

1 **The relationship between television exposure and children’s cognition and behaviour:**

2 **A systematic review.**

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1 Abstract

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3 The aim of this article is to systematically review the literature studying the association
4 between television viewing and children's executive function, academic performance,
5 attention, language and play. Using keywords: *television, children, infants, attention,*
6 *language, education* and *cognition*, five online databases were searched. Seventy-six studies
7 that met all the inclusion criteria were reviewed. The findings suggest the relationship
8 between television viewing and children's development is complex. First, the likely effects of
9 television may depend on children's individual characteristics, family and social context.
10 Second, the features of television, such as content and editing pace, and the type of exposure
11 (foreground or background) may affect outcomes. Specifically, watching high-quality
12 educational content during preschool years improves children's basic academic skills and
13 predicts subsequent positive academic performance. Conversely, television viewing in
14 infancy is disruptive to play; it reduces the quality and quantity of child-parent interactions
15 and is associated with inattentive/hyperactive behaviours, lower executive functions, and
16 language delay, at least in the short-term. It remains unclear whether these interactions
17 between television and cognition are long lasting. Future research should focus on the
18 systematic investigation of the pathways that link particular components of television and the
19 type of exposure with individual and contextual factors, to investigate their potential unique
20 and combined effects on development. Researchers must also address the challenge of
21 investigating the diverse and rapidly changing technologies to which the current generation of
22 children are exposed.

23

24 *Keywords:* children, television, attention, achievement, language, play.

25

1. Introduction

The relationship between screen-based media, television in particular, and children's cognitive development has been researched for over four decades, producing conflicting results. On the one hand, literature provides support for the long-term benefits of educational television for cognitive development and behaviour (e.g., Mares & Pan, 2013). On the other hand, the negative associations reported in correlational studies between television and children's development, especially attention and language outcomes, are a cause for concern among parents and early-years professionals.

There is little doubt that children and adolescents are prolific users of visual media. Adolescents simultaneously use a variety of different media, multitasking between a computer to do their homework, chatting with their friends on social networking sites, and listening to music or playing a computer game (Roberts & Foehr, 2008). Younger children still prefer "traditional" television over newer forms of media (Ridout, 2013). However, in light of recent figures showing that three-quarters of under-fives in the UK use a tablet or a smartphone (Childwise, 2016), traditional media may soon lose its dominance, even among the youngest of users. Although watching television remains young children's favourite pastime, the rise in popularity of touchscreen devices and the new means of accessing TV content have created further challenges for researchers that go above and beyond studying the potential effects of single-screen viewing. As Oaks (2009, p.1139) puts it "media exposure is now like air or water: ubiquitous, ever evolving and not easily coded as data for a given analysis". Therefore, it appears timely to examine and summarise the results of research into traditional media, to identify robust associations and effects, to help develop a theoretical framework that could guide future research on children's development in this "new media age".

1 The extent to which cognitive processes are affected by television viewing is
2 contentious. Some studies indicate that time spent viewing (e.g., Christakis, Zimmerman,
3 DiGiuseppe & McCarty, 2004), exposure to particular content (e.g., Connors-Burrow,
4 McKelvey & Fussell, 2011), early onset (e.g., Chonchaiya & Pruksananonda, 2008) and
5 editing pace (e.g., Lillard & Peterson, 2011) are associated with poor attention, lack of
6 behavioural control, delayed language and deficits in executive functions. However, other
7 studies have suggested that television viewing is not a strong predictor of these cognitive
8 skills (Schmidt, Rich, Rifas-Shiman, Oken & Taveras 2009; Bittman, Rutheford, Brown &
9 Unsworth, 2011; Stevens & Mulrow, 2006). Finally, there is some support for the potential
10 benefits of watching age-appropriate educational content. For example, watching programmes
11 designed to reinforce preschool learning (e.g., *Sesame Street* or *Blues Clues*) improves
12 children's early numeracy and literacy skills (Baydar, Kağıtçıbaşı, Küntay & Gökşen, 2008)
13 and is associated with positive educational outcomes in adolescence (Anderson, Huston,
14 Schmitt, Linebarger & Wright, 2001).

15 Despite these inconsistencies, abundant correlational evidence, supported by a number
16 of methodologically sound experimental studies, should allow one to identify the key
17 associations between television viewing and developmental outcomes, as well as the
18 mechanisms underlying these relations. Given the complexity of today's digital media, and
19 the challenges that this rapidly evolving technology poses for scientific inquiry, it is
20 important to identify any methodological gaps in past research to guide the creation of
21 effective ways of investigating the potential impact of new media on children's development.

22 Previous reviews tended to summarise findings pertinent to a particular age group (e.g.,
23 Thakkar, Garrison & Christakis, 2006), synthesised literature concerning a single TV
24 programme (e.g., Fisch, Truglio & Cole, 1999; Mares & Pan, 2013) or focused on a single
25 outcome measure (e.g., Moses, 2008; Nikkelen, Valkenburg, Huizinga & Bushman, 2014).

1 No review to date has integrated the findings covering a wide age range and a broad spectrum
2 of outcomes. Thus, the aim of this article is to review the current state of literature to explore
3 the associations between childhood television viewing and this broad spectrum of outcomes.
4 Specifically, we intend to evaluate this literature in the light of the strengths and weaknesses
5 of the different research methodologies used. Most research has used one of two methods:
6 either cross-sectional or longitudinal correlation between television viewing and
7 psychological measures. However, in the last decade, there has been an increase in the
8 number of experiments, which predominantly examine vocabulary learning from televised
9 material, the effects of editing features on children's cognition and behaviour and child-
10 caregiver interactions in the presence of television. Finally, this review aims to offer a
11 comprehensive synthesis of the current literature and to provide a resource for researchers
12 studying the potential effects of media on children's cognitive development.

13

14 **2. Methods: Search procedure and inclusion criteria**

15 MedLINE (PubMed), Cochrane Library, ERIC, PsycARTICLES, and the Web of
16 Science were last searched in December 2015 using the following strategy: child* OR infant*
17 OR preschool* AND television OR film AND attention, play, academic, education,
18 behaviour, cognition, vocabulary, language. Further hand searching of the reference lists in
19 the relevant published literature was conducted to identify any studies that were not returned
20 in the electronic search. There was no date restriction concerning the manuscript publication.
21 Only articles published in the English language were considered for inclusion.

22 To be included in the review, the studies had to involve participants younger than 14
23 years or, for longitudinal research, participants had to be younger than 14 during the first
24 wave of data collection. Furthermore, included studies had to investigate either the
25 associations between (correlational studies) or the effects of (experiments) foreground or

1 background television exposure on cognition, attention or play. Finally, for the experimental
2 studies, the outcome variable had to measure the effects of television on specified outcomes,
3 and not attention to or comprehension of the material presented on the screen. Materials used
4 in the studies considered for the review included “real-life” television/films (including those
5 that were specially edited for the purpose of the study), and specifically-designed videos that
6 were developed for the sole purpose of research. To provide a comprehensive summary of the
7 literature, studies that adopted a variety of methodologies were included (cross-sectional
8 correlational studies, prospective and retrospective cohort studies and experiments).
9 However, case study reports were excluded from the review. Finally, this article
10 predominantly focuses on the cognitive outcomes; therefore, studies investigating social and
11 emotional outcomes, including aggression, were excluded from this review.

12

13 **3. Results**

14 Using the pre-set criteria, the initial search of the relevant databases identified 8,812
15 studies. Duplicates were removed (1,166) and the exclusion criteria applied to the title and the
16 abstract, which removed another 7,561 articles. After scrutiny of the full text of the remaining
17 85 articles, 14 further articles were eliminated. The most common reasons for exclusion were:
18 the outcome measure was related to attention to or comprehension of television, rather than
19 the effects of the programme on subsequent attention and cognition, or the outcome measure
20 was outside of the scope of this review (e.g., mental health problems unrelated to attention
21 disorders, imagination or social play). A further five manuscripts were added during review
22 process. This procedure resulted in 76 articles being retained for analysis. The manuscripts
23 kept for review were divided according to method into three groups: cross-sectional
24 correlation, longitudinal correlation and experimental. For descriptions, see Tables 1, 2 and 3.

1 Where published, study description includes effect sizes, odds ratios and confidence intervals;
2 otherwise p-values are reported.

3 The articles in this review have been divided into four broad topics. First, there are
4 studies that examine the relationship between television viewing, executive function and
5 academic performance (sections 3.1.1., 3.2.1. and 3.3.1.). These studies are integrated to
6 reflect current literature, which suggests that effective executive function is associated with
7 academic success, particularly in mathematics and reading (Best, Miller & Naglieri, 2011;
8 Blair & Razza, 2007; Cragg & Gilmore, 2014; Latzman, Elkovitch, Young & Clark, 2010;
9 Pontiz, McClelland, Matthews & Morrison, 2009). Second, there are studies that examine the
10 relationship between television viewing and attention problems. Attention is either measured
11 directly in experimental research (section 3.3.2.) or more indirectly through measures of
12 hyperactivity/inattention associated with attention deficit hyperactivity disorder (ADHD) in
13 correlational studies (sections 3.1.2. and 3.2.2.). Third, sections 3.1.3., 3.2.3 and 3.3.4. review
14 the evidence relevant to the associations between television exposure and language
15 development. Finally, the literature on the influence of foreground and background television
16 on children's play and child-caregiver interactions observed during unstructured play is
17 reviewed in section 3.3.3.

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19 **3.1. Cross-sectional correlation studies**

20 Cross-sectional design offers a quick and relatively uncomplicated way to examine the
21 differences between groups of participants by concurrent measurement of skills or behaviour
22 of interest (Robinson, Schmidt & Teti, 2005). The results of cross-sectional correlation
23 studies provide a rationale for subsequent, more thorough longitudinal or experimental
24 research (Kraemer, Yesavage, Taylor & Kupfer, 2000). For a detailed summary of the studies
25 included in this section, see Table 1.

1 *3.1.1. Executive function and academic performance*

2 Developmental literature provides robust evidence for a relationship between
3 executive function and children’s math skills (for a review see Cragg & Gilmore, 2014), word
4 reading and reading comprehension (e.g., Christopher et al., 2012). Therefore, in this
5 subsection, we first review the studies that investigated the relationship between television
6 exposure and executive function and, second, the literature that examined the associations
7 between television viewing and academic performance in early and middle childhood.

8 Nathanson, Aladé, Sharp, Rasmussen, and Christy (2014) tested 4-year-olds on four
9 measures of executive function. In addition, data were collected regarding onset age of
10 television viewing, overall exposure, foreground viewing, genre and channel viewing,
11 vocabulary knowledge and sleep. They found children who started watching television at a
12 younger age, and who watched more television overall, had poorer executive function.
13 Moreover, educational cartoon viewing was negatively associated with performance on
14 executive function assessments. In contrast, Public Broadcasting Service channel predicted
15 better executive function scores, perhaps because, as researchers suggested, children’s
16 programmes shown on PBS were not interrupted by fast-paced commercials.

17 In contrast to performance-based measures of executive function, Linebarger, Barr,
18 Lapierre and Piotrowski (2014) assessed a group of preschoolers (3 to 5 years) and primary
19 school children with a parent-reported measure. Participants in this study were categorised
20 into “low risk” or “high risk” depending on their family ethnicity, economic and educational
21 background. For primary school children from high-risk families watching educational
22 television predicted higher executive function. Moreover, parenting style moderated this
23 relationship; increased parental responsiveness together with increased amount of educational
24 programmes viewing was associated with increased executive function scores. Conversely,
25 greater exposure to background television predicted lower executive function in high-risk

1 preschoolers and low-risk primary school children. Parenting style moderated the latter
2 relationship; an increase in parental inconsistency together with an increased background
3 television exposure was related to decreased executive function. Finally, foreground watching
4 of children's entertainment programmes predicted higher executive function in low-risk
5 preschoolers. Overall, these results suggest that the potential effects of television on the
6 development of executive functioning depend on the type of exposure (i.e., background or
7 foreground), content (e.g., educational, entertainment) and are further intensified by parenting
8 style.

9 Together, the results of Nathanson et al. (2014) and Linebarger et al. (2014) suggest
10 children's television habits are related to executive function skills. However, the exact nature
11 of this association is nuanced, and depends on factors such as children's age, socioeconomic
12 environment, and type of programming watched. For example, the negative relationship
13 between background television exposure and executive function skills of preschoolers from
14 high-risk families present in Linebarger et al.'s (2014) study was not replicated by the study
15 of Nathanson et al. (2014). However, the majority of participants in the latter study came
16 from families that might have been considered "low-risk" according to Linebarger and
17 colleagues' classification. Finally, it is worth noting that executive function was assessed by
18 different methods in these studies. Past literature suggests that although both performance-
19 based measures and ratings of everyday executive function are valid, they capture different
20 aspects of performance; the former reflects participants' *optimal* functioning and the latter
21 reflects their *typical* functioning (Toplak, West & Stanovich, 2013).

22 Similarly, research investigating the relations between television exposure and
23 academic performance presents mixed findings. In four studies reviewed in this section
24 children's reading and math abilities were measured with selected subtests of different
25 standardised tests of academic achievement. Only one of these articles examined preschool

1 academic skills. The remainder focused on academic achievement during early and middle
2 school years.

3 Clarke and Kurtz-Costes (1997) examined the associations between television viewing,
4 Home Learning Environment (HLE), parental employment and school readiness of preschool
5 children from African-American families with low socioeconomic background. The authors
6 assessed three components of HLE: number of books owned by a child; frequency of a child
7 being read to by a parent; and frequency of a child receiving educational instruction, such as
8 explanation of new words. Television viewing was negatively associated with children's
9 school readiness and the quality of HLE. Yet, the relationship between HLE and school
10 readiness was not significant.

11 However, it appears that the negative relation between television viewing and pre-
12 academic skills, documented by Clarke and Kurtz-Costes (1997), may be only relevant to
13 children of preschool age, or children from disadvantaged socioeconomic environment. An
14 investigation by Anderson and Maguire (1978) did not provide support for negative relations
15 between television viewing and academic performance. In this study, children from grades
16 three to six (ages not reported) were tested on numeracy, vocabulary and reading
17 comprehension. There was no significant association between television viewing and the test
18 variables. However, children who participated in this study came from predominantly middle-
19 class families, and were selected based on their superior IQ scores. Schweizer, Moosbrugger,
20 and Goldhammer (2005) demonstrated links between several different types of attention and
21 intelligence, and perhaps higher-than-average IQ moderates the relationship between
22 television viewing and cognitive performance.

23 Similarly, Roberts, Bachen, Hornby and Hernandez-Ramos (1984) researched the
24 associations between television viewing and primary school children's reading abilities, and
25 found no evidence that the amount of viewing predicted reading outcomes. The researchers

1 focused their investigation on the relations between television use and motivation for viewing
2 television/reading and reading achievement of children from second, third and sixth grade
3 (ages not reported). The results did not show any significant associations between the
4 variables measured in the study for the second-grade children. Moreover, for older children
5 (third and sixth graders) the amount of television viewing was not a significant predictor of
6 reading achievement. Conversely, children's reading ability appeared to be related to
7 motivation for watching television. Using television to learn was negatively related to reading
8 achievement in both age groups, whereas watching television to unwind predicted better
9 reading, but only in sixth-grade children. However, it is worth noting here that the researchers
10 collected information directly from the children, which should prompt a degree of caution in
11 interpreting the findings from this study. Collecting questionnaire data from primary school
12 children poses many challenges, such as, for example, low motivation and concentration,
13 difficulty with answering ambiguous questions, and young children's unwillingness to give
14 honest personal opinions for fear of giving a wrong answer (Borgers, de Leeuw & Hox,
15 2000).

16 In contrast to the findings of Anderson and Maguire (1978) and Roberts et al. (1984),
17 the results of Shin's (2004) study suggest that the amount of television viewing in middle
18 childhood may have detrimental direct and indirect effects on academic performance. The
19 author obtained data from children aged from 6 to 13 years to examine four hypotheses about
20 the relations between television and children's development: (1) *stimulation hypothesis*,
21 watching well-designed educational programming aids learning; (2) *time displacement*
22 *hypothesis*, television substitutes activities that offer more intellectual stimulation; (3) *mental-*
23 *effort and passivity hypothesis*, watching television promotes "mental laziness"; and (4)
24 *attention-arousal hypothesis*, viewing fast-paced, action-filled programming increases
25 impulsivity and reduces the ability to sustain attention. The researcher investigated the

1 relationship between television viewing, reading, homework, and whether these variables
2 predicted reading and numeracy skills. Using structural equation modelling, the author
3 demonstrated that the amount of television viewing was negatively associated with time spent
4 doing homework and reading. Conversely, it was positively associated with impulsive
5 behaviour. Moreover, the results showed that these three relations hindered academic
6 performance. Shin (2004) suggested that the results supported hypotheses 2, 3 and 4 but not
7 1. However, even though the author stipulated that the *stimulation hypothesis* predicted an
8 association between viewing “well-designed” and “informative programs” (Shin, 2004,
9 p.368) and academic achievement, no attempt was made to measure content in this study.

10 In general, the importance of content has been largely overlooked in the studies that
11 examined the potential role of television in children’s academic performance. With an
12 exception of Anderson and Maguire (1978), who analysed the type of programming that
13 children were exposed to, viewing time was the primary predictor in the reviewed literature.
14 This approach, to treat television viewing as an undifferentiated activity, limits the possibility
15 of pinpointing the mechanisms that drive any observed associations. Furthermore, it appears
16 that when researchers included children with a broader range of individual (e.g., IQ) or family
17 factors (e.g., parents’ attitudes towards TV), the relationship between television viewing and
18 the measured outcomes was not significant.

19 In fact, the family context, in which the viewing occurs, may hold the key to explaining
20 some of the results. Somewhat surprised by the lack of a significant association between HLE
21 and school readiness in preschool children, Clarke and Kurtz-Costes (1997) suggested a new
22 variable - *the family value system* - that could explain their findings. Perhaps limitations
23 associated with the low socioeconomic status, such as for example, restricted budget, may
24 prevent parents from buying books. Yet, families, who have high aspirations for their
25 children’s future may place more *value* on alternative educational activities, that were not

1 measured in the study, to support children's learning. At the same time, these parents may
2 discourage activities that are thought to have low educational value, such as television
3 viewing. Therefore, as Clarke and Kurtz-Costes (1997) suggest, the family value system may
4 mediate the relation between preschoolers' pre-academic skills and HLE measured in their
5 study.

6

7 *3.1.2. Attention problems*

8 Viewing time was the primary predictor in a variety of studies that examined the
9 association between television and attention problems. However, studies reviewed below
10 varied greatly in the number and type of confounding variables included in the analyses, and
11 in the method of assessing television exposure (see Table 1 for details).

12 Based on parental estimates, Miller and colleagues (2007) calculated the average daily
13 viewing time in a group of 4-year-olds. After controlling for age, gender, and socioeconomic
14 status, an association was found between television viewing and both teachers' reports of
15 ADHD behaviours and a direct measure of motor activity. Conversely, parents' reports of
16 attention problems were not associated with television viewing. In similar research,
17 Ebenegger et al. (2012) examined the association between television viewing and
18 hyperactivity/inattention rated by parents of 4- to 6-year-olds. Higher scores on this measure
19 were associated with more television viewing. Although these studies point to a relationship
20 between the amount of time spent on television viewing and the presence of attention
21 problems in young children, they both utilise parental recall of television viewing. Global
22 measures, such as the estimates of typical weekly viewing time, have been found to be biased
23 and less accurate than, for example, viewing diaries (Anderson, Field, Collins, Lorch &
24 Nathan, 1985; Rich, Bickham & Shrier, 2015). Using a more precise estimate of television
25 exposure, Connors-Burrow et al. (2011) failed to demonstrate an association between the

1 amount of viewing and teachers' assessments of hyperactivity, aggression and social skills in
2 5-year-olds from low-income families. However, viewing inappropriate content was
3 associated with classroom hyperactivity, higher aggression scores and poorer social skills.

4 Finally, in a carefully designed study, Collins (1990) examined whether television
5 exposure was correlated with preschoolers' cognitive performance and with parental ratings
6 of children's temperament. Parents of participants completed detailed 10-day viewing diaries,
7 which were used to establish the amount, content and pace of programming watched.
8 Children completed a battery of cognitive assessments (including measures of IQ
9 performance, perseverance, impulsivity and sustained attention). Television viewing did not
10 predict children's cognitive performance. Yet, it is worth noting, that children in this study
11 scored slightly higher than average on the IQ measures. Thus, it is plausible the associations
12 between television viewing and children's cognitive outcomes were moderated by their
13 superior intelligence (see section 3.1.1. for a brief discussion). Conversely, parental ratings of
14 motor activity were positively related to the amount of television watched. Moreover,
15 watching entertainment and "action shows" was positively associated with motor activity. It
16 appears that it was the content of programming, rather than pace that explains these results.
17 For example, the researcher found that boys, who watched *Mister Rogers Neighborhood*,
18 were judged as less active than boys who watched more sports. Both *Mister Rogers*
19 *Neighborhood* and sports shows were slow-paced. Thus, it was suggested that a show's
20 content rather than its pace might explain the results.

21 Four studies investigated whether television viewing was associated with attention
22 problems in middle childhood and early adolescence. Levine and Waite (2000) collected
23 individual viewing diaries from 8- to 11-year-olds, as well as parental estimates of their
24 child's viewing, to calculate a television-viewing index. Viewing time was positively
25 associated with teachers' ratings of ADHD behaviours in the classroom, but not with any

1 other of the measures used in the study (e.g., Stroop performance and parental ratings of
2 distractibility/hyperactivity).

3 Controlling for similar variables, Özmert, Toyran and Yurdakök (2002) collected
4 survey data from the parents of second and third grade Turkish children (ages not reported).
5 Parents provided information about their children's viewing habits, behaviour and social
6 functioning. Watching television for more than 2 hours per day predicted lower social
7 competence and attention problems. Yousef, Eapen, Zoubeidi and Mabrouk (2014), who
8 examined data from 5- to 15-year-olds reported similar results. Watching television/playing
9 video games for more than 2 hours per day was associated with withdrawn, attention
10 problems, and delinquent and aggressive behaviour. Conversely, using the same outcome
11 measure, Ferguson (2011) did not find a relationship between television viewing or exposure
12 to violent content and the presence of attention problems in 10- to 14-year-olds from low-
13 income Hispanic families. In this study, attention problems were predicted by social and
14 personal variables, such as family environment, male gender, antisocial traits and anxiety.
15 Perhaps the inclusion of these factors might explain the differences between the findings of
16 Ferguson (2011) and the previous two studies, as they controlled for fewer confounding
17 variables.

18 The link between time spent watching television and occurrence of attention problems
19 was also investigated by three large population-based studies. Twenty per cent of 4- to 12-
20 year-old children taking part in a Scottish health survey watched television for more than 3
21 hours a day (Shiue, 2015). Watching television for more than 3 hours a day was associated
22 with poorer psychosocial adjustment as assessed by the Strengths and Difficulties
23 Questionnaire. However, this level of viewing was not related to the hyperactivity/inattention
24 subscale of this questionnaire. In contrast to this, using the same outcome measure, Egmond-
25 Frölich, Weghuber and Zwaan (2012) found an association between television viewing and

1 the scores on hyperactivity/inattention subscale with 6- to 17-year-olds. Furthermore,
2 Lingineni and colleagues (2012) performed a cross-sectional study of 5- to 17-year-old
3 children. Approximately 10% of children in this sample had a diagnosis of ADHD. The
4 researchers found that watching television for more than 1 hour a day was one of six factors
5 that increased the odds of the ADHD diagnosis.

6 Based on the results of these three large-scale studies, it appears that watching
7 television should be considered a risk factor, particularly in relation to children's mental
8 health and psychological wellbeing. However, there are limitations to consider. First, each
9 study had a somewhat different focus, and this was reflected in the wide range of covariates
10 included in the analyses (see Table 1 for details). Second, all studies relied on either parental
11 or self-report of television viewing and health-related outcomes, therefore introducing the
12 possibility of recall bias. Finally, none of the studies controlled for content. It is plausible that
13 older children and adolescents, who have less parental supervision, watch more inappropriate
14 content. Thus, the observed associations between television viewing and attention and
15 behavioural problems could be driven by the quality rather than the quantity of television.

16 This lack of consideration of content may be of particular importance, as a recent
17 study has suggested that children's media content preference may be genetically pre-
18 disposed. Testing a sample of 5- to 9-year-old children, Nikkelen, Vossen and colleagues
19 (2014) demonstrated a relationship between the serotonin transporter-linked 5-HTTLPR
20 polymorphism and violent media use. This polymorphism has previously been linked to the
21 development of ADHD (see Gizer, Ficks & Waldman, 2009 for the meta-analysis).
22 Furthermore, the results of this study showed an association between violent media use and
23 children's attention problems. Finally, there was an indirect significant relation between the
24 genotype and ADHD behaviour mediated through violent media use.

1 In summary, over 70% of the studies reviewed in this section present evidence for
2 positive associations between television viewing and attention problems. However, the
3 contribution of this evidence to our understanding of the potential role that television viewing
4 might have in the development of children’s attention is limited in two ways. First, the
5 researchers largely overlooked the importance of content. Yet, in studies that controlled for
6 content (i.e., Collins, 1990; Conners-Burrow et al., 2011) the relationship between the amount
7 of viewing and measured outcomes was eliminated. Second, with very few exceptions
8 (Collins, 1990; Ferguson, 2011), the authors did not consider the broader individual and
9 family context, in which television viewing occurred. Instead they focused on researching
10 basic links between TV viewing and attention without more detailed consideration of a host
11 of interacting variables “...that lead children on a path from exposure to outcomes.” (Barr &
12 Linebarger, 2010, p.555). Thus, the evidence, which came from the investigation of such
13 rudimentary models, appears to be inadequate to explain the complex relationships between
14 television exposure and attentional outcomes (Barr & Linebarger, 2010).

15

16 *3.1.3. Language development*

17 The reports of language outcomes in cross-sectional literature are scarce. Only three
18 studies examined the relationship between television viewing and language outcomes in
19 young children. First, Zimmerman, Christakis and Meltzoff (2007) measured the association
20 between television/film content and infants’ (birth to 2 years) language skills. Of four types of
21 content examined (baby TV/DVDs, educational, entertainment and adult), only watching
22 programmes directed specifically at infant audience was negatively related to early language
23 development.

24 Second, Lin, Chern, Chen, Chen and Yang (2015) compared language skills of two
25 groups of 15- to 35-month-olds. The groups were matched for age and gender, but differed in

1 television viewing (137 vs. 16 minutes/day). High exposure to television increased the risk of
2 language delay. Moreover, children with language delay tended to watch more television than
3 their typically developing peers (117 vs. 53 minutes/day). Third, Chonchaiya and
4 Pruksananonda (2008) compared television viewing habits between 2-year-olds with or
5 without language delay. Children with language delay started watching television at a
6 younger age (7- vs. 12-months), and spent more time watching television (3.1 vs. 1.0
7 hours/day). Watching television before a child's first birthday and watching more than 2
8 hours/day increased the risk of language delay over six times. Moreover, lone-viewing,
9 lacking child-caregiver interaction during television watching, was associated with eight
10 times greater risk of having language delay.

11 Although television may be detrimental to infants' development, the three most
12 significant risk factors for language delay in this study were unrelated to television exposure.
13 Neglectful parenting increased the odds of language delay by over 30 times, and delivery by
14 caesarean section or family history of language/developmental delay were both associated
15 with an odds ratio of about 10 times. Similarly, Lin and colleagues (2015) reported that a low
16 level of maternal education was the strongest risk factor for language delay in their study
17 (about four times). Therefore, as with the suggestions made in the concluding paragraphs of
18 sections 3.1.1. and 3.1.2., it appears that family factors should be given serious consideration
19 in the investigation of the mechanisms that underlie the associations between television
20 exposure and children's development. Finally, without random allocation of participants into
21 each viewing group, there is no certainty that the differences observed in the latter two studies
22 are in fact due to television viewing rather than other unmeasured variables. However, they
23 offer interesting comparisons between developmental outcomes of children, who were or
24 were not exposed to high levels of television at a young age, which could not be made
25 experimentally due to ethical considerations.

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3.1.4. Summary of cross-sectional studies

Although the results of many cross-sectional studies report negative associations between television viewing and children’s cognitive development and - in particular - attention, questions can be raised about the value of the evidence they provide. On the one hand, it appears that there is a positive association between the amount of television viewing and the presence of attention problems in preschool and older children (e.g., Ebenegger et al., 2012; Özmert et al., 2002). Furthermore, increased impulsivity associated with television viewing, in conjunction with displacing the activities that promote learning (such as reading and homework), may lead to poorer educational outcomes (Shin, 2004). Also, excessive television exposure in infancy (> 2 hours/day) is an important risk factor for language delay (e.g., Lin et al., 2015). On the other hand, these associations are mainly observed in the literature based on the investigation of relatively simple theoretical models.

For example, age, gender and socioeconomic status have been included in most of the investigated models. However, individual, family and social factors that may mediate the relationships between television viewing and developmental outcomes have been largely overlooked in cross-sectional research (Oakes, 2009). Indeed, when these factors were included in analyses, they appeared to be stronger predictors of developmental outcomes than TV viewing per se (e.g., Ferguson, 2011; Linebarger et al., 2014). Moreover, evidence suggests that individual factors, such as IQ, may moderate the associations between television viewing and developmental outcomes (Anderson & Maguire, 1978; Collins, 1990).

Additionally, some methodological concerns raise questions about the robustness of the evidence. First, with few exceptions, most of the cross-sectional research described here used global measures of television viewing, based on parental recall, which may be subject to bias. Average daily viewing time, reported across the various studies ranges from less than 1

1 hour/day (e.g., Roberts et al., 1984; Ebenegger et al., 2012) to over 3 hours (e.g., Conners-
2 Burrow et al., 2011; Clarke & Kurtz-Costes, 1997). This wide range may be a true reflection
3 of differences between television viewing depending on children's age or cultural factors.
4 However, it may also be a result of inaccurate measurement, arising from the type of response
5 scales used in a study, respondents' bias to give socially desirable answers, or simply poor
6 recall. Another question raised by assessing the amount of viewing is what exactly is being
7 measured. Is it the amount of time a child spends in a room when the television is on? The
8 time a child has her eyes fixed on a screen? Or perhaps the time a child is immersed in
9 watching a programme (Moses, 2008)?

10 Second, most of the studies reviewed in this section have employed well-validated
11 measures such as the Strengths and Difficulties Questionnaire (Goodman, 1997), Child
12 Behavior Checklist (Achenbach, 1991), or The Bayley Scales of Infant Development -2nd
13 Edition (Bayley, 1993). However, the assessment of complex skills such as attention or
14 language with a single measure (sometimes reduced to several items or a subtest of a
15 particular measure) appears too restrictive (Moses, 2008). Moreover, several studies relied on
16 arguably less reliable parental assessment of ADHD behaviours (e.g., Miller et al., 2007), or
17 on parent-reported ADHD/ADD diagnosis (Lingieni et al., 2012). It is likely that when
18 consent was sought and the information about the study was provided to participants, parents
19 were made aware of the potential negative associations between television exposure and
20 behaviour. As Russell, Rodgers and Ford (2013) suggest, parents may be more likely to report
21 the presence of ADHD symptoms if the diagnosis was suggested to them by a healthcare
22 professional, but not yet confirmed. Similarly, parents of children who watched a lot of
23 television may have been more likely to report attention difficulties than parents of children
24 who exhibited similar behaviour, but watched a moderate amount.

1 Third, most studies did not attempt to account for the content viewed. In fact, findings
2 from the studies where the type of content was controlled for, suggest that *what* children
3 watch rather than *how much* they watch is a better predictor of developmental outcomes. The
4 lack of information about what children watch may be of particular importance when
5 considering findings from large-scale, population-based studies, which included participants
6 from a wide age range. Older children and adolescents have more choice over what they
7 watch and may choose programmes based purely on entertainment value. Moreover,
8 television programming directed at 5-year-old audience differs in content and form to that
9 directed, for example, at 10-year-old viewers. Considering television viewing to be an
10 undifferentiated activity may lead to oversimplifying the possible relationships between
11 viewing behaviour and developmental outcomes.

12 In sum, although cross-sectional studies have been useful in recognising associations
13 between exposure to television and developmental outcomes, they do not allow us to draw
14 causal inferences or establish a temporal sequence, thus it is impossible to determine when
15 the association developed, or how it may change across time (Robinson et al., 2005).
16 Moreover, the key limitations of cross-sectional research are the lack of precise viewing
17 measures and the potential reporting bias, restricted outcome assessment, and a frequent
18 omission of potential moderators, such as content, or contextual variables, from the
19 investigated models. Nevertheless, the investigation of the literature revealed a number of
20 variables (i.e., content, age of exposure, family context and individual differences, and
21 foreground vs. background exposure) that may play a key role in developing a better
22 understanding of the complex relations between television exposure and children's
23 development.

24

25 **3.2. Longitudinal correlation studies**

1 Longitudinal design allows the observation of “early-later” relationships (Robinson et
2 al., 2005) and suggestions to be made about the temporal sequence
3 of co-variables; thus it enables plausible inferences about causes and effects. Furthermore, it
4 is a suitable alternative when controlled experiments would be unethical (Mann, 2003), such
5 as, for example, exposing children to high levels of television. This section reviews evidence
6 from 31 studies related to the long-term correlates of television viewing to executive function,
7 academic performance, attention problems and language development. For a detailed
8 description of the studies, see Table 2.

9

10 *3.2.1. Executive function and academic performance*

11 The cross-sectional literature reviewed in section 3.1.1. suggests that programming
12 content and family context may play a role in understanding the mechanisms that underlie the
13 associations between television viewing and executive function. The following two studies
14 provide further evidence for the importance of these variables. In a prospective cohort study,
15 Barr, Lauricella, Zack and Calvert (2010) investigated whether the television content children
16 are exposed to at young age (child-directed vs. adult-directed) predicted subsequent cognitive
17 outcomes¹. Parents completed viewing diaries when their children were 1- and 4-years-old,
18 and assessed their children’s behaviour at age 4 by completing a questionnaire measure of
19 executive function. The results suggested that the type of content children watched was
20 related to their cognitive skills. Watching adult-directed programmes in infancy was
21 associated with poor executive function at age 4, as measured by the questionnaire. In
22 addition to parental assessment of executive function, 4-year-olds completed a battery of
23 cognitive tests. After controlling for parental education, the results showed that high
24 exposure to adult-directed content at age 4 was associated with poorer cognitive performance

¹ Although this study has a longitudinal design, one of the investigated hypotheses is cross-sectional. However, for clarity, the results of both longitudinal and cross-sectional investigations are presented together in this subsection of the review.

1 (poorer language skills, school readiness skills, and lower scores on executive function
2 measure). Conversely, watching child-directed programming both in infancy and at 4 years
3 was not associated with these negative outcomes. Overall, the results of this study suggest
4 that the relationship between watching television and cognitive outcomes depends on content.
5 Watching child-directed programming was unrelated to both performance and parent-reported
6 executive functioning, whereas exposure to adult-directed content was associated with poor
7 executive function.

8 Blankson, O'Brien, Leerkes, Calkins and Markovitch (2015) used performance-based
9 cognitive measures to examine the relationship between preschool television viewing at 3 and
10 4 years and vocabulary and executive function at 5 years. The researchers also measured the
11 quality of Home Learning Environment (HLE assessed with a number of books at home, joint
12 reading activities, explicit teaching of new concepts and words and availability of toys and
13 other learning materials at home) and the quantity and quality of parental scaffolding (parent-
14 child interactions measured during a problem-solving task). At baseline (age 3), there was a
15 negative correlation between the amount of television viewing and the quality of HLE and
16 cognitive scaffolding. However, there was no association between television viewing at age 3
17 and executive function and vocabulary at age 5 (after controlling for socioeconomic status
18 and ethnicity). Instead, these were predicted by parental scaffolding. Similarly, at age 4, there
19 was a negative correlation between the amount of television and HLE and parental
20 scaffolding. Yet again, television viewing at 4 was not predictive of vocabulary and executive
21 function at age 5. The only significant association was between the level of parental
22 scaffolding and vocabulary.

23 These two studies had different strengths. Barr et al. (2010) used a more accurate
24 measure of television viewing (a viewing diary), and collected information about content as
25 well as capturing information about viewing at a younger age. However, Blankson et al.

1 (2015) controlled for the level of cognitive stimulation at home. Perhaps the way television is
2 used in the household contributes to the overall educational climate within the home. For
3 example, parents who provided more cognitive stimulation may have also encouraged their
4 children to watch age-appropriate educational programming. Conversely, families, in which
5 parents rarely engaged in educational activities with their children, may have used television
6 purely for entertainment purposes, and in consequence paid little attention to the educational
7 value of the programmes to which their children were exposed.

8 Two studies, using large population-based samples investigated the relations between
9 viewing in infancy and early childhood and children's school readiness and early educational
10 outcomes. First, Zimmerman and Christakis (2005) examined whether television viewing
11 before the age of 3 and between ages of 3 and 5 years predicted early academic skills and
12 working memory at the age of 6. There was an association between television viewing before
13 the age of 3 and poorer single word reading and text comprehension. Furthermore, early
14 television viewing predicted poorer working memory and early numeracy skills, but only in
15 children from low-income families. Conversely, television viewing between the age 3 and 5
16 was *positively* associated with reading comprehension scores. Second, Pagani, Fitzpatrick,
17 and Barnett (2013) reported that more time spent viewing television at 29 months was
18 negatively associated with vocabulary scores, early numerical skills and teachers' ratings of
19 classroom engagement at 65 months.

20 In contrast, Ritchie, Price and Roberts (1987) failed to provide evidence of a
21 meaningful relation between the amount of viewing and school outcomes. The researchers
22 examined changes in television viewing, leisure reading and reading achievement across a
23 three-year period in primary school children. It appears that neither reading time, nor reading
24 skills were related to the amount of television viewing in primary school children. Yet,
25 caution should be applied to the interpretation of these results. The researchers asked children

1 and not parents to quantify the amount of television viewing and reading at home (see section
2 3.1.1. for a brief discussion). The correlations between children's estimates collected via a
3 questionnaire and viewing diary were only moderate (r-values ranging from .40 to .65), which
4 raises questions about the reliability of the viewing data analysed in this study.

5 Although the results of Zimmerman and Christakis (2005) and Pagani and colleagues
6 (2013) suggest that television is negatively related to school readiness and early educational
7 outcomes, they tested the amount of viewing rather than the content. A carefully designed
8 study conducted by Wright et al. (2001) provided evidence that content might be critical to
9 these outcomes. They examined patterns of television viewing and their relationship to early
10 academic skills in two cohorts of children (with initial ages of 2 and 4 years) over a period of
11 3 years. For the younger cohort only, watching educational television at 2 to 3 years was
12 positively related to basic academic skills, vocabulary, and school readiness at the age of 3.
13 Also for the younger cohort only, watching animated cartoons at 2 and 3 years predicted
14 poorer word recognition at the age of 3, and lower vocabulary at the age of 5. For both
15 cohorts, viewing "general audience programmes" was associated with worse outcomes on
16 several cognitive measures (younger - poor numeracy and vocabulary, older - letter/word
17 knowledge). Furthermore, this study provided some evidence for children's cognitive skills
18 driving later viewing. For the younger cohort, better performance on letter-word recognition,
19 vocabulary, and school readiness tests at age 3 predicted less viewing of general audience
20 programmes at 4 to 5 years. For the older cohort, higher scores on the test of letter-word
21 recognition at age 5 were positively related to watching educational television at 6 to 7 years.
22 Finally, low vocabulary scores at age 5 predicted more cartoon viewing at ages 6 to 7 years.

23 Overall, these findings suggest that watching adult-directed content may have potential
24 detrimental effects during childhood, irrespective of the age of exposure. Moreover, only
25 young viewers (age 2-3) appear to benefit from watching educational television. Finally, this

1 study provides evidence for a bidirectional relationship between content preference and
2 children's cognitive skills.

3 Further evidence that the relations between television exposure and educational
4 outcomes are complex comes from a study by, Shariff, Wills and Sargent (2010). The authors
5 collected self-reported information to examine relationships between amount of television
6 viewing, watching inappropriate content, and school performance in older children (10- to 14-
7 year-olds). Using structural equation modelling, the researchers tested a model that proposed
8 several potential pathways leading to inferior school performance. The results did not support
9 the direct pathway, from television exposure to educational performance. However, it appears
10 that there was an indirect negative relation between viewing inappropriate content and
11 educational performance. Specifically, viewing inappropriate content predicted poorer school
12 outcomes through an increase in substance use and sensation seeking. Moreover, specifically
13 viewing R-rated "adult only" films increased problem behaviour at school, which in turn
14 resulted in poorer educational outcomes.

15 Studies reviewed so far in this section have had a relatively short duration; the interval
16 between the baseline and the last wave of data collection varied between one and three years.
17 Thus, their findings cannot provide evidence for persistent associations. The remaining part
18 of this section describes findings from four studies that investigated long-term outcomes of
19 television viewing.

20 In a population-based study, Pagani, Fitzpartick, Barnett and Dubow (2010)
21 investigated prospective associations between television viewing at 29 and 53 months and the
22 level of academic performance and classroom behaviour at 10 years. The amount of
23 television viewing at 29 months predicted lower levels of classroom engagement and
24 mathematical skills (but not reading) at age 10. Viewing at 53 months had no relation to
25 subsequent performance. The latter result implies that the potential effect of television

1 viewing on educational outcomes may be restricted to infancy. This suggestion is supported
2 by results of a study that examined the relationship between changes in television viewing
3 and academic performance between the ages of 6 and 12 years (Hofferth, 2010). Overall, for
4 the majority of children taking part in this study, changes in television viewing were not
5 related to changes in educational performance. Significant findings were restricted and
6 contradictory. For White boys an increase in amount of television viewing predicted higher
7 scores on letter-word recognition, whereas for Black girls an increase in television viewing
8 predicted lower scores on text comprehension.

9 Although these two studies spanned a relatively long period, they examined children's
10 educational outcomes in relation to the overall viewing time, without considering content. In
11 contrast, Anderson and colleagues (2001) focused their investigation on the long-term
12 developmental correlates of television content watched by preschoolers. The comparison of
13 preschool and adolescent viewing habits suggested that content preferences remained stable
14 across time. Moreover, the type of content watched during preschool years, but not the
15 amount watched, appeared to have long-term associations with educational outcomes.

16 For girls, the amount of viewing at age 5 predicted poorer high school grades;
17 conversely, boys' preschool viewing time was positively associated with academic
18 achievement during adolescence. However, more detailed analyses showed that these results
19 were explained by content watched. The girls who watched more child-informative
20 programmes at age 5 tended to have better grades at high school, although this relationship
21 was not statistically significant. The boys' results were more conclusive; viewing child-
22 informative programmes during preschool years predicted better high school grades. In
23 contrast, the girls who watched violent cartoons at 5 had lower grades. However, this
24 relationship was partially mediated by teen viewing of violent content. For boys, preschool
25 viewing of violent content did not predict high school grades; however, watching violent

1 content in adolescence was negatively associated with high school grades. Overall, these
2 results suggest that the content of programming watched, rather than the amount, during
3 preschool years predicts teen educational outcomes. Moreover, the only robust long-term
4 association between preschool viewing and teen grades appears to be the positive relation
5 between boys' exposure to child-informative programmes and average grades in adolescence.

6 Although the findings of Pagani et al. (2010) and Wright et al. (2001) suggest that some
7 associations between television and academic outcomes are long-lasting, they do not allow us
8 making inferences about the potential role of early TV viewing beyond adolescence. Hancox,
9 Milne and Poulton (2005) examined prospective associations of television viewing and
10 educational attainment through into adulthood. The results indicated that the amount of
11 television viewing in childhood (5 to 11 years) and adolescence (13 to 15 years) was
12 positively associated with leaving school with no qualifications, and negatively related to
13 achieving a university degree. Furthermore, adolescent viewing was a strong predictor of
14 leaving school without qualifications, whereas childhood viewing was negatively related to
15 achieving a university degree. Although these findings suggest that watching television may
16 have far-reaching consequences that extend beyond school years and potentially impact adult
17 life, Hancox and colleagues (2005) did not consider in their investigation important
18 moderating variables such as content and family context.

19 In sum, the findings from the studies that measured the amount of viewing suggest that
20 infancy TV exposure may have negative consequences for children's later educational
21 attainment. Conversely, the evidence pertaining to older viewers' academic outcomes is less
22 clear. Considering the heterogeneity of the measures used, the varied choice of covariates and
23 a different length of the interval between the study phases, it is likely that the mixed findings
24 stem from the differences in study design rather than reflect a lack of systematic relations.
25 Finally, the findings from the studies that investigated the potential role of content are

1 consistent with the evidence presented in earlier sections of this review. The relationship
2 between watching educational TV and academic outcomes is positive, whereas watching
3 inappropriate adult-directed content predicts lower educational attainment.

4

5 *3.2.2. Attention problems*

6 Although useful for identifying associations between television exposure and attention
7 problems, the cross-sectional literature could not provide answers regarding the mechanisms
8 that drive such associations. While longitudinal research has advantages in this regard, its
9 potential to explain the underlying causal mechanisms depends on the complexity of the
10 investigated models and the robustness of the measures used

11 In a prospective cohort study Cheng, Maeda, Yoichi, Yamagata and Tomiwa (2010)
12 investigated whether early television exposure was associated with subsequent behaviour in
13 under-threes. Mothers reported their children's daily television viewing at ages 18 and 30
14 months. In addition, children's behaviour was assessed at 30 months. After controlling for
15 child and mother characteristics, there was a positive association between daily television
16 exposure at 18 months and hyperactivity/inattention. Furthermore, there was a significant
17 linear trend indicating that as the number of viewing hours at age 18 months increased,
18 hyperactivity/inattention problems at age 30-months increased and pro-social behaviour
19 decreased.

20 Although this study provided evidence for the relationship between television viewing
21 and decrease in attention and pro-social behaviour in infants, it did not measure children's
22 baseline behaviour. Perhaps parents of infants, who demonstrate difficult behaviour early on,
23 turn to television to soothe their otherwise unsettled children. Therefore, the associations
24 between later television exposure and behavioural problems, such as, for example,
25 inattention, might be confounded by children's early behavioural traits. Radesky, Silverstein,

1 Zuckerman and Christakis (2014) examined whether infants' self-regulation at 9 months
2 predicted the amount of television use at 24-months. A questionnaire completed by parents at
3 ages 9 and 24 months measured children's behaviour regulation. Infants with moderate to
4 severe self-regulation problems watched more television as toddlers than infants who had no
5 or mild behavioural regulation difficulties. Furthermore, children with persistently poor self-
6 regulation were 40% more likely to watch 2 hours of television a day. Likewise, children
7 whose self-regulation skills deteriorated since infancy were at increased risk of watching
8 more television. It is worth noting that researchers did not collect information about television
9 exposure at 9 months. Perhaps the positive relationship between infants' self-regulation and
10 later viewing was confounded by television exposure in infancy.

11 Further evidence for an interdependent relationship between behavioural difficulties
12 and television viewing comes from a study conducted by Verlinden and colleagues (2012).
13 The researchers assessed the *occurrence* (onset of behaviour at 36-months) and *persistence* (a
14 continuous presence of behaviour at both 18- and 36-months) of attention problems and
15 aggression in a large sample of children. Information about the amount of viewing and type
16 of content was collected at 24 and 36 months. Neither the amount of television nor viewing
17 unsuitable content at 24 months predicted the occurrence of attention problems and
18 aggression at 36 months. However, "high television exposure" (a high amount of viewing at
19 24- and 36-months and increased viewing between these time points) was associated with the
20 occurrence of attention problems and aggression at 36 months and the persistence of these
21 problems. Finally, an increase in viewing was strongly related to persistence of attention
22 problems and aggression. Therefore, it appears that children with early behavioural
23 difficulties may be particularly drawn to watching television. Acevedo-Polakovich, Lorch and
24 Milich (2007) suggest that children who demonstrate difficult behaviour, such as children
25 with ADHD, struggle with peer relationships and experience a higher level of conflict in their

1 interactions with caregivers at home. Perhaps, as Acevedo-Polakovich et al. (2007) suggest,
2 watching television offers a mutually enjoyable alternative to social interaction for children
3 with behavioural difficulties and others in their social environment.

4 Four further large studies examined the relationship between the amount of television
5 viewing and subsequent ADHD behaviours. Christakis and colleagues (2004) examined
6 whether the amount of television viewing at age 1 and 3 was associated with attention
7 problems at 7 years. After controlling for confounding variables, there was a positive
8 association between the score children obtained on the hyperactivity subscale of the
9 questionnaire measuring behaviour problems and the amount of television they watched at the
10 age of 1 year and 3 years. Furthermore, Landhuis, Poulton, Welch and Hancox (2007)
11 investigated whether attention problems in adolescence were related to childhood (i.e., ages 5
12 to 11) television viewing. The researchers demonstrated that, after controlling for early
13 attention, cognitive ability and socioeconomic status, the amount of television viewing in
14 childhood was related to attention problems in adolescence. However, this relationship was
15 reduced once adolescent viewing was controlled for.

16 The data from Christakis and colleagues' (2004) study were subsequently reanalysed in
17 two independent studies. First, to explore the developmental trajectories of television viewing
18 and attention problems across the six-year period (Stevens, Barnard-Brak & To, 2009), and
19 second, to examine the robustness of the original findings by using a different statistical
20 technique and adding more covariates to the model (Foster & Watkins, 2010). Stevens and
21 colleagues (2009) used the same data as Christakis et al. (2004); however, instead of using
22 two time points (television viewing at ages 1 and 3 years, and attention outcomes at 7 years)
23 to evaluate the relationship between the variables, they mapped the developmental trajectories
24 of television viewing and attention problems between the ages of 4 and 10, and examined the
25 relationship between both. The analysis of changes in television viewing revealed that after a

1 rapid rise in early childhood, there was a steady increase in viewing during the six-year
2 period. In contrast, attention problems and hyperactivity peaked between the ages of 6 and 7,
3 and then gradually declined. The examination of the relationship between the amount of
4 television and attention problems during the time, when the children were 6 years old,
5 indicated that there was no significant association between the increase in viewing and
6 hyperactivity/inattention. Furthermore, although there was a significant association between
7 attention problems at 4 years and the subsequent increase in television viewing, it was
8 deemed weak ($\beta = .05$) and thus of little importance. Finally, there was no significant
9 association between the amount of viewing and attention problems in 4-year-olds.

10 In the second re-analysis of the data first presented by Christakis and colleagues (2004),
11 Foster and Watkins (2010) used semi-parametric regression, which allowed a more sensitive
12 non-linear approach to investigating the relationship between the amount of television
13 viewing, covariates and attention outcomes. This reanalyse failed to support the original
14 interpretation of the findings. First, the association between early childhood viewing and later
15 attention problems was only significant for children who watched excessive amounts (i.e.,
16 between 6 and 7 hours of television a day). Moreover, the inclusion of two additional
17 covariates to the model (maternal achievement and family poverty status) rendered this
18 relationship not significant.

19 More support for the lack of a meaningful relationship between the amount of viewing
20 and subsequent attention problems comes from a study by Stevens and Mulslow (2006).
21 Using a structural equation model, the researchers examined the data from two samples of
22 children (the second sample was used to cross-validate the model) to test for the association
23 between kindergarten television viewing and the presence of ADHD symptoms (measured by
24 teachers' and parents' ratings) in the first grade (age not reported). Controlling for
25 socioeconomic status, no statistically significant relationship was found between television

1 viewing and subsequent ADHD symptoms. Furthermore, using a large population-based
2 sample, Parkes, Sweeting, Wight and Henderson (2013) found no association between the
3 amount of television viewing at 5 years and hyperactivity/inattention at 7 years reported (by
4 mothers on a questionnaire measure of behaviour). However, children who watched more
5 than 3 hours of television a day at the age of 5 years demonstrated increased conduct
6 problems between the ages of 5 and 7 years. Finally, Schmiedeler, Niklas and Schneider
7 (2014) demonstrated that the amount of television exposure (based on the child- and parent-
8 reported viewing amount) did not predict attention problems at school age. Instead,
9 hyperactivity and inattention at school age were related to child's early home learning
10 environment.

11 It appears that not only the quality of learning environment, but also other aspects of
12 home life may be important for the development of attention. Martin, Razza and Brooks-
13 Gunn (2012) examined the associations between "chaos in the households" – measured by the
14 lack of routine, family instability, having the television on, noise and crowding – of 2-year-
15 olds and developmental outcomes at 5 years. Having the television habitually on at home was
16 associated with poorer attention and increased aggression. Other measures of household
17 chaos were not associated with the measured outcomes.

18 All of the studies reviewed so far in this section measured the amount of exposure,
19 overlooking the importance of television content. Yet, as we have discussed above, *what*
20 children watch rather than *how much* they watch may be crucial to subsequent developmental
21 outcomes. However, only two longitudinal studies tried to capture the contribution of content
22 in explaining the relationships between television viewing and attention. Tomopoulos et al.
23 (2007) collected television exposure data (including names of programmes and total viewing

1 time) at 21 and 33 months from Latino mother-child dyads². The programmes watched by
2 children were categorised. Further, children's behaviour was assessed at 33 months with a
3 questionnaire measure. There was a positive association between total television viewing at
4 21 months, aggressive behaviour and the presence of externalising problems (i.e., unruly,
5 antagonistic and hyperactive behaviour). Moreover, aggressive behaviour was associated with
6 viewing non-educational programmes at 21 and 33 months. Finally, viewing non-educational
7 programmes at 33 months was positively associated with the scores on externalising problems
8 scores. In contrast, viewing educational content at 21 months did not predict subsequent
9 problem behaviour.

10 Adopting a longer interval between the study phases, Zimmerman and Christakis (2007)
11 investigated the association between the type of content watched in early childhood and later
12 attention problems. Viewing entertainment programmes (both violent and non-violent) before
13 the age of 3 years predicted higher hyperactivity 5 years later. In contrast, no associations
14 were found between the exposure to entertainment content at the age of 4 to 5 years and
15 attention problems 5 years later. In addition, viewing educational television at an early age
16 was not associated with subsequent attention problems.

17 Overall, the longitudinal literature provides some evidence for a bidirectional
18 relationship between television exposure and behaviour (Radesky et al., 2014; Verlinden et
19 al., 2012), which suggests that children with early attention difficulties may be particularly
20 drawn to watching television. There is less evidence for high levels of television viewing
21 simply causing attention deficits. However, when content was considered, the potential
22 negative outcomes associated with watching television were more apparent – with problems
23 observed among children that were exposed to content which was designed to entertain (e.g.,

² Some analyses performed in this study are cross-sectional. However, for clarity, all results from longitudinal studies are reported in this section of the review.

1 cartoons). Conversely, watching educational content was unrelated to subsequent attention or
2 problem behaviour.

3

4

5 *3.2.3. Language development*

6 Some cross-sectional literature suggests that although television viewing is not the
7 most significant risk factor for language delay, it should be considered as an important
8 variable associated with early language outcomes. Three longitudinal studies assessed the
9 relationship between early television exposure and infants' language development.

10 Tomopoulos and colleagues (2010) examined whether exposure to various media (i.e.,
11 television, video/DVD, films and games), and media content, at age 6 months predicted
12 language skills at 14 months in infants from families with low socioeconomic status. The
13 overall amount of television exposure was negatively related to language development.

14 Moreover, exposure to older child/adult-directed content predicted poorer language skills.

15 Duch and colleagues (2013) provided further support for the negative relationship
16 between television exposure and communication skills of 12- to 24-month-olds from low-
17 income families. Children taking part in this study were categorised according to viewing
18 time (either "under 2 hours per day" or "over 2 hours per day"). High exposure predicted
19 poorer communication skills a year later. Furthermore, watching child-directed content for
20 more than 2 hours per day decreased subsequent communication skills. High exposure to
21 adult content was not related to communication scores. However, at baseline assessment there
22 were only 19 children who were exposed to more than 2 hours of adult-directed content daily,
23 and so perhaps, as the authors suggested, the study was underpowered to detect a relationship
24 between the variables.

25 In a carefully designed study, Linebarger and Walker (2005) collected detailed

1 viewing logs from parents every three months between ages 6 and 30 months to examine
2 developmental trajectories of television viewing and language skills. Parents recorded
3 information regarding children's overall viewing time and names of programmes viewed.
4 Researchers classified programmes listed by parents into three broad categories: child-
5 educational, child-entertainment and adult programming. The overall viewing time predicted
6 lower word production at 30 months. Furthermore, watching child-educational programmes,
7 but not child-entertainment and adult programming, was also negatively related to word
8 production. Conversely, expressive language scores (obtained in a play-based assessment of
9 early communication behaviour) were positively associated with time spent viewing
10 television. Moreover, watching adult programmes, but not those directed to children,
11 predicted expressive language growth. Finally, watching programmes directed at child
12 audiences was unrelated to expressive language outcomes.

13 These associations appeared to be further qualified by children's preference for
14 specific kinds of programme. Watching shows with no structured story, such as *Sesame Street*
15 (despite its well-documented benefits for preschool learning), or programmes that provided
16 few or low-quality language examples (e.g., "baby talk" used in *Teletubbies*) predicted poorer
17 language skills. Conversely, watching programmes that may stimulate language development
18 through clear labelling, encouraging vocalizations, and interactions with on-screen characters
19 (e.g., *Dora the Explorer*, *Blues Clues*) was associated with positive language outcomes.
20 Collectively, the negative associations between television viewing and language development
21 are particularly evident for children from low socioeconomic environments (Tomopoulos et
22 al., 2010; Duch et al., 2013). However, for children from middle- to high-income families
23 (Linebarger & Walker, 2005), the relationships between television viewing and language
24 outcomes are more nuanced.

1 In contrast to these findings, Schmidt and colleagues (2009) found no evidence that
2 television viewing before the age of 2 was associated with poorer vocabulary at the age of 3,
3 once maternal and household characteristics were controlled for. Similarly, based on data
4 from older children, Bittman and colleagues (2011) found no relationship between the amount
5 of television viewing and children’s vocabulary knowledge – although other relationships
6 were significant. The researchers examined traditional media (television and print) use, as
7 well as children’s access to new media devices (e.g., computers, games consoles, etc.), co-
8 viewing and parental media monitoring practices in two cohorts of children over a four-year
9 period. For the younger cohort (0- to 5-year-olds), having a television in the bedroom and
10 background television predicted lower receptive vocabulary scores at age 5 years. In contrast,
11 watching television together with parents was associated with increased vocabulary scores of
12 5-year-olds. For the older cohort (4- to 9-year-olds), having a television in the bedroom
13 predicted lower vocabulary scores at age 9.

14 The results of this study did not show any evidence for the negative relationship
15 between the amount of television viewing and children’s subsequent language outcomes.
16 Although families that took part in this research represented diverse socioeconomic
17 backgrounds, the percentage of highly educated mothers was relatively high (10%), whereas
18 families with low socioeconomic status were underrepresented. Previous research shows that
19 maternal education and family income are strong positive predictors of language outcomes
20 (e.g., Hoff, 2003). Likewise, consistent with the suggestions of other researchers (e.g., Clarke
21 & Kurtz-Costes, 1997; Schmiedeler et al., 2014), home environment and parental
22 characteristics may be stronger predictors of language outcomes than the amount of television
23 children are exposed to. Well-educated parents may have a greater awareness of paediatric
24 media guidelines, and consequently their children are exposed to less television overall, and
25 watch programmes that are age-appropriate and contain educational material.

1 Indeed, some television may have the potential to support children's language
2 development. Rice, Huston, Truglio and Wright (1990) investigated the relation between
3 watching *Sesame Street* and vocabulary development in two cohorts of children (with initial
4 ages of 3 and 5). For the younger cohort, viewing the programme at age 3 and 4- to 5 was
5 positively related to vocabulary growth at age 5. Preschoolers, who are the target audience of
6 *Sesame Street*, appeared to benefit from the language-enhancing content of the programme.
7 In contrast, for the older cohort the relationship between watching *Sesame Street* at age 5 and
8 6-7 was not significant. Perhaps, as Rice and colleagues (1990) suggested, the content of
9 *Sesame Street* is well suited to support the rapid development of vocabulary during preschool
10 years, yet ineffective in enhancing the learning of older children who need to acquire more
11 sophisticated language skills. Moreover, the notion that the potential effects of content may
12 be mediated by a viewer's age is supported by the findings of Linebarger and Walker (2005)
13 described earlier in this section, which demonstrated a negative association between watching
14 *Sesame Street* and infants' language growth. Unlike preschoolers', infants' cognitive skills
15 are too immature to benefit from vocabulary-enhancing content presented on a television
16 screen (for a discussion see Barr, 2010).

17 Finally, there is a suggestion that television viewing may be associated with
18 anatomical changes in brain structures important for the development of verbal abilities and
19 overall intelligence in children and adolescents. Using functional magnetic resonance
20 imaging, Takeuchi and colleagues (2013) provided evidence for cross-sectional and
21 longitudinal relations between the amount of television viewing and positive changes in
22 grey/white matter volume in the frontopolar, medial prefrontal, visual cortex,
23 hypothalamus/septum and sensorimotor areas. Although it is unclear whether these observed
24 structural changes in various parts of the brain are detrimental, the same study also reports
25 negative changes in verbal IQ. Specifically, in the cross-sectional analysis the amount of

1 television viewing predicted lower verbal IQ. In the longitudinal analysis, the amount of
2 television viewing predicted a decrease in verbal IQ after 3 years. However, there was no
3 evidence for long-term associations between time spent watching television and performance
4 IQ or full scale IQ. Moreover, the authors suggested that the associations between brain
5 changes and behaviour were not strong and could be explained by other variables, such as the
6 rate of physical maturation.

7 Longitudinal evidence supports the findings from cross-sectional studies, and suggests
8 that television exposure (both amount and specific content) could be potentially detrimental
9 to infants' language development. The evidence related to older children is too limited to
10 draw any meaningful conclusions. The amount of viewing beyond infancy appears to be
11 unrelated to children's vocabulary development, while exposure to educational content
12 predicts subsequent vocabulary growth - albeit only in preschool children.

13

14 *3.2.4. Summary of longitudinal studies*

15 The evidence reviewed in this section suggests that the longitudinal relationships
16 between television viewing and subsequent developmental outcomes are complex and may be
17 mediated by a host of contextual and individual factors. Several studies reviewed in sections
18 3.2.1. and 3.2.3. point to negative associations between early television exposure and both
19 cognitive and educational outcomes. These relations are mostly restricted to children who
20 started watching television early (< 3 years), come from disadvantaged socioeconomic
21 backgrounds, or are exposed to content that is inappropriate for their age (e.g., Barr et al.,
22 2010; Tomopoulos et al., 2010; Wright et al., 2001). Conversely, watching television at older
23 age appears to be generally unrelated to subsequent cognitive and educational outcomes.
24 Moreover, age also appears to be an important moderator of the direction in the relationships
25 between viewing educational content and subsequent academic achievement. Depending on

1 the age of exposure, the observed relations were negative (infancy; Linebarger & Walker,
2 2005), positive (preschool; e.g., Rice et al., 1990), or null (school-age; e.g., Wright et al.,
3 2001).

4 Similarly, studies reviewed in section 3.2.2. fail to provide a clear picture of the
5 relationship between television viewing and subsequent occurrence of attention problems.
6 Although the results of smaller scale research point to an association of infant television
7 viewing with attention and behavioural problems (Cheng et al., 2010; Tomopoulos et al.,
8 2007), the results of investigations involving larger samples are less straightforward. For
9 example, initial data analysis suggested that there was an association between exposure to
10 television in infancy and attention problems in early/middle childhood (Christakis et al.,
11 2004). However, this apparent relationship was not robust, as after adjusting for additional
12 confounding variables, and using a more powerful statistical approach to data analysis, the
13 associations found in the original study were no longer significant (Foster & Watkins, 2010).
14 Nevertheless, other factors such as the type of content watched and background exposure to
15 television may influence long-term relations between children's attention and behavioural
16 outcomes (Martin et al., 2012; Zimmerman & Christakis, 2007).

17 Longitudinal studies seem to be well-suited to address the limitations of the cross-
18 sectional research; however, they are not flawless. Many limitations of longitudinal research,
19 such as relying on imprecise viewing measures, limited outcome assessments and omission of
20 content, mirror the concerns that were raised about the cross-sectional studies in section 3.1.4.
21 The drawbacks of television literature discussed in the following paragraphs are specific to
22 the nature of longitudinal design.

23 First, in the majority of studies reviewed in this section, data were collected at two time
24 points; yet cognitive and behavioural variables were assessed only once. The authors assumed
25 that the "cause" (i.e., television exposure), preceded the outcome. However, without the

1 simultaneous assessment of cognition/attention, it is neither possible to establish the presence
2 of early indicators of developmental problems, nor to assess change. Indeed, Stevens and
3 colleagues (2009) demonstrated that the trajectories of television viewing and attention
4 problems did not develop in parallel. Thus, further multi-phase longitudinal investigations are
5 needed to map the trajectories and make more robust inferences about the direction of the
6 association between television exposure and developmental outcomes.

7 It is conceivable that the proposed “causal relationship” between television viewing and
8 developmental outcomes is bidirectional; children with attention difficulties may turn to
9 television more than their typically developing peers (Acevedo-Polakovich et al., 2007;
10 Nikkelen, Valkenburg, Huizinga & Bushman, 2014). In fact, the results of three studies cited
11 in this review seem to support this suggestion, as they suggest that both the amount and
12 content preferences can be predicted by early behavioural traits and cognitive skills (Radesky
13 et al., 2014; Verlinden et al., 2012; Wright et al., 2001).

14 The length of the interval between the two study phases varied from one year (e.g.
15 Cheng et al., 2010) to five years (Zimmerman & Christakis, 2007). Although, as Taris and
16 Compier (2003) point out, it is very difficult to assess the duration of the “causal lag” (i.e., the
17 time required for the causal variable to have an effect on the outcome variable), neither of the
18 studies reviewed here provided a clear rationale for choosing a particular interval between the
19 two study phases. Finally, studies differed in the choice of confounding variables (see Table 2
20 for details), and as demonstrated by Foster and Watkins (2010) adding additional covariates
21 to the model rendered a previously significant association between the amount of television
22 and attention problems non-significant.

23

24 **3.3. Experimental studies**

1 Controlled experiments allow one to develop an understanding of how particular
2 features of television affect children’s cognition and attention. A hypothesis formulated in the
3 literature suggests that fast pace, which characterises children’s programming, may over-
4 stimulate developing brains and ultimately lead to deficits in attention (Singer, 1980;
5 Christakis, 2009; Christakis, 2011). Twenty-five per cent of the studies reviewed in this
6 section investigate the immediate effects of television pacing on children’s executive function
7 and attention. Moreover, in line with research providing evidence for the importance of
8 parent-child interactions to young children’s cognitive and social development (e.g., Bernier,
9 Carlson, Deschênes & Matte-Gagné, 2012; Blewitt, Rump, Sheals & Cook, 2009), several
10 studies included in this section examined parent-child interactions in the presence of
11 foreground or background television. Finally, several articles investigated the educational
12 values of infant programming and the conditions under which under-threes can learn words
13 from televised material. For a detailed description of the studies included in this section see
14 Table 3.

15

16 *3.3.1. Executive function and academic performance*

17 Correlational literature suggests that programming content and family context of
18 exposure are important in understanding the relations between television viewing and
19 executive function performance. However, controlled experiments have done little to examine
20 the effects of these variables on children’s executive function. Nevertheless, the results of two
21 studies suggest that television does affect these processes. Lillard and Peterson (2011)
22 examined the immediate effects of a programme pacing on children’s executive function.
23 Four-year-olds were assigned to one of two experimental groups (fast-paced or slow-paced
24 film) or a control (drawing). Children who watched a fast-paced cartoon performed
25 significantly worse on a post-viewing test of executive function compared to the control

1 group. These results suggest that children are sensitive to programme pacing. However, as
2 researchers did not measure children’s executive function prior to film exposure, the
3 difference in post-viewing scores could have resulted from either an improvement in
4 executive function following the educational activity, or a decline after exposure to a fast-
5 paced cartoon. Moreover, this difference may have resulted from exposure to different
6 content. One group watched a slow-paced educational programme aimed at preschoolers,
7 whereas the second group watched a fast-paced entertainment show directed at older children.

8 Building on these findings, Lillard, Drell, Richey, Boguszewski and Smith (2015)
9 examined whether pacing or content drove post-viewing differences in executive function.
10 The authors hypothesised that processing fantastic content (i.e., events or characters that defy
11 natural laws) taxed children’s cognitive resources and, consequently, might lead to short-term
12 executive function depletion. To test their prediction, they compared 4-year-olds executive
13 function following viewing of a fast-fantastic entertainment show, a fast-fantastic educational
14 show or story reading. Children who listened to the story performed significantly better on
15 executive function tasks than children who watched either the entertainment show or the
16 educational show (other comparisons were not significant). Thus fast editing and fantastic
17 content may deplete executive function, even when children watch a programme that is
18 broadly categorised as “educational”.

19 To further investigate fantastic content and pacing, in the second experiment, Lillard et
20 al. (2015) varied the amount of fantastic content and the editing pace across experimental
21 films. The analysis revealed a significant main effect of content, but not pacing. The results of
22 this study support the findings of correlational research showing negative associations
23 between television viewing and executive function development reviewed earlier in this
24 article (e.g., Barr et al., 2010). Moreover, they suggest that the mechanisms, which explain
25 how watching television suppresses the development of executive function, are more

1 consistent with content-based theories related to the effects of television on cognitive
2 functioning.

3 Field experiments are infrequent in television effects research (Oakes, 2009). An early
4 study examined the effects of restricting 6-year-olds daily television viewing time on IQ
5 scores, cognitive performance, and the choice of leisure-time activities (Gadberry, 1980).
6 During the 6-week period, children in the restricted-viewing group had their television time
7 reduced by at least 50%, compared to control children. In addition, parents in both groups
8 were encouraged to engage in daily 20 minutes of joint activities with their children.
9 Restricting television time resulted in the increase in performance IQ scores, reading time,
10 and more thoughtful behaviour. However, one cannot be certain that parents in both groups
11 equally engaged their children in shared activities.

12 Furthermore, restricting the overall amount of viewing may not be the only way to
13 improve children's academic skills, as correlational research shows the positive associations
14 between exposure to educational content and academic achievement (e.g., Rice et al., 1990;
15 Wright et al., 2001). Two studies investigated the effects of repeated exposure to an
16 educational programme on children's emergent literacy and school readiness. Six- and 7-
17 year-olds either watched 17 episodes of an educational programme designed to foster the
18 development of early literacy skills or continued their usual school routine (Linebarger,
19 Kosanic, Greenwood & Doku, 2004). Although improvements in literacy skills and reading
20 scores were noted for some children in the experimental group, they varied as a function of
21 age and pre-intervention reading assessment. Exposure to educational content was only
22 beneficial for younger children who were moderately-, or not-at-risk for developing reading
23 problems. There was no advantage of watching the programme for either the 6-year-olds who
24 were at-risk of developing reading problems or for the older children.

1 In a similar investigation, Baydar and colleagues (2008) assessed the effects of repeated
2 viewing of an educational programme on the school readiness of 4- to 7-year-old Turkish
3 children who did not have access to formal preschool education. Compared with children who
4 were instructed to watch an entertainment programme, children who watched an educational
5 show improved their skills in early numeracy, literacy and vocabulary. These effects were
6 further qualified by the frequency of exposure to educational content. Children who watched
7 the programme often achieved the biggest educational gains, whereas rare exposure had no
8 effect on improving school readiness. Furthermore, Baydar and colleagues (2008)
9 demonstrated *compensatory effects* of watching educational television; children with low pre-
10 intervention school readiness skills benefited from the programme significantly more than
11 children who had adequate skills prior to the exposure. The results are in contrast to those of
12 Linebarger et al. (2004), who suggested that children at risk of developing reading difficulties
13 did not benefit from exposure to an educational programme. Varied forms of intervention
14 assessment can perhaps explain these differences in relative outcomes: the former study
15 assessed basic skills such as receptive vocabulary, whereas the latter focused on a more
16 comprehensive assessment of complex reading skills. Finally, the medium of television may
17 be inadequate to support the learning of complex literacy skills that go beyond acquiring new
18 vocabulary.

19 Overall, the evidence from studies reviewed in this section supports findings from
20 correlational research that age-appropriate high quality educational programming can support
21 children's early learning. However, the learning-enhancing qualities of educational
22 programmes may be diminished by the introduction of fantastic content, which was found to
23 be taxing on children's cognitive resources. Finally, the extent to which children may benefit
24 from watching educational TV depends on their baseline skills and the complexity of the
25 assessed competence.

1

2 3.3.2. Attention measures

3 Correlational literature shows links between the amount of viewing and children's
4 *everyday* attention functioning (but see sections 3.1.2. and 3.3.2. for a discussion of
5 methodological issues). Furthermore, it suggests that programming content may be critical to
6 understanding these relations. However, experimental researchers have not explored these
7 findings further. Instead, they have investigated the effects of programmes' visual and editing
8 features on children's attention. In these studies, attention was either operationalised with
9 children's engagement in a task during free-play or measured directly with a continuous
10 performance test.

11 Two experimental studies, which examined the effects of editing pace on preschoolers'
12 subsequent play (Anderson, Levin & Lorch, 1977; Geist & Gibson, 2000), have produced
13 inconsistent results. Anderson and colleagues (1977) asked 4-year-olds to watch either a
14 specially edited fast- or slow-paced version of *Sesame Street*, or listen to a story read by a
15 parent. Immediately following this session, children took part in cognitive tests and a 10-
16 minute play assessment. The researchers found no evidence that the pacing of a television
17 programme had an effect on behavioural outcomes.

18 In contrast, a study by Geist and Gibson (2000) reported negative consequences of
19 watching a fast-paced programme. They investigated whether viewing a fast-paced
20 entertainment programme would result in unsettled behaviour in 4- and 5-year-olds. Children
21 were assigned to one of the two experimental groups: watching *Mister Rogers Neighborhood*
22 – a slow-paced educational show; *Mighty Morphin' Power Rangers* – an action filled, rapidly
23 edited entertainment programme. Control group children took part in educational activities.
24 During the post-viewing play session, children who watched the entertainment show switched
25 between activities more frequently, and spent less time on the task, than children in the

1 control group. These results were interpreted as suggesting that action filled, rapidly edited
2 television causes an immediate shortening of children's attention span, and has a detrimental
3 effect on the subsequent task perseverance. However, it is not clear whether the observed
4 detrimental effects should be attributed to content, pace, or, the combination of both.

5 To overcome the pace/content confound, Cooper, Uller, Pettifer and Stoltz (2009)
6 produced their own experimental films, which were identical in content, and differed only in
7 the number of edits. The effects of editing on 4-7-year-olds' *optimal* attention were examined
8 with a flanker-type continuous performance task. Differences were found between the
9 orienting scores of the fast- and slow-edit groups; "orienting" is the process by which
10 attention is directed towards a stimulus (Posner, 1980). Four-year-olds who watched a slow-
11 paced film had higher orienting scores compared to children in the fast-edit group. This effect
12 was reversed for 6-year-olds. Finally, in all age groups, children who watched a slow-edited
13 film were less accurate.

14 To examine whether other visual features of the medium affect children's attention,
15 Bellieni and colleagues (2010) investigated the differences in the attention-capturing potential
16 of colour and black-and-white film. Ten-year-old children performed an auditory vigilance
17 test. During the experiment, either a cartoon's soundtrack was played, or the black-and-white
18 or colour cartoon was shown. Compared to the soundtrack only, the black-and-white and
19 colour films had a similar effect on the attention. Children made more errors and took longer
20 to respond when either version of the film was played during the task. Taken together, the
21 results of these two experiments suggest that the editing pace, but not the presence of other
22 visual features of the medium (such as the colour), may have an effect on children's sustained
23 attention. Moreover, the results of Bellieni et al. (2010) support correlational findings of the
24 potential negative effects of background television (e.g., Martin et al., 2012).

25

1 3.3.3. *Free-play and child-caregiver interactions*

2 A small number of studies have focused on the short-term effects of background and
3 foreground television viewing on infants' play and child-caregiver interactions. Schmidt and
4 colleagues (2008) investigated whether background television affected play episode duration
5 and focused attention during play in under-threes. The researchers found that when the
6 television was on, children played less, and the length of focused attention was reduced when
7 they did play. In this experiment, the programme played in the background was directed at
8 adult audiences, and was hard to understand for very young children.

9 In a similar study, Setliff and Courage (2011) examined the effects of background
10 television on the quality of infants' interactions with toys during a free-play session. In the
11 presence of background television, the mean length of focused attention and the duration of
12 the longest play episode were shorter than when the television was off. Although infants spent
13 more time looking at the toys than the television, irrespective of whether it was on,
14 background television interfered with infants' play. When the television was on, the frequent
15 shifts of visual attention, between the toys and screen, provided evidence that TV "grabbed"
16 infants' attention, and thus disrupted play. However, background television did not hold
17 infants' attention for long, nearly 50% of the looks were shorter than 2 seconds. Again,
18 because the television programme used in this study was directed at older children and adults,
19 it may have been incomprehensible to the infants.

20 Kirkorian, Pempek, Murphy, Schmidt and Anderson (2009) provided further evidence
21 supporting the notion that adult-directed background television hinders child-parent
22 interactions. The presence of background television reduced parents' responsiveness to their
23 children's attempts to elicit attention and their involvement in children's play. In contrast, its
24 effect on children's reactions to parental bids for attention was not significant. Overall, the

1 results suggested that the reduction in the quantity of child-parent interactions observed
2 during background television was due to less parental involvement in their child's play.

3 Courage, Murphy, Goulding and Setliff (2010) investigated whether any detrimental
4 effects of background television occurred with infant-directed programmes, and compared
5 infants' behaviour during an unstructured play session when the television was either on or
6 off. The results showed that in the presence of a background infant-directed programme, both
7 6- and 18-month-olds looked more frequently at the toys than the film or parent. However,
8 background television interrupted 18-month-olds' play, as demonstrated by the reduced
9 duration of looking at the toys. Furthermore, when the television was on, parents talked to 6-
10 month-olds infants less. Finally, play interactions between parents and 18-month-olds were
11 shorter in the presence of a background programme. Overall, these results suggest that the
12 presence of infant-directed background television may have a distracting effect on infants'
13 interactions with toys, and it may reduce the quality and duration of parent-child
14 communication and play.

15 The latter result is particularly important, as previous research provides convincing
16 evidence for the beneficial effects of parental involvement in children's play (e.g., Tamis-
17 LeMonda, Shannon, Cabrera & Lamb, 2004). Furthermore, the benefits of high-quality
18 parental stimulation during early years have implications for subsequent cognitive
19 development, with research providing evidence for strong links between parental scaffolding
20 and the development of children's verbal abilities and executive function (e.g., Hammond,
21 Müller, Carpendale, Bibok & Liebermann-Finestone, 2012).

22 The studies reviewed so far in this section (with an exception of Courage et al., 2010)
23 used materials that were directed at older children and adult audiences. Perhaps some of the
24 detrimental effects on children's play and interactions with adults could be explained by the
25 incomprehensibility of the shows played in the background. Moreover, it is plausible that

1 background television that emits background noise, which might be disruptive to verbal
2 interactions, could be more harmful compared to foreground co-viewing of age-appropriate
3 material that encourages parents to label objects and actions on the screen.

4 To address these questions, Pempek, Demers, Hanson, Kirkorian and Anderson (2011)
5 investigated the effects of repeated home co-viewing of two different infant DVDs on
6 subsequent parent-child interactions. One group was assigned to watch *Sesame Beginnings* - a
7 program specifically designed to demonstrate developmentally appropriate joint activities
8 such as reading, physical play, singing or dancing. The other group received *Baby Einstein*.
9 This programme does not promote shared parent-child activities; however, it emphasises
10 naming of objects and actions. Following a two-week exposure, parent-child interactions
11 were assessed in the laboratory; one session measured dyads' behaviour during unstructured
12 play, another during a DVD presentation. Compared to watching *Baby Einstein*, home co-
13 viewing of *Sesame Beginnings* was associated with increased parent-child interactions in the
14 free-play session. However, the quantity and quality of parent-child interactions were reduced
15 during the video presentation session for both groups. Instead of playing together, parents and
16 infants directed their attention at the screen. These results are in line with findings related to
17 the negative effects of background television on dyadic interactions (e.g., Courage et al.,
18 2010; Kirkorian et al., 2009). Although moderate co-viewing of infant-directed shows may
19 promote an increase in subsequent positive child-parent interactions, television reduces the
20 amount and quality of dyadic interactions, which in the long-term may be harmful rather than
21 beneficial to children's development.

22

23 3.3.4. *Language*

24 Paediatricians' recommend that children under the age of 18 months should not watch
25 television at all (American Academy of Pediatrics, 2016). Furthermore, the findings from the

1 correlational literature suggest that both the amount of TV and watching specific content are
2 negatively related to language development. Despite these concerns, producers of infant-
3 directed programmes market their products as developmentally stimulating and educational
4 (Christakis, 2009).

5 Two studies investigated this assertion by examining the effects of repeated exposure to
6 *Baby Wordsworth* DVD on infants' knowledge of specific words emphasised in the
7 programme as well as general language skills growth. Robb, Richert and Wartella (2009)
8 compared the difference in receptive and expressive language of 12-to 15-month infants, who
9 repeatedly watched this DVD at home during a six-week period, to infants who did not watch
10 the show. Exposure to the programme had no effect on early language development. Instead,
11 language growth was positively related to both the amount of time a child was read to, and
12 (weakly) the amount of background television exposure at home.

13 Building on this research, Richert, Robb, Fender and Wartella (2010) expanded their
14 investigation to the effects of repeated *Baby Wordsworth* exposure on general language
15 growth in 12- to 25-month-olds. Similarly to the findings of Robb and colleagues (2009),
16 watching the DVD had no effect on learning of the specific words introduced in the
17 programme, or affected general language development in participating infants. The only
18 significant finding in this study was a negative relation between the onset age of baby DVDs
19 viewing and language assessment scores. Furthermore, DeLoache and colleagues (2010)
20 demonstrated that 4 weeks of repeated exposure to a popular baby DVD did not result in
21 infants' learning the words emphasised in the programme beyond normal age-related growth.
22 Only infants who did not watch the DVD, but whose parents intentionally incorporated new
23 vocabulary in everyday activities, showed substantial language growth. Overall, these three
24 studies suggest that watching infant-directed programming of this type does not benefit early
25 language development.

1 In fact, the literature provides robust evidence that television has very limited potential
2 to teach new vocabulary to infants and very young children (<3 years). For example, Krcmar
3 (2011) showed that 6- to 24-month-olds, who learned novel vocabulary following one brief
4 demonstration by a parent, did not benefit from a *single* DVD tutorial specifically designed to
5 teach them novel words. In comparison, *repeated* exposure to a DVD featuring novel words
6 did result in new vocabulary learning, but only for infants older than 17 months. Infants
7 younger than 16 months did not benefit from these presentations (Krcmar, 2014).

8 Moreover, it appears that the inability to learn novel vocabulary following a single
9 DVD presentation persists beyond infancy into toddlerhood. Roseberry, Hirsh-Pasek, Parrish-
10 Morris and Golinkoff (2009) demonstrated that children younger than 36 months were unable
11 to learn new verbs from a single exposure to an instructional DVD. However, when the on-
12 screen content was supported with a live tutorial by the experimenter, children showed
13 evidence of word learning. Although children older than 36 months were able to learn novel
14 verbs from DVD material only, compared with the presentation supported by the
15 experimenter's tutorial, their understanding of the meaning of newly acquired words was
16 superficial.

17 Strouse, O'Doherty and Troseth (2013) provided evidence that adult support during the
18 presentation of televised material enhances linguistic ability even for over-threes. The
19 researchers examined the effects of varying levels of parental involvement during co-viewing
20 on children's vocabulary growth and story comprehension. After a month-long co-viewing of
21 a televised storybook, all children learned vocabulary featured in the story. However,
22 children's understanding and general vocabulary growth varied depending on the quality of
23 parental involvement during co-viewing. Children, whose parents elicited a discussion about
24 the content through asking questions about the story, were most successful on the measure of
25 comprehension. These children also showed a significant improvement in their general

1 expressive vocabulary. Interestingly, Strouse et al. (2013) showed that non-parental support
2 (i.e., a recording of an actress directing children's attention to the content presented on the
3 screen and asking questions) improved children's comprehension, but did not result in general
4 vocabulary growth.

5 The collective evidence from the studies reviewed so far suggests that young children's
6 ability to learn vocabulary from televised content is limited. Appropriate parental support
7 (e.g., questioning, drawing attention to key content, etc.) may reduce some of the limitations
8 inherent in on-screen presentation of educational content. However, considering the evidence
9 showing that television creates an environment that hinders high-quality child-parent
10 interactions (Courage et al., 2010; Kirkorian et al., 2004; Pempek et al., 2011), it is
11 questionable whether parents will provide appropriate support during co-viewing. In fact, the
12 evidence from the three studies reviewed below suggests that successful spontaneous parental
13 support (i.e., not prescribed by the experimenter) is unlikely.

14 For example, Lavigne, Hanson & Anderson, (2015) compared the quantity and quality
15 of parent language directed at infants during play sessions in the laboratory. Compared to
16 free-play, during viewing of a baby DVD, parents spoke less. Moreover, the quality of
17 parental language decreased during co-viewing; parents uttered fewer new words and their
18 mean length utterance was shorter. Although parents spoke less to their infants when
19 watching a DVD, they used a wider range of vocabulary as evidenced by an increased
20 number of new words per utterance.

21 Nathanson and Rasmussen (2011) found similar effects when maternal responsiveness
22 and communication with toddlers and preschoolers was compared across three popular
23 childhood activities: television viewing, play and book reading. Consistent with the findings
24 of Lavigne and colleagues (2015), the presence of foreground television had a detrimental
25 effect on parent-child interactions. The quantity of communication when watching television

1 was reduced compared with play and book reading. Moreover, during co-viewing, mothers
2 asked fewer questions, gave fewer responses that were contingent to child's prior
3 communication, and made fewer attempts to elicit further responses from their child or to
4 label objects and events in the shared environment. Finally, Tanimura, Okuma and Kyoshima
5 (2007) provided further evidence that the presence of television suppresses parental verbal
6 communication with their young children. When the television was on, sentences spoken by
7 parents became shorter and the frequency of parental utterances and the use of explanatory
8 sentences were reduced.

9 In conclusion, infant programming has very limited potential to "teach" vocabulary to
10 under-threes. Although this is not evidence of negative effects of television on children's
11 language growth *per se*, it appears that the presence of television creates an environment that
12 is unfavourable to fostering early language growth. First, when infants are watching the
13 television they are either not learning (Krcmar, 2011), or their learning is of a lesser quality
14 (Roseberry et al., 2009; Strouse et al., 2013). Second, foreground and background TV
15 diminishes the quality and quantity of parental communication (Lavigne et al., 2015;
16 Nathanson & Rasmussen, 2011; Tanimura et al., 2007), which further reduces infants'
17 opportunities to acquire the new language. Perhaps collectively, these findings could explain
18 the negative associations between screen exposure and language development documented in
19 the correlational literature (e.g., Chonchaiya & Pruksananonda, 2008; Duch et al., 2013; Lin
20 et al., 2015; Tomopoulos et al., 2010).

21

22 3.3.5. *Summary of experimental studies*

23 Collectively, the experimental findings related to child-parent interactions consistently
24 point to the potentially detrimental effects of television viewing. Television is effective in
25 grabbing the attention of children and parents, and consequently is disruptive to play and

1 reduces parental verbal communication and responsiveness to children's needs. Moreover,
2 they corroborate the results of correlational research that show a negative association between
3 the amount of television viewing and language development (e.g., Duch et al., 2010; Lin et
4 al., 2015; Tomopoulos et al., 2010; Zimmerman et al., 2007) and suggest that these negative
5 associations might be explained by a reduced quantity and quality of parent-child
6 communication in the presence of television. Finally, under-threes find it difficult to learn
7 from the on-screen presentation of educational material (e.g., Krcmar, 2011; Krcmar, 2014;
8 Roseberry et al., 2009) and exposure to baby DVDs appears to be of no value to infants'
9 language growth (e.g., Robb et al., 2009; Richert et al., 2010; DeLoache et al., 2010).
10 Conversely, during preschool years, high-quality television has the potential to aid learning of
11 pre-academic concepts (Baydar et al., 2008) and improve competence in more complex skills
12 (Linebarger et al., 2004), depending on the child's baseline level of ability.

13 The results of the studies investigating the effects of pacing on children's cognition and
14 behaviour are less conclusive. The findings from two studies imply that watching fast-paced
15 programming has short-term negative consequences for executive function (Lillard &
16 Peterson, 2011) or task perseverance (Geist & Gibson, 2000). However, both studies failed to
17 control for content. Thus the extent to which these negative effects of television can be
18 attributed to pacing is questionable. In fact, the findings of Lillard et al. (2015) support the
19 notion that content matters more than pacing. Moreover, when content is controlled for, fast
20 pace appears to be inconsequential for children's behaviour (Anderson et al., 1977) or even
21 beneficial for certain tasks (Cooper et al., 2009). Finally, experimental research on the effects
22 of television pacing is limited to the investigation of short-term outcomes. Therefore, it is
23 unclear whether the *cumulative* effects of exposure to fast-paced programming lead to the
24 longer lasting change in children's cognition and behaviour.

25

1 **4. General Discussion**

2 The aim of this review was to provide a systematic and comprehensive summary of the
3 literature regarding the associations between television viewing and children's cognition and
4 behaviour. Due to the limited availability of unpublished research, we were unable to
5 compare the findings of unpublished work with the results of published studies that addressed
6 the same questions, which is the most direct method of assessing the potential publication
7 bias (Song, Hooper & Loke, 2013). However, this review includes a relatively high
8 proportion of studies that reported non-significant findings, thus suggesting a low risk of
9 publication bias. For example, the proportion of negative findings (i.e., where the results did
10 not support the tested hypotheses) reported in the correlational and experimental literature
11 was 19.2 and 12.5%, respectively. In comparison, the proportion of negative findings
12 published in general psychology/psychiatry literature is approximately 8% (Fanelli, 2010).

13 The selected studies investigated the short-term effects of viewing in infancy and
14 childhood, as well as the long-term associations that spanned from infancy and early
15 childhood throughout adolescence and into adulthood. The majority of the research reported
16 here focused on behavioural measures. However, two studies (Nikkelen, Vossen et al., 2014;
17 Takeuchi et al., 2013) looked beyond the observable behaviour, and investigated the role of
18 genetic disposition in the preference for violent media content and structural changes in the
19 brain associated with television exposure.

20 A variety of methodological approaches and a wide range of outcome measures used in
21 the studies summarised in this article reflect the complexity of the topic. The overarching
22 finding from this review is that treating television viewing as an undifferentiated activity is
23 inadequate to explain its likely effects. Rather, effects of exposure to television depend on a
24 host of variables that either characterise the child (e.g., age, individual characteristics, family

1 context), are inherent to the medium (e.g., content and editing features), or even the type of
2 exposure (foreground vs. background viewing).

3 One consistent finding is that age of exposure matters. Educational television appears to
4 enhance preschoolers' learning. Conversely, the evidence of benefits for school-age children
5 is very limited. Moreover, exposure to some educational shows was negatively related to
6 infants' language growth (Linebarger & Walker, 2005). In fact, studies that measured
7 exposure in *infancy* (both with and without content analysis) consistently demonstrated that
8 television viewing is associated with negative developmental outcomes. This is seen with
9 attention (Cheng et al., 2010; Christakis et al., 2004; Tomopulous et al., 2007), educational
10 achievement and executive functions (Barr et al., 2010; Nathanson et al., 2014; Zimmerman
11 & Christakis, 2005) and language outcomes (Chonchiya & Pruksananonda, 2008).

12 The period from birth to 3 years may be developmentally sensitive due to the rapid
13 growth and maximal plasticity of the brain (Christakis, 2009). Moreover, during infancy,
14 qualitative changes in cortical structures that underpin a brain's functional potential co-occur
15 with the emergence of fundamental cognitive skills (Dawson, Ashman, & Carver, 2000).
16 Neuroscience literature documents the relations between cortical maturation and the
17 development of attention (Ducharme et al., 2012), working memory (Short et al., 2013) and
18 more general cognitive ability (Deoni et al., 2016). However, these associations are likely to
19 be moderated by the inter-play of individual genetics and early experience (Walhovd,
20 Tamnes, & Fjell, 2014). Currently, it is not clear whether certain parenting practices, such as
21 allowing infants to watch television, have a lasting influence on the developing brain. In fact,
22 most of the evidence describing relations between early experiences and cortical changes
23 comes from comparative literature and, as such, should be interpreted with caution
24 (Thompson & Nelson, 2001).

1 There is, however, well-documented evidence that infants and children under the age
2 of 3 years learn less from television than they do from real-life demonstration (Barr, 2010).
3 “Video deficit” describes under-threes’ pervasive difficulty to extend knowledge acquired
4 from “symbolic” sources (e.g., photographs, picture books, films) to real-world objects and
5 situations (Anderson & Pempek, 2005; Barr, 2010; Barr, 2013). Adequate adult support may
6 mitigate some of the constraints on children’s learning from symbolic sources (Roseberry et
7 al., 2009; Strouse et al., 2013). However, achieving enough parental support to enhance the
8 understanding of material presented on screen seems challenging outside of well-controlled
9 laboratory conditions. First, qualitative literature suggests that parents often use the television
10 as a “digital babysitter” when they need some respite from the demands of childcare or have
11 to attend to household chores (e.g., Bentley, Turner, & Jago, 2016; Jago et al., 2016), thus,
12 suggesting much viewing occurs without active parental support. That is, a parent may be in
13 the same room but is not actively involved in supporting their child’s understanding of the
14 televised content. Second, the results of experimental research provide substantial evidence
15 that foreground and background television creates an environment unfavourable to child-
16 parent communication (Lavigne et al., 2015; Nathanson & Rassmussen, 2011; Tanimura et
17 al., 2007).

18 The latter indicates that television may reduce children’s opportunities to acquire and
19 practice language. Moreover, when infants are watching television, they are missing out on
20 other activities that may promote development. Indeed, the finding that the decrease in play
21 equalled the amount of time children directed their attention at background television
22 (Schmidt et al., 2008), may suggest that television directly displaces play. Therefore, the
23 negative outcomes associated with viewing during infancy, documented in the correlational
24 literature, may be explained by (1) children’s limited ability to understand and learn from

1 television; (2) direct displacement of developmentally-appropriate activities; and (3) a
2 reduction of high-quality parent-child interactions.

3 In addition to the negative outcomes associated with early viewing, the overall amount
4 of exposure seems to be associated with unfavourable developmental outcomes. Low to
5 moderate viewing does not predict later attention and behaviour problems; however, high
6 exposure to television in infancy (>2 hours a day) and early childhood (>3 hours a day) is
7 negatively related to attention, and is associated with later conduct problems (Foster &
8 Watkins, 2010; Parkes et al., 2013; Shiue, 2015). It is important to note two limitations
9 concerning this evidence. Firstly, not only the viewing data but also behavioural ratings were
10 derived from responses provided by parents. As Foster and Watkins (2010) point out, relying
11 on parental reports leads to potential problems. First, parents may provide inaccurate
12 information about the amount of television their children watch. Second, when confronted
13 with questions about their children's bad behaviour and attention problems parents may give
14 answers that are more socially desirable, and under report problems. Indeed, Levine and
15 Waite (2000) and Miller and colleagues (2007) found a positive association between the
16 amount of television viewing and teachers' assessments of hyperactivity/inattention, but not
17 parental ratings of attention problems.

18 Secondly, correlational study outcomes may be influenced by confounding variables.
19 The studies presented in this review varied greatly in terms of the number and the type of
20 covariates, and in fact Foster and Watkins (2010) demonstrated that the analysis of the same
21 dataset could lead to different interpretations depending on the covariates included in the
22 model. Furthermore, as Nikkelen, Valkenburg and colleagues (2014) point out, individual
23 differences, such as family circumstances, peer relations, gender or temperament might
24 moderate the associations between the measured outcomes and media exposure. This further
25 draws our attention to the importance of the context in which television viewing occurs, as

1 well as to individual-level factors that may mediate the associations between television
2 exposure and developmental outcomes (Oakes, 2009).

3 With very few exceptions (e.g., Ferguson, 2011; Shariff et al., 2010), television
4 research failed to consider personal variables other than age and gender. Yet, the evidence
5 suggests that amount and content of television viewing may be predicted by one's early
6 behavioural traits or determined by genetic predisposition (e.g., Nikkelen, Vossen et al.,
7 2014; Radesky et al., 2014); whereas personal variables, such as self-control or sensation-
8 seeking, act as mediators of the relationship between television exposure and measured
9 outcomes (e.g., Shariff et al., 2010). Although, being in a high quality home learning
10 environment was related to less viewing (Blankson et al., 2015; Clarke & Kurtz-Costes,
11 1997), whether the wider socio-family context of viewing (e.g., watching television with
12 friends or alone, at home or in a child-care setting, etc.) is meaningful, we may only guess, as
13 there is no research that addressed this question. Therefore, more research is needed to
14 identify individual and social environment variables that increase children's sensitivity to
15 screen use, as well as to establish protective factors that can provide a buffer against any
16 negative effects. Moreover, it is currently unknown *how much* television children must watch
17 and *for how long* before it meaningfully affects their development. In consequence, bearing in
18 mind the lack of consistent results of longitudinal studies and the paucity of research that
19 spans over a prolonged period, it is difficult to draw clear conclusions about the long-term
20 effects of television viewing on cognitive and behavioural outcomes.

21 A further cause of inconsistent findings could be differences in *what* children watch.
22 What children watch may be more important than *how much* they watch. It appears that both
23 foreground and background exposure to programmes that are created for an adult audience
24 (and are thus inappropriate for young viewers) are associated with problem behaviour, poor
25 attention (Connors-Burrow et al., 2011; Schmidt et al., 2008) and other negative cognitive

1 outcomes (Barr et al., 2010). In addition, Zimmermann and Christakis (2007) suggest that
2 there is an association between viewing children's entertainment shows, which are designed
3 to amuse and occupy (rather than to aid learning), and later attention problems.

4 There are two plausible explanations for why content may be detrimental for
5 developmental outcomes. Firstly, one way that children learn behaviour is through the
6 observation of others (Bandura, 1971). Thus children who watch inappropriate content
7 (especially without an adult present, which could provide a buffer against potentially harmful
8 material – Austin, 2001) may learn and later imitate undesirable behaviours or language
9 observed on the screen. Second, children are mostly incapable of understanding the content of
10 the adult-directed television. Instead, children's attention may be maintained through
11 perceptually salient audio-visual features that elicit an orienting response to what is
12 happening on the screen (Christakis, 2009; Singer, 1980). Over time, this may reduce
13 children's ability to engage in reflective processing, and lead them to develop a preference for
14 a high level of stimulation and frequent change (Wright et al., 1984).

15 Conversely, beyond infancy, watching age-appropriate educational television not only
16 can enhance children's learning in the short term (Baydar et al., 2008; Linebarger et al.,
17 2004), but also relates to long-term positive academic outcomes (Anderson et al., 2001; Rice
18 et al., 1990; Wright et al., 2001). Yet again, the potential benefits of viewing educational
19 content may be moderated by other variables, such as age of the viewer, pre-existing skill
20 level and the complexity of the measured outcome. On the one hand the literature provides
21 consistent evidence for learning-enhancing benefits of exposure to quality content during
22 preschool years (e.g., Rice et al., 1990). On the other hand, the circumstances under which
23 older children learn from educational TV are more nuanced. For example repeated exposure
24 to educational content has the potential to improve basic literacy and numeracy in children

1 with low-level pre-intervention skills (Baydar et al., 2008); however, it is not as effective in
2 supporting the learning of more complex skills, such as reading (Linebarger et al., 2004).

3 In addition to content, *formal features* of television programming (e.g., editing actions,
4 such as cuts, camera angle changes, and active motion) may be detrimental to children's
5 cognition and attention. Zimmerman and Christakis (2007) argue that children's
6 entertainment programmes are characterised by a fast pace (with frequent scene and character
7 changes). Not only the speed of events that unfold in front of a child is much faster, compared
8 to real-life events, but also the number of auditory and visual stimuli a child has to process is
9 beyond the capacity of a young brain, and results in overstimulation (Christakis, 2011;
10 Singer, 1980). In fact, there is a growing interest in the effects of editing pace in the current
11 literature. A small number of studies presented in this review provide interesting but
12 inconsistent evidence about the effects of editing features. The presence of a pace/content
13 confound (e.g., Geist & Gibson, 2000; Lillard & Peterson, 2011) may explain these
14 inconsistencies. Designing and producing one's own materials (e.g., Cooper et al., 2009)
15 allows for the manipulation of pace while controlling the content (although this may reduce
16 ecological validity).

17 The research on which this review is based, investigated a variety of hypotheses about
18 the potential effects of viewing on children's developmental outcomes. However, very few
19 studies attempted to systematically explore the mechanisms underlying the relationship
20 between television viewing and developmental outcomes (Linebarger et al., 2014; Shariff et
21 al., 2010; Shin, 2004). Future research should use the existing empirical evidence to develop
22 and test specific theoretical proposals to establish the mechanisms that underlie the
23 associations between television viewing and particular developmental outcomes.
24 Furthermore, television research employed a wide range of measures, each potentially
25 capturing different aspects of children's cognition and behaviour. For example, attention

1 outcomes have been measured with parents' or teachers' subjective perceptions of children's
2 *everyday* behaviour rated on standardised questionnaires such as the Strengths and
3 Difficulties Questionnaire (Goodman, 1997), or Child Behaviour Checklist (Achenbach,
4 1991). However, several studies used less rigorous measures, such as selected subscales of
5 these questionnaires (e.g., Christakis et al., 2004; Egmond-Frölich et al., 2012). Conversely,
6 experimental research focused on the investigation of children's *optimal* performance under
7 well-controlled laboratory conditions. Furthermore, collective evidence from correlational
8 literature points to the importance of content. Yet, the efforts of experimental researchers to
9 discern the effects of various types of content on specific developmental outcomes have been
10 limited – particularly in relation to attention and executive function research. Therefore, there
11 is a need for researchers to work collaboratively to develop uniform protocols to address
12 some of the methodological limitations present in the past literature, thus enabling us to
13 answer more detailed questions about the long-term impact of television on developmental
14 outcomes.

15 Finally, past research focused on examining the correlates and effects of traditional
16 television viewing. Today's children have a variety of different screen media at their disposal
17 and “worries about the effects of TV in the living room seem quaint” (Rich et al., 2015,
18 p.1737). In fact, in the UK 53% of 3- to 4-year-olds use a tablet at home, and this figure rises
19 to 73% for children aged 8 to 11 years (Ofcom, 2015). Moreover, the results of a recent study
20 about children's media preferences and screen multitasking indicate that although traditional
21 television is still favoured by young children, tablets are now equally as popular as long-
22 established DVDs among 3- to 6-year-olds (Kostyrka-Allchorne, Cooper & Simpson, in
23 press). Thus, future studies should examine the developmental consequences of this increased
24 exposure to new media.

1 In conclusion, this review suggests that television cannot be treated as a unitary activity,
2 and collectively, the evidence points to the importance of content over quantity. Moreover,
3 age, content and family context appear to be the key moderators of the direction and the
4 strength of the relationship between television and developmental outcomes. However, the
5 state of the current literature does not allow one to draw clear conclusions about the potential
6 long-lasting effects of viewing, and the detailed mechanisms underlying the associations
7 between particular features of television and different developmental outcomes. Finally, the
8 present review integrates the findings relevant to television exposure on a traditional
9 television screen. However, with the rise in popularity of new media platforms, and
10 availability of new ways of accessing television content, future research should explore how
11 to optimise media use, by identifying harmful features, as well as the potential opportunities
12 and the problems created by the availability of the new interactive devices.

13

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17

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