH, through time taken to complete the task and self-reported awkwardness scores. Future studies should aim for a more even sample and work on improving the practice trials. References

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Appendix

Figure A1

Information Sheet Provided to Participants

University of Essex

Examining the Nature of Communication Difficulties Between Autistic and Non-Autistic Individuals

Date of approval:

Invitation to our study
If you identify as [autistic/non autistic] (delete as appropriate), we would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or you would like more information.

What happens if you agree to participate
We are examining the way that you communicate with neurotypical (NT) and autistic (Au) peers in a 'Chinese Whispers' style task. To start with, you'll be put in a room, separate from other participants. This is just to stop you from interacting with each other ahead of the task. When it's your turn to participate, you will be brought into a room with another participant (or a researcher if you are first in the chain). You will then be told a story about a bear, pay attention, because you will be asked to recall to recall the story later. You will then be left alone in the room. If you are the final person in the chain, you will then be asked to repeat the story aloud. Otherwise, another participant will then enter the room and you will tell them the story, and then leave.
Once the chain is complete, you will be taken into another room where you and a partner will work together to complete an 'escape room' in the game Minecraft. You and your partner will work together to complete simple puzzles and work through the rooms, these puzzles are not based upon game skill and instead depend on your ability to work together with your partner. This should take approximately 20 minutes.
After completing both tasks, you will be asked a few questions about the experiment, these are for our own reference and not a test. This will include watching a video recording of your interactions in the 'Chinese whispers' task and ranking them on several factors.

Informed consent
Should you agree to take part in this experiment, you will be asked to sign a consent form before the experiment commences.

Withdrawal
Your participation is voluntary and you will be free to withdraw from the project at any time without giving any reason and without penalty. If you wish to withdraw, you simply need to notify the principal investigator (see contact details below). If any data have already been collected, upon withdrawal, your data will be destroyed if possible, unless you inform the principal investigator that you are happy for us to use such data for the scientific purposes of the project. It will not be possible to destroy any data that have already been shared anonymously on data sharing repositories.

University of Essex

Data gathered

- We will collect the following data from each participant: Video recording of you hearing and repeating the story. Self-report ratings of rapport with participants you interacted with. Your opinions on the task after completion.
- We are using your data to: Observe how you interact with people of the same or different neurotype as you, to identify barriers to successful interactions.
- Your data will be gathered by Jamie-Louise Williams
- Personally identifying data will be stored in XXXX only accessible to Jamie-Louvise Williams, Dr Gethin Hughes, Dr Sara Garib-Penna and researchers working under their direction.
- Signed consent forms will be kept separately from individual experimental data and locked in a drawer in the Principal Investigator's office.
- Your personally identifying data will be retained indefinitely.
- Our legal basis for processing your personally identifying data is that you have consented to it.
- The data controller is the University of Essex.
- Essex University's Data Protection Officer can be contacted on dpo@essex.ac.uk.
- Your data may be anonymised (so that you cannot be identified from them) and published in scientific journal articles, and shared in permanent, publicly accessible archives accessible from any country.

Funding

The research is funded by XXXX

Ethical approval

This project has been reviewed on behalf of the University of Essex Ethics Sub-committee 1, and had been given approval with the following Application ID: ETH2324-0239

Concerns and complaints

If you have any concerns about any aspect of the study or you have a complaint, in the first instance please contact the Principal Investigator of the project (see contact details below). If you are still concerned or you think your complaint has not been addressed to your satisfaction, please contact the Director of Research in the Principal Investigator's department (see below). If you are still not satisfied, please contact the University's Research Integrity Manager (see below).

Contact details

Principal investigator
Jamie-Louise Williams (jw20979@essex.ac.uk)
Dr Gethin Hughes (ghughes@essex.ac.uk)
Dr Sara Garib-Penna (sgarib@essex.ac.uk)

Co-investigators

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Prof Sheina Orbell (sorbell@essex.ac.uk)

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University of Essex Research Integrity Manager
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Figure A2

Consent Form Provided to Participants

University of Essex

Department of Psychology

CONSENT FORM

Title of the Project: Examining the Nature of Communication Difficulties Between Autistic and Non-Autistic Individuals

Researchers: Jamie Williams, Dr Gethin Hughes, Dr Sara Garib-Penna

Please initial box

1. I confirm that I have read and understand the Information Sheet labelled ETH2324-0239 (Version 1). I have had the opportunity to consider the information, ask questions and have had any questions answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw from the project at any time without giving any reason and without penalty. I understand that any identifiable data collected up to the point of my withdrawal will be destroyed unless I give permission for the data to be kept. It will not be possible to delete data that have already been shared anonymously on data sharing repositories ☐
3. I understand that the identifiable data provided will be securely stored and accessible only to the members of the research team directly involved in the project or other researchers under the direction of the Principal Investigator, and that confidentiality will be maintained. ☐
4. I consent to have my data published in research publications, in which case the data will remain completely anonymous. ☐
5. I consent to have my anonymised data shared on publicly accessible repositories (this may help other researchers in the future). ☐
6. I consent to having my data processed as described in the Information Sheet labelled ETH2324-0239 (Version 1). ☐
7. I agree to be contacted in the future by the researchers in order for them to obtain further information or invite me to participate in further studies; I am under no obligation to provide further information or participate in further studies. ☐
8. I agree to take part in the above study. ☐

Participant Name	Date	Participant Signature
________________	________	____________________
Researcher Name	Date	Researcher Signature
________________	________	____________________

Consent form (version x) Date Page 1 of 1
ERAMS reference: EAxxxxxx

Figure A3

A Summary of Milton's (2012) Double Empathy Hypothesis Provided to Participants in the 'Informed' condition

Milton's 'Double Empathy Hypothesis' (2012)

For a long time now, there has been an assumption that communication difficulties are a symptom of autism, even being outlined in the DSM-V as a symptom (APA, 2024). The Double Empathy Problem/Hypothesis (Milton, 2012) takes a more neurodiversity-positive approach to these communication difficulties. Milton suggested that two people with very different life experiences may struggle to communicate effectively with each other, and may have different communication styles. This suggests that the communication difficulties between autistic and non-autistic people are caused by misunderstandings on both sides, not just the autistic person.

The people you interact with throughout the tasks today may be autistic or non-autistic. Depending on your own neurotype (autistic or non-autistic) this may impact your communication. Try to be mindful of the different communication styles suggested by the double empathy problem throughout your interactions.

Figure A4

The Story Provided to Participants in the Diffusion Chain Task

The bear woke up to find himself at sea. He was lying flat on his back, in a little yellow fishing boat, with puffins flying above him. For a minute he lay very still, trying to remember how he'd got there. The last thing he remembered was having a lot of cake at lunchtime (which sounds like a great lunch!) – but how had he got out to sea? It was then that he noticed that the puffins above him were circling and disappearing into puffs of steam! The bear sat up in the boat, and put his little black hat back on. The boat began to sway, and the bear was surrounded by clouds of soft steam. He dipped his paw in the sea and to his surprise found tea instead of water! In a panic, he dived out of the boat and into the tea-sea. He swam towards what looked like a dark corner (don't ask me why there's a corner in the middle of the sea), hoping to hide. He swam deep into the corner, but instead of coming to a point, it turned into a spout! There was light at the end of the spout. He swam with all his might towards the light and when he reached the opening, jumped into the bright sunlight below. He opened his eyes to find himself back in his kitchen, covered in crumbs, and with a cold pot of tea beside him. Was it a dream? He'll never know!