Watching television in a home environment: effects on children's attention, problem solving and comprehension

Sarah E. Rose[a]*, Alexandra M. Lamont[b] and Nicholas Reyland[c]

[a]Staffordshire Centre for Psychological Research, Staffordshire University, Stoke-on-Trent, UK;
[b]School of Psychology, Keele University, Newcastle-under-Lyme, UK;
[c]Royal Northern College of Music, Manchester, UK.

*Corresponding author. Email: s.e.rose@staffs.ac.uk

Funding. This work was supported by Grant SG101562 from the British Academy.

Acknowledgements. The authors wish to thank Lucy James, Leanne Savigar, Jackie Perestrelo, Ben Wilson and Joshua Roberts-Brown who assisted with the coding, Danielle Cheetham who post-tested the comprehension test used, and all the children and parents who participated.

Author Contribution Statement: A.L. and N.R. conceived the idea. A.L was responsible for leading the project and holder of the grant. All authors contributed to the experimental design. S.R. collected and coded all the data. A.L. and S.R. analyzed the data. S.R. took the lead in writing the manuscript, to which A.L made a significant contribution. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Watching television in a home environment: effects on children's attention, problem solving and comprehension

Correlational studies have suggested some harmful effects of television viewing in early childhood, especially for the viewing of fast-paced entertainment programs. However, this has not been consistently supported by experimental studies, many of which have lacked ecological validity. The current study explores the effects of pace of program on the attention, problem solving and comprehension of 41 3- and 4-year-olds using an ecologically valid experimental design. Children were visited twice at home; on each visit they were shown an episode of a popular animated entertainment program which differed in pace: one faster paced, one slower paced. Children's behavior was coded for attention and arousal during viewing, attention and effort on a problem-solving task after viewing, and performance on unrelated (problem-solving) and related (program comprehension) tasks. The faster-paced program was attended to more, while 3-year-olds showed more attention and effort on the problem-solving task after watching the slower program, but there were no significant differences in performance on unrelated or related tasks depending on pace. The lack of differences observed in this naturalistic setting together with the high levels of comprehension of the programs watched provides some evidence to counter the 'harm' perceived in young children watching fast-paced entertainment programs.

Keywords: television; child development; problem-solving; pace; attention

Introduction

Young children watch television (TV) a lot. Three- to 4-year-old children in the USA and UK watch TV on average for two hours a day, the most of all young children (Ofcom, 2017, 2019; Rideout, 2017). Exposure to TV can be seen as harmful by both parents (Pearson et al., 2011) and policymakers (American Academy of Pediatrics, 2016), and the dangers of TV have been highlighted in popular media (e.g. Sigman, 2007). However, there are also perceived benefits of TV watching. Some parents feel TV can increase their young children's ability to focus and improve their behavior (Rideout, 2017), and many feel media technologies are beneficial to their children's development (Vittrup et al., 2016). The research evidence is far from clear on whether, and how, TV watching can benefit young children, with studies focusing on different effects of watching different types of program at different time points. The current paper addresses a piece of the puzzle by studying young children in a naturalistic environment – their homes – to explore the impact of pace on behavior while viewing, comprehension of the program, and cognition and behavior directly after viewing.

Existing research has explored both short and long-term effects of exposure to TV. Beginning with long-term effects, the quantity of time spent watching TV has been related to a number of other measures. Children who watch more TV exhibited high levels of emotional instability and low levels of agreeableness, openness to experience and conscientiousness compared to those who watch less TV (Persegani et al., 2002). A systematic review suggested a positive association between the amount of time spent watching TV and ADHD type behaviors, specifically attention problems and hyperactivity (Nikkelen et al., 2014). High amounts of time spent viewing TV in early childhood (<3 years) were associated with attentional problems occurring early in school life (Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004; Miller et al.,

2006). However, other research found no association between the amount of time spent watching TV and attention (Ennemoser & Schneider, 2007) and a re-analysis of the data utilized by Christakis et al. found that TV viewing in early childhood was only associated with later attention problems in a small sub-sample of participants who watched 7 or more hours per day (Foster & Watkins, 2010).

In addition to the relationship between TV viewing and attention, much research has focused on the association between TV viewing and executive functioning (EF). EF refers to the cognitive processes involved in goal-directed problem solving, including working memory, selective attention, inhibitory control, and error correction (Marcovitch & Zelazo, 2010; Miyake et al., 2000). Difficulties in these underlying cognitive processes have been found to result in difficulty maintaining focus on tasks and also more general behavioral, social, and academic problems in preschool-aged children (Kim et al., 2013; Utendale & Hastings, 2010). Previous research has suggested that the amount of time preschoolers spent watching TV negatively predicts their performance on tasks involving EF skill (Barr et al., 2010; Blankson et al., 2015; Nathanson et al., 2014; Nikkelen et al., 2014). However, another, albeit smaller, body of evidence suggested a positive association between the amount of time preschoolers spent watching TV and EF skills (Linebarger et al., 2014; Yang et al., 2017).

One explanation for these inconsistent findings is that it may depend on the type of TV watched. Barr et al. (2010) found negative associations only for the amount of adult-directed TV watched at 1- and 4-years-of age and EF scores at age 4, not the amount of child-directed TV. Similarly, although Nathanson et al., (2014) found a negative correlation for both overall TV viewing and frequency of watching educational cartoons with EF, a positive correlation between EF and frequency of watching American PBS (Public Broadcasting Service) programs was found.

Experimental evidence on the immediate and short-term impact of TV watching on EF supports the differential effects of different types of TV, and suggests that this is causal. Lillard and Peterson (2011) concluded that watching 11 minutes of fast-paced "entertainment" but not slow-paced "educational" TV had a negative effect on 4-year-old children's performance on a range of EF tasks. After further study Lillard, Drell, Richey, Boguszewski & Smith (2015) concluded that it was specifically watching fantastical content that impaired 4-year-old children's EF. Therefore, although watching TV may be associated with lower EF in both a short- and long-term context, in experimental studies of short term impact these effects are only found with specific types of content.

One aspect of EF that has been focused on is the development of selective attention. Attention is related to general arousal, and research consistently supports the need for an optimal range of arousal in order to foster attention and learning (Reynolds & Romano, 2016; Ruff & Capozzoli, 2003). Attention while watching TV increases linearly and rapidly over the first few years of life (Anderson, Lorch, Field, Collins, & Nathan, 1986; Anderson & Hanson, 2010; Schmitt, 2001; Valkenburg & Vroone, 2004). Features and content of the TV program being watched influence children's attention to the screen (Calvert et al., 1982; Wright et al., 1984). Preschool children exhibited greater visual attention (i.e. looking time) to faster-paced programs containing more cuts and sound effects (Alwitt et al., 1980; Schmitt et al., 1999) and to programs which were more easily comprehensible to them (Anderson, Lorch, Field, & Sanders, 1981; Valkenburg & Vroone, 2004; Wright et al., 1984).

Evidence also suggests that the type of content watched determines the extent, and direction, of the impact on children's attention. Experimental research found that 4- and 5-year-olds who had watched a fast-paced "entertainment" program

demonstrated lower attentional capacity directly after watching compared to those who had watched a slow-paced "educational" program (Geist & Gibson, 2000). Similarly, arousal levels were higher in preschool children who had watched fast-paced programs containing aggression compared to slower-paced programs without aggression (Gröer & Howell, 1990). However, as the programs used in both these studies also differed in content as well as pace, it is unclear which of these may have accounted for the difference in attention found. More recent evidence supports the influence of pace, as fewer errors were made by 4-year-olds on an attention task after watching a fast- compared to slow-paced 3.5-min clip of an adult reading a story (Cooper et al., 2009). However, Kostyrka-Allchorne, Cooper, Gossmann, Barber, & Simpson, (2017) found that fast-paced programs could have negative consequences for younger children's sustained attention, as after viewing a fast-paced program 2- to 4-year-old children were observed to shift their attention between toys more frequently than children who had watched a slow-paced program. Consequently, although faster pace may increase the attention that preschoolers give to the screen, differences in their attention and arousal behavior after watching may be less consistent, with some studies finding a facilitative effect of increased pace and others a negative effect.

Pace has also been related to young children's ability to understand what they are watching, with younger children comprehending slow-paced programs better than fast-paced ones (Wright et al., 1984). However, comprehension is not necessarily an outcome of attention: higher levels of visual attention (based on looking time) while viewing did not lead to enhanced comprehension of the program watched by young children (Lorch et al., 1979; Wright et al., 1984). Conversely, the comprehensibility of the program may actually determine the amount of visual attention children give (Anderson et al., 1981). For example, children attend less to programs that are aimed at

adults (Valkenburg & Vroone, 2004). Furthermore, Wright et al. (1984) found that 9-year-old, but not 6-year-old, children attended to programs in synchrony with their pace: longer looks to slow-paced and shorter looks to faster-paced programs. This suggests that as children develop, they become more strategic viewers, altering their attention based on the content and demands of the program.

A consistent limitation of experimental research investigating both the impact of TV on children's developing EF and attention is that even when program content is considered as a mediating factor, most studies compare TV programs that vary both in formal features (e.g. pace) and the type of content (e.g. educational vs entertainment). As only a small number of studies have attempted to control content while varying pace (Anderson et al., 1977; Cooper et al., 2009; Lillard et al., 2015) it is vital that further research investigates the impact on children's behavior of pace independent of content. This is especially relevant as the pace of children's TV is increasing (Koolstra, van Zanten, Lucassen, & Ishaak, 2004; Reyland, 2010). Furthermore, more experimental research is needed to understand the extent to which the association between TV watching and children's behavior may be causal.

Much of the existing experimental research lacks ecological validity, as data has been collected in laboratory settings (Anderson et al., 1981; 1977; Cooper et al., 2009; Lillard et al., 2015; Lillard & Peterson, 2011; Wright et al., 1984). This is problematic as previous research has found that children's viewing is significantly altered depending on the context that they are in. The amount of time that 5-year-old children spent looking at the TV decreased from 87% in an environment without toys to 44% in an environment with toys (Lorch, Anderson, & Levin, 1979). This suggests that children's attention to the TV is likely to be different in a research setting compared to a home

setting (where toys and other distractors are likely to be present). Furthermore, this difference may affect their behavior, including EF skills, directly after viewing.

The importance of considering the content of TV programs and the context in which children watch TV was further emphasized by Christakis (2009), who argued that *what* children watch and *how* they watch are important factors which moderate the nature of television exposure effects. Therefore, the current research aims to observe 3- and 4-year-old children, the age group who watch the greatest amount of TV (Ofcom, 2017), watching two content-matched but differently paced programs in their home viewing environment. Previous research had tended to focus either on children's behavior while watching TV or their behavior or task performance after watching, most often on tasks requiring EF skills or assessing their comprehension of the program watched. In the current study all three are included. Associations between behavior while watching the two differently paced programs and subsequent behavior and task performance can therefore be considered. Much previous research on television viewing in young children used look frequency and duration as a measure of attention, but following arguments that attention comprises more than just looks and is made up of external behaviors, psychological engagement, and physiological response (e.g. Ruff & Rothbart, 1996), the current study includes a range of behavioral measures of verbal and non-verbal attention and arousal in addition to accuracy scores on the tasks. Moreover, to allow for the investigation of individual differences, parent reports of children's temperament and home TV experiences are also included. This is important as associations between different personality traits and TV viewing have been suggested (Persegani et al., 2002), and early differences in temperament predict TV viewing in early childhood (Radesky et al., 2014) with those who display problems with self-regulation at age 9-month viewing more TV at age 2 years.

To control for differences in the home viewing environments and between children a within-group design was used. Therefore, participants were visited in their homes on two separate occasions, and shown a fast- and slow-paced episode of a popular UK children's entertainment program. Attention and arousal were observed and coded while watching. A problem-solving game involving a range of EF skills followed, with behavior and performance scored for attention, effort, and success. Finally a comprehension and recall test was given about the just-viewed program, scored for accuracy. Data on children's temperament (Surgency, Negative Affect and Effortful Control; Putnam & Rothbart, 2006) and viewing habits were also gathered using parental self-report questionnaires.

As young children's attention to TV programs increases with age (Anderson, Lorch, Field, Collins, & Nathan, 1986; Anderson & Hanson, 2010; Schmitt, 2001; Valkenburg & Vroone, 2004) it was hypothesized that 4-year-olds would have higher attention scores while watching both the fast- and slow-paced program than the 3-year-olds. Furthermore, both age groups were expected to show higher attention and arousal levels when watching the fast- compared to slow-paced program (Alwitt et al., 1980; Gröer & Howell, 1990; Lang, Zhou, Schwartz, Bolls, & Potter, 2000; Schmitt et al., 1999). It was hypothesized that 4-year-olds would perform better on the problem solving task than 3-year olds, as EF skills improve with age (e.g. Garon, Bryson, & Smith, 2008). Differences in behavior and performance on the problem solving task after watching the fast compared to slow paced program might be evident, however due to conflict in previous research between facilitative (Cooper et al., 2009) and harmful effects (Geist & Gibson, 2000; Kostyrka-Allchorne et al., 2017; Lillard & Peterson, 2011) of fast-paced programs, the direction of this hypothesis was unclear. As comprehension of programs watched improves with age (Wright et al., 1984) 4-year-

olds should perform better than 3-year-olds on the comprehension task. In addition, it was predicted that comprehension of the slow-paced program would be greater than that of the fast-paced program, as previously found by Wright et al. (1984).

In relation to temperament, it was predicted that positive associations between the amount of time parents report that their children spend watching TV and surgency would be found, but that associations with Effortful Control would be negative. This reflects existing evidence that greater amounts of TV viewing are associated with more hyperactive behavior (e.g. Nikkelen et al., 2014) and lower levels of executive functioning (e.g. Nathanson et al., 2014). It was also predicted that children's temperament would influence their attention and arousal levels while watching and their subsequent behavior and performance on the problem solving and comprehension tasks.

Method

Participants

Thirty-nine mothers, two fathers and their children within three months of their third or fourth birthday participated. This resulted in data from 21 3-year-olds (mean age 37.1 months, range 33-40 months, 13 girls) and 20 4-year-olds (mean age 48.1 months, range 45-52, 10 girls). Participants were recruited through opportunity and snowball sampling, with adverts being placed in local nurseries, schools and children's centers. No inducement to participate was given, and most participating families were of white, middle class background. Thirty-two children attended part- or full-time nursery while five were cared for exclusively by their parents (for three children care arrangements were unknown). Thirty-one came from a household in which at least one parent had a university level or professional qualification. Four came from households where the highest education level was vocational qualifications (five were unknown). All parents

gave affirmative written consent and all children were verbally briefed and gave assent. The project was given ethical approval and American Psychological Association ethical guidelines were followed throughout.

Materials

A popular UK children's program, *Postman Pat*, was used for the study. This commercially available television program is aimed at preschoolers and has been aired since 1981, with the most recent episodes produced in 2017. Although the storylines and many of the characters have remained consistent over time, the pace of the program (frequency of cuts, scene changes, camera angles, number of characters per episode and sound effects) has increased (Reyland, 2010).

Piloting: To identify two episodes of *Postman Pat* which aroused similar interest levels in preschool-aged children, four 5-minute clips from different series (series 1, 1981; series 2, 1997; series 3, 2004; series 6, 2008) were shown to a different sample of 16 3- and 4-year old children (mean age 3yrs 7months) individually in their nursery, in an area without toys. While watching, the children's behavior was recorded by a camera placed directly behind the television and from this the researcher coded each child's behavior for nonverbal attention and mood during each clip. For each of these a single score representing a summary of the behavior observed during the clip was recorded on the appropriate 5-point ordinal scale (nonverbal attention: 1= spent almost no time looking at the TV screen, 5 = spent almost all the time looking at the TV screen; mood: 1 = very restless and unsettled, appeared not to be enjoying the program at all, 5 = very settled and content, appears to be enjoying the program). Table 1 shows the mean non-verbal attention and mood ratings for each of the four clips. Series 2 and Series 6 were selected as the most similar in terms of children's responses (no significant difference in attention, $t(15) = -0.29$, $p = .774$, $d = 0.05$, and mood ratings, $t(15) = -0.24$, $p=.817$, $d =$

0.07) but different in terms of pace (Series 2 average shot length 7.3 seconds; Series 6 average shot length 3.4 seconds).

[Table 1 near here]

Both Series 2 (1997) and Series 6 (2008) were produced on DVD, with the same contemporary animation style, consistent principal characters and voices used for the different characters. One episode was selected from each series for the main study, based on similar plot complexity as judged by the researchers and unlikeliness of being recently watched by the children: "Postman Pat and the Robot" (Series 2, air date 1997) and "Flying Christmas Stocking" (Series 6, air date 2008). The programs were shown un-edited in their full 15-minute run time.

Several measures were used to test post-viewing behavior. Firstly, to measure EF, a commercially available, age-appropriate and educational game "Block Buddies" was used. This drew on familiar skills to young children of block building and pattern matching, but was novel to the children taking part in this study as it was not widely available in the UK. It required children to replicate patterns shown on cards using a set of 21 colored blocks. The cards showed patterns of increasing difficulty, starting from two-block patterns. Two sets of five cards of matched difficulty levels (based on the manufacturer's ratings) were used, one after each episode. The number of correctly replicated patterns was counted. Successful completion of the patterns required a range of skills associated with EF, especially working memory and goal-directed problem solving.

Post-viewing comprehension was assessed using two measures. The first was a sequencing task (as used by Lowe & Durkin, 1999; Wright, Huston, & Ross, 1984) requiring the child to place five images from the program in the correct order. Secondly, as a complementary measurement of understanding, five comprehension

questions were asked, one per image; following scaffolding principles typically used with young children (e.g. Wood, Bruner, & Ross, 1976), children were given prepared verbal and then picture prompts if required to encourage their engagement with the task. For both episodes two questions relating to central content and three to peripheral content were included. Following a similar procedure used by Wright et al., (1984), post-testing of these sequencing tasks and questions was carried out with a different group of 16 3- and 4-year-olds who had not watched either of the original programs but were asked if they could guess the answers given the same materials. In this post-test group, no child was able to correctly sequence the pictures or to correctly answer any of the questions without prompts. However, with the same prompts given to the main study children and a more lenient sequencing scoring (3 = fully correct, 2= one change to be correct, 1= two changes to be correct, 0 = more than two changes to be correct), these post-test children scored significantly higher on comprehension of the slow (M= 5.25 SD 1.43) compared to fast program (M = 3.31, SD 1.40 ($t(15)=4.810$, $p<.001$). Thus, children in the main study were only scored based on their initial answers prior to any prompts (one point per answer) and a point was given for entirely correct sequencing.

Parents completed the 36-item Children's Behavior Questionnaire (CBQ): Very Short Form (Putnam & Rothbart, 2006). This is a valid, reliable and widely used measure of child temperament for 3- to 7-year-olds (Putnam & Stifter, 2008; Rothbart, Ahadi, Hershey, & Fisher, 2001). This generated scores of Surgency, Negative Affect, and Effortful Control. To gain information about children's TV viewing habits a questionnaire of 20 items was constructed specifically for this research. A mixture of open and closed questions was asked, including amount of TV watched (average weekday and weekend-day viewing reported in hours and minutes), rules regarding TV

watching (free text response), child's favorite programs, familiarity with *Postman Pat* and perceptions about how their child engaged with TV.

Procedure

Data collection took place in participants' homes to provide a naturalistic viewing context. Therefore, the sizes of the rooms and TV screens varied between participants. The child's parent was always present in the room and in some families a younger sibling was also present. Two separate visits were made at a similar time of day, during the morning or afternoon, as close to one week apart as possible. The same room with the same people present and the same TV screen was used on both visits and the same procedure was followed. One episode of *Postman Pat* was shown (counterbalanced in order between children) on each visit. A video camera was set up behind the television to capture as much of the room as possible and set to record for the duration of the visit. Parents were told that the study involved observing children in their own homes and to not discourage the child from moving around and behaving in any way which they would normally deem acceptable while viewing. Parents completed the CBQ during the first visit and the Television Viewing Habits questionnaire during the second visit: this was done while their child watched the program. The researcher sat behind the child to observe their behavior, but not distract them. Children either sat or moved around the room as they chose.

After the episode had finished the researcher moved to the floor and invited the child to come and play a game with them, introducing the Block Buddies task as a fun puzzle game. The researcher had the first 'go' showing the child the card and talking through the placement of the blocks as she recreated the shape shown on the card (different sets of cards were used on the two visits). During this the researcher placed one of the blocks in the incorrect orientation and then demonstrated recognizing and

correcting this error. The researcher then invited the child to take part, showing them the next picture, handing them the blocks and telling them to try making the pattern shown. This was continued for 5 minutes at a pace dictated by the child. Once the child declared each puzzle finished, they were shown the next card; cards were shown in order of increasing difficulty regardless of whether they had completed the previous puzzle successfully or not.

Finally, the child was invited to play a 'memory game' to assess comprehension: five pictures from the program were laid out and the child was asked to try to put them in order, using prompts about which picture came first, at the beginning and what came next and so on. After they had completed the sequence to their satisfaction (without feedback) the comprehension question relating to each picture was asked.

Coding & inter-rater reliability

Children's behavior while viewing the TV episode and the Block Buddies task was observed and coded using 5-point ordinal scales, as done in previous research with young children into cognitive, language and motor development (Bayley, 2006) and attention (Gaertner, Spinrad, & Eisenberg, 2008).

Behavior while viewing was coded in nine time-segments: the opening credits, followed by seven segments approximately 100 seconds long, and the closing credits. Drawing on previous literature identifying relevant aspects of behavior expected to be affected by television viewing, verbal and non-verbal attention and arousal behavior during each of these nine intervals was coded on separate 1-5 ordinal scales, as illustrated in Table 2. To facilitate cross-program comparisons, without undue emphasis being placed on individual features of the storyline, results were averaged across all nine segments for analysis. If for one of the nine segments there was no score, for example the child had made no vocalizations, the mean score was calculated based on

only those segments for which there were scores recorded. Coding was based on the external behavior displayed by children rather than any assumptions about underlying cognitive processing. Therefore, a child displaying low levels of arousal could also be showing high levels of attention (i.e. sustained looks at the TV) representing 'attentional inertia' (Richards & Anderson, 2004) which has been found to be related to better memory of TV content among adults (Burns & Anderson, 1993).

[Table 2 about here]

Coding of behavior while viewing the TV episode was initially carried out 'live' by the researcher. This had the advantage of continuously coding the child's behavior even when the child moved out of shot of the camera. As the researcher was not blind to the age of the child nor the episode being watched, four independent raters used the coding scheme (Table 2) to code TV viewing behavior from video recordings. Initially these raters coded mute versions of the video files so that they were blind to the experimental condition. They then re-watched with audio to code for verbal attention. Reliability of ratings given by the four independent raters and the researcher was good across all four independent raters and the researcher for non-verbal attention ICC(1,1) = .82, CI [.76, .87], Cronbach's α = .95; verbal attention ICC(1,1) = .74, CI [.56, .87], α = .81 and arousal ICC(1,1) = .78, CI [.71, .84], α = .95. Thus, the researcher's ratings were used for analysis as these represented the most complete data (i.e. including coding when the child had moved out of shot of the camera). As verbal and non-verbal attention scores were strongly correlated ($r(61)=66$, $p<.001$) and not all children made verbalizations while watching, these two scores were averaged to create a score for overall attention which was used in the final analysis. If a child had made no vocalizations within any of the nine segments their average attention score was based only on their non-verbal attention.

After viewing, the child's overall attention and effort during the Block Buddies tasks were scored from the video recordings on two separate ordinal scales (see Table 2). The number of puzzles attempted and correctly solved were also noted as a measure of EF post-viewing. To check the reliability of the researcher's coding of overall attention and effort another independent rater coded 20% (16) of the videos of children completing the Block Buddies task. Reliability was good for both effort, ICC(1,1) = .78, CI [.49, .92], Cronbach's α = .78 and overall attention, ICC(1,1) = .74, CI [.40, .90], Cronbach's α = .74. Finally, combined comprehension accuracy scores for sequencing and questions were used as a measure of post-viewing comprehension, with a minimum of 1 and maximum of 6. All materials and coding schemes are provided at https://osf.io/gzf6a/?view_only=1bbae19ac7fd4945b0abb294eb3fa14a.

Analytic Approach

Data was screened for outliers through examining z-scores for all variables. Only one z-score of >+3 or <-3 was identified, which was on the variable of mean attention for the fast-paced program. The z-score was -3.4; this represented a value of 1.89 (compared to a mean of 4.47). Histograms were checked, and together with skew and kurtosis values indicated that the distribution of all continuous variables was approximately normal with one exception: mean attention to the fast-paced program. Whereas all other skew and kurtosis values were <2 or >-2, the kurtosis for overall attention to the fast-paced program was 4.05. With the outlying score of 1.89 mentioned above removed, the kurtosis reduced to 1.74. To make sure that the presence of this outlying score was not affecting the analysis, and the interpretations made, sensitivity analysis as recommended by Clark-Carter (2009) was carried out. This involved all analyses which

include the variable of mean attention to the fast-paced program being conducted both with and without the outlying data point.

To assess the differences in children's behavior while watching, after watching and performance on the problem solving and comprehension tasks a series of 2 (fast- vs slow-paced) by 2 (3- vs 4-year-olds) mixed-ANOVAs were carried out. To control for type I error without substantially increasing the risk of type II error, Bonferroni corrections were used within each family of tests. Consequently, when significant interactions were followed up using simple effects analysis a Bonferroni correction was used to reduce the chances of obtaining false-positive results (type I errors). This is consistent with the analytical approach used in similar research (Landrum et al., 2019; Möller et al., 2019). Trends are reported when effect sizes, calculated using partial eta squared, are medium to large. For these, observed power is also reported, based on G*Power 3.1.9.4 calculations using effect sizes specifications as in Cohen (1988).

Hierarchical multiple regressions were used to test the effects of temperament on the amount of TV watched, behavior while watching, and performance on the problem solving and comprehension tasks. Age (in months) and gender were entered first and the temperament variables of Surgency, Effortful Control and Negative Effect were entered second. This allowed the influence of age and gender to be controlled for so that the effects of temperament could be considered independently. The behavior while watching (attention & arousal) variables were included when the dependent variable was performance on the problem solving and comprehension tasks, and they were entered in step 3. Separate regressions were carried out for the fast- and slow-paced programs so that the influence of temperament could be compared between the two programs. For all the regressions collinearity was not a problem as tolerance values were <.10 and the variance inflation factor (VIF) was <10. There were no outliers

detected through checking standardized residuals or considering Cook's Distance and Leverage Values. Furthermore, the standardized residuals were normally distributed, and a scatter graph of standardized residuals plotted against predicted values indicated homogeneity of variance and no discernible pattern.

Results

Parents reported that on average their child watched TV for 2.54 hours a day (SD=1.24), with no differences between age groups (M=2.60 (SD=1.28) for 3- & M = 2.49 (SD1.24) for 4-year-olds). The associations between children's scores for Surgency (M=4.89, SD=0.74), Effortful Control (M=5.54, SD=0.76), Negative Affect (M=3.8, SD=0.83) and the amount of TV watched in a typical week, as reported by parents, were analyzed using a hierarchical multiple regression. Age and gender accounted for 2% of the variance in the amount of time spent watching TV, R^2 =.02, $F(2,38) = 0.45$, p = .642. The temperament variables of Surgency, Effortful Control, and Negative Affect explained an additional 20% of the variance in time spent watching TV. Although this model was also not significant, R^2 =.22, $F(5,35) = 1.96$, p=.109, Effortful Control was a significant predictor of time spent watching TV, β=-.372, p=.026. All other predictors did not explain a significant proportion of the variance.

Based on parent reports 63% of the children in the sample never, or only occasionally, watched *Postman Pat* episodes and the frequency of watching *Postman Pat* did not differ between age groups, $t(39)$=-0.18, p=.861, d=.05. The order that children watched the two episodes in in the current study had no impact on attention or arousal while viewing, attention, effort or performance on the Block Buddies task or performance on the comprehension task.

Attention & Arousal During Viewing

Looking at behavior during viewing (Table 3), overall attention varied significantly between programs, $F(1,39)=35.54$, $p<.001$, $\eta^2_p=.48$, with more attention being given to the fast than the slow program. There were no significant age differences, $F(1,39) = 1.23$, $p = .275$, $\eta^2_p=.03$, or interactions with age, $F(1,39) = 0.71$, $p =.405$, $\eta^2_p=.02$. Arousal levels did not significantly differ between programs, although there was a trend (with an effect size between medium and large and a power of .49) to show more arousal to the slow program, $F(1,39)=3.66$, $p=.063$, $\eta^2_p =.09$. There were no interactions with age, $F(1,39) =0.23$, $p = .631$, $\eta^2_p=.06$, or differences of age, $F(1,39) <0.01$, $p = .992$, $\eta^2_p<.01$. Analyzing the two programs separately, the associations between temperament measures of Surgency, Negative Affect and Effortful Control with overall attention and arousal levels while watching were tested in hierarchical multiple regressions. None of the models were significant and none of the predictor variables explained a significant amount of the variability in either overall attention or arousal levels to either the fast- or slow-paced program. To ensure that these conclusions were not influenced by the outlying score within the overall attention given to the fast-paced program, the hierarchical multiple regression and ANOVA were repeated without this value. Outcomes were highly similar and there was no difference in significance values. Therefore, despite the presence of an outlying score, confidence can be had in these findings.

[Table 3 near here]

Cognition After Viewing

Performance on the Block Buddies task enabled a comparison of the immediate short-term effects of viewing the fast- and slow-paced program (Table 4). Although there were no overall differences in attention given to the task after watching the fast- and slow-paced programs, $F(1,39) = 1.75$, $p = .194$, $\eta^2_p = .43$, or between the 3- and 4-

year-olds, $F(1,39)=1.19$, $p = .283$, $\eta^2_p=.30$, there was an interaction between age and program, $F(1,39)=6.02$, $p=.019$, $\eta^2_p=.13$, as 3-year-olds gave significantly more attention to the task after the slow program but there were no differences for 4-year-olds. Overall, 4-year-olds made more effort than 3-year-olds regardless of the program watched, $F(1,39) = 6.49$, $p = .015$, $\eta^2_p = .14$, and there was a trend (with an effect size between medium and large and an observed power of .44) for more effort being made after the slow- compared to fast-paced program, $F(1,39) = 3.43$, $p = .072$, $\eta^2_p= .08$. This was clarified further by the significant interaction between program and age, $F(1,39)=5.02$, $p= .031$, $\eta^2_p=.11$, as 3-year-olds made significantly more effort after the slow program, but there was no difference for 4-year-olds. In terms of task success, significantly more puzzles were solved by the 4-year-old children compared to the 3-year-olds, $F(1,38)=14.75$, $p<.001$, $\eta^2_p =.28$. There was no interaction between program and age, $F(1,38) <0.01$, $p <.999$, $\eta^2_p<. 01$, but there was a trend (with an effect size between medium and large and observed power of .43) for more puzzles to be solved after the fast program, $F(1,38)=3.46$, $p=.071$, $\eta^2_p=.08$. To explore the extent to which temperament (Surgency, Negative Affect and Effortful Control, entered in step 2) and behavior (attention and effort, entered in step 3) during the task predicted task success, separate hierarchical multiple regression analyses were carried out for each program and each dependent variable, controlling for age and gender (entered in step 1). There were no significant associations between the temperament variables and behaviors or success for either program[1].

[1] Significant associations with age in months were found for effort after the slow-paced program and for the number of tasks successfully completed after the fast- and slow-paced programs. This replicated the findings from the ANOVA.

[Table 4 near here]

Comprehension of Program

Children's comprehension scores did not differ between the fast (M=2.95, SD=1.36) and slow-paced (M=2.85, SD=1.53) programs, $F(1,39)=0.14$, $p=.713$, $\eta^2_p< 01$ and there was no interaction between age and program, $F(1,39)=0.78$, $p=.384$, $\eta^2_p=.02$. However, there was a trend (with an effect size between medium and large, and observed power of .44) for age, as 4-year-olds (M=3.23, SD=1.29) recalled more information than 3-year-olds (M=2.60, SD=1.53), $F(1,39)=3.332$, $p=.076$, $\eta^2_p=.079$. Analyzing the two programs separately, hierarchical multiple regression assessed the extent that temperament (entered in step 2) and attention and arousal while viewing (entered in step 3) predicted comprehension scores, with age and gender controlled for (entered in step 1). For the fast-paced program none of the predictor variables accounted for a significant amount of the variance in comprehension scores and all three models were non-significant. For the slow-paced program none of the predictor variables accounted for a significant proportion of the variance, but there was a trend for those participants with higher arousal scores while viewing to perform worse on the comprehension questions (β=-.1.93, p=.063). Moreover, the final model containing age, gender, temperament variables and arousal and attention while viewing was significant, and these variables accounted for 33% of the variance in comprehension scores for the slow-paced program, R^2 =.33, $F(7,33) = 2.35$, p=.046. Comparisons with previous models show that age and gender accounted for 9%, temperament for an additional 8% and therefore behavior while viewing accounted for 16% of the variance in scores representing a medium effect size. Sensitivity analysis involved the hierarchical multiple regressions for the fast-paced program being rerun with the outlying score for attention given to the fast-paced program removed from the data set. When compared

the outcomes were highly similar and there was no difference in significance values. Therefore, despite the presence of an outlying score confidence can be had in these findings.

Discussion

The primary aim of the current research was to assess the extent to which the pace of an age-appropriate entertainment program influenced 3- and 4-year-old children's attention during and directly after watching the program, behavior and performance on an unrelated task requiring EF skills directly after watching the program, and program comprehension. Children attended more to the fast-paced program than the slow-paced one. This is supportive of earlier findings that young children attend more to features such as the cuts and sound effects (Alwitt et al., 1980; Schmitt et al., 1999) which are more frequently found in more recent fast-paced programs (cf. Reyland, 2010). There was also a moderate trend for children to show higher arousal while watching the slow- compared to the fast-paced program. Together with the lack of influence of the temperament measures on any of the outcomes, these findings suggest that young children may be attending more to the fast-paced program, with some potentially displaying 'attentional inertia'. Therefore, attention in young children may be malleable, rather than reflecting a more permanent attentional style or temperament trait. The malleability of visual attention has potential implications for enhancing learning processes (cf. Frick, Colombo, & Saxon, 1999), as increased attention could facilitate learning.

Although previous research (Anderson, et al., 1986; Anderson & Hanson, 2010; Schmitt, 2001; Valkenburg & Vroone, 2004) had found that with increasing age children tended to pay more attention to TV programs, no age differences for attention or arousal while viewing were found in the present study. There are at least two

explanations for this finding. The age range of participants was considerably smaller than in previous research, and therefore may have not been enough to detect subtle age-related changes. Furthermore, since attention can be related to how comprehensible children find the program that they are watching (Anderson, et al., 1981; Valkenburg & Vroone, 2004; Wright et al., 1984) and as *Postman Pat* is aimed at preschoolers, both slow- and fast-paced programs may have been equally comprehensible to both 3- and 4-year-old children.

No significant differences were observed in performance on the unrelated EF problem-solving task after fast- or slow-paced programs, which provides further evidence to support a lack of negative outcomes following fast-paced programs, counter to Lillard and Peterson (2011). The trend towards enhanced EF for both age groups after the fast program, although not significant, is in the same direction as earlier findings of enhanced attention performance in young children after viewing faster-paced programs (Cooper et al., 2009; Kostyrka-Allchorne et al., 2017). One possible explanation for these potentially conflicting findings is that the EF tasks used by Lillard et al. predominantly required sustained attention and following of rules, whereas those tasks used by Kostyrka-Allchorne et al. involved switching attention. Similarly, although the block building task used in our study required sustained attention in terms of staying on task and visually attending to the pattern to be replicated, shifting of attention was also required to focus on the different blocks required to make the puzzle. Adherence to rules and inhibitory control were not required during the block building task. Therefore, taken together these findings suggest that the impact of pace of television on EF may vary depending on the specific cognitive skills being considered, although further research would be required to disentangle these more robustly.

It was found that 4-year-olds performed better on the block building task than 3-year-olds, which is in accordance with previous research suggesting that EF develops with age (e.g. Garon, et al., 2008). This may in part be explained by differences in children's behavior after watching, as 4-year-olds also made more effort compared to 3-year-olds. Furthermore, the pace of the program may have also affected the attention given to the task by the younger children. For 3-year-olds, viewing the fast-paced program led to slightly less attention and effort to the following unrelated task. Although not significant, this somewhat supports previous findings (Geist & Gibson, 2000; Kostyrka-Allchorne et al., 2017) that a faster-paced program negatively impacted sustained attention directly after viewing. Although these studies included children of a similar age to the current research (4- to 5- and 2.5- to 4-year-olds respectively) they were not designed to investigate age differences, and thus this finding remains tentative.

Pace made no difference to comprehension of the programs, with children performing averagely after both programs. This is somewhat contradictory to previous evidence for a negative association between pace and comprehension among 5- to 7-year-olds (Wright et al., 1984). However, this earlier finding may have been a result of other differences in the programs used, such having live or animated characters. In the present study both programs were animated, keeping this factor constant. The current finding that children paid more attention to the fast-paced program but that this did not lead to any difference in their subsequent performance on a comprehension task supports the view that children may alter their attention strategically, as slower-paced stories are often easier to comprehend and have more predictable storylines compared to fast-paced ones, requiring less attention. This ability to alter attention effectively depending on the characteristics of the program being watched further supports evidence that 5-year-old children who watched TV in an environment with toys present

effectively distributed their attention such that they could process auditory and visual information from television while engaging with the toys (Pezdek & Hartman, 1983). Furthermore, this confirms previous research suggesting that visual attention is not directly predictive of comprehension (Lorch et al., 1979).

The amount of TV watched by children in the current study was comparable with estimates from British population-based studies (Ofcom, 2017, 2019). Of the temperament variables, Effortful Control was the only significant predictor of the amount of time spent viewing TV, supporting the prediction that children who watch more TV should have lower Effortful Control. No association between Surgency and the amount of TV viewing was found. This is somewhat inconsistent with previous research (e.g. Nikkelen et al., 2014), which had found associations between hyperactivity and TV viewing. However, it must be noted that although high Surgency ratings had been related to high ratings for hyperactivity (Martel, 2016), surgency had also been highly correlated with extraversion (De Fruyt et al., 2006), and no associations between extraversion and amount of TV viewed had been found for children (Persegani et al., 2002). As far as we know, this is the first study to collect data on surgency and young children's TV viewing, and therefore it seems that although hyperactivity could be associated with watching more TV, surgency in young children is not.

Given the individual differences in attention as well as the potential confounding factor of preferences for particular television programs, the within-subjects design of this study provides more robust findings than earlier studies using between-subjects designs (Cooper et al., 2009; Lillard et al., 2015; Lillard & Peterson, 2011). In addition, children's attention, behavior and comprehension were all studied in the highly ecologically valid context of the home and using real unedited television programs,

matched broadly on content but differing in pace. Therefore, this study provides a more valid insight into children's real-world behavior while watching television. However, due to the programs being of a similar type and shown to the children unedited, they did not differ in pace as much as some used in past research. For example, Cooper et al.'s (2009) conclusions were based on comparing a slow program with a shot change every 15 seconds to a fast-program with a shot change every 4 seconds, whereas the programs used in the current study had a difference in frequency of shot changes of only 3.9 seconds. Consequently, further research would be required to fully address the effects of pace on children's TV watching and behavior after watching, as it is possible that had an even faster-paced program been used, larger, or different, consequences of increased pace may have been found.

Furthermore, using episodes from an already existing TV program meant that the storylines were not directly comparable between the fast- and slow-paced episodes and there were other small differences in the programs. For example, in the faster-paced episode *Postman Pat* had a much larger fleet of vehicles. There are also likely differences in the moment-to-moment progression of the storylines that could influence children's responses to the programs. Therefore, in addition to pace, some of these aspects may have influenced children's attention and arousal while watching. In future research it would be valuable for researchers and producers to work together to develop programs specifically for research use, in which all but the variable of interest, e.g. pace, could be tightly controlled for.

The ecologically valid research setting provided important data on how children engage with television and other media in the home, where there are a range of other potential distractors. While this was a strength of the data it also posed some challenges; in particular, it was not possible to include physiological measures of attention like

heart rate or more controlled behavioral measures such as eye tracking as used with young children in laboratory studies (e.g. Gröer & Howell, 1990; Richards & Cronise, 2003). Future research should seek to find more innovative technological methods that can combine the full range of attentional variables in naturalistic settings.

Finally, revisiting important points raised in the Introduction, firstly, this paper only explored the effect of pace in an entertainment program, and future studies should apply the holistic approach here to compare the effects of different types of program such as educational and hybrid 'edutainment'. Secondly, this paper has only addressed the immediate effects of watching TV on attention, behavior and cognition, and the links between individual experiences and longer-term effects of TV watching require much further investigation.

In summary, this research provides a timely and rigorous yet ecologically valid contribution to an area of international relevance. Young children worldwide are spending a significant amount of time watching TV (Chan & McNeal, 2006; Ofcom, 2019; Rideout, 2017) and the pace of children's TV is generally increasing (Koolstra et al., 2004). Overall, this study provides important evidence to counter the 'harm' held to result from young children watching faster-paced television, suggesting conversely that there may be little difference in the effects of fast-compared to slow programs. However, this may depend on the type of cognitive skill being assessed, as the effects of pace on skills such as attention shifting may differ to those such as inhibitory control. This has potential links to evidence that playing video games may have negative associations with proactive, but not reactive cognitive control (Bailey et al., 2010). Therefore, future research should consider programs that differ to various extents in terms of pace and tasks that assess specific cognitive skills, as there may be

combinations where pace may be beneficial, have little effect, or have a negative effect on some EF skills.

References

Alwitt, L. F., Anderson, D. R., Lorch, E. P., & Levin, S. R. (1980). Preschool children's visiual attention to attributes of television. *Human Communication Research*, *7*(1), 52–67. https://doi.org/10.1111/j.1468-2958.1980.tb00550.x

American Academy of Pediatrics. (2016). Policy Statement: Media and Young Minds. *Pediatrics*, *138*(5), e20162591. https://doi.org/10.1542/peds.2016-2591

Anderson, D. R., & Hanson, K. G. (2010). From blooming , buzzing confusion to media literacy : The early development of television viewing From blooming , buzzing confusion to media literacy : The early development of television viewing. *Developmental Review*, *30*(2), 239–255. https://doi.org/10.1016/j.dr.2010.03.004

Anderson, D. R., Levin, S. R., & Lorch, E. P. (1977). The Effects of TV Program Pacing on the Behavior of Preschool Children. *AV Communication Review*, *52*(2), 159–166.

Anderson, D. R., Lorch, E. P., Field, D. E., Collins, P. A., & Nathan, J. G. (1986). Television Viewing at Home: Age Trends in Visual Attention and Time with TV. *Child Development*, *57*(4), 1024. https://doi.org/10.2307/1130376

Anderson, D. R., Lorch, E. P., Field, D. E., & Sanders, J. (1981). The Effects of TV Program Comprehensibility on Preschool Children's Visual Attention to Television. *Child Development*, *52*(1), 151. https://doi.org/10.2307/1129224

Bailey, K., West, R., & Anderson, C. A. (2010). A negative association between video game experience and proactive cognitive control. *Psychophysiology*, *47*(1), 34–42. https://doi.org/10.1111/j.1469-8986.2009.00925.x

Barr, R., Lauriceila, A., Zack, E., & Calvert, S. L. (2010). Infant and Early Childhood Exposure to Adult-Directed and Child-Directed Television Programming: Relations with Cognitive Skills at Age Four. *Merrill-Palmer Quarterly*, *56*(1), 21–48. https://doi.org/10.1353/mpq.0.0038

Blankson, A. N., O'Brien, M., Leerkes, E. M., Calkins, S. D., & Marcovitch, S. (2015). Do Hours Spent Viewing Television at Ages 3 and 4 Predict Vocabulary and Executive Functioning at Age 5? *Merrill-Palmer Quarterly*, *61*(2), 264–289. https://doi.org/10.13110/merrpalmquar1982.61.2.0264

Burns, J. J., & Anderson, D. R. (1993). Attentional Inertia and Recognition Memory in Adult Television Viewing. *Communication Research*, *20*(6), 777–799. https://doi.org/10.1177/009365093020006002

Calvert, S. L., Huston, A. C., Watkins, B. A., & Wright, J. C. (1982). The Relation between Selective Attention to Television Forms and Children's Comprehension of Content. *Child Development*, *53*, 601–610. https://www.jstor.org/stable/1129371?seq=1#page_scan_tab_contents

Chan, K., & McNeal, J. U. (2006). Children and media in China: an urban-rural comparison study. *Journal of Consumer Marketing*, *23*(2), 77–86. https://doi.org/10.1108/07363760610655014

Christakis, D. A., Zimmerman, F. J., DiGiuseppe, D. L., & McCarty, C. A. (2004). Early Television Exposure and Subsequent Attentional Problems in Children. *Pediatrics*, *113*(4), 708–713. https://doi.org/10.1542/peds.113.4.708

Christakis, Dimitri A. (2009). The effects of infant media usage: what do we know and what should we learn? *Acta Paediatrica*, *98*(1), 8–16. https://doi.org/10.1111/j.1651-2227.2008.01027.x

Clark-Carter, D. (2009). *Quantitative psychological research : the complete student's companion*. Psychology Press.

Cooper, N. R., Uller, C., Pettifer, J., & Stolc, F. C. (2009). Conditioning attentional skills: examining the effects of the pace of television editing on children's attention. *Acta Paediatrica (Oslo, Norway : 1992)*, *98*(10), 1651–1655.

https://doi.org/10.1111/j.1651-2227.2009.01377.x

De Fruyt, F., Bartels, M., Van Leeuwen, K. G., De Clercq, B., Decuyper, M., & Mervielde, I. (2006). Five types of personality continuity in childhood and adolescence. *Journal of Personality and Social Psychology*, *91*(3), 538–552. https://doi.org/10.1037/0022-3514.91.3.538

Ennemoser, M., & Schneider, W. (2007). Relations of television viewing and reading: Findings from a 4-year longitudinal study. *Journal of Educational Psychology*, *99*(2), 349–368. https://doi.org/10.1037/0022-0663.99.2.349

Foster, E. M., & Watkins, S. (2010). The value of reanalysis: TV viewing and attention problems. *Child Development*, *81*(1), 368–375. https://doi.org/10.1111/j.1467-8624.2009.01400.x

Frick, J. E., Colombo, J., & Saxon, T. F. (1999). Individual and developmental differences in disengagement of fixation in early infancy. *Child Development*, *70*(3), 537–548.

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin*, *134*(1), 31–60. https://doi.org/10.1037/0033-2909.134.1.31

Geist, E. A., & Gibson, M. (2000). The Effect of Network and Public Television Programs on Four and Five Year Olds Ability to Attend to Educational Tasks. *Journal of Instructional Psychology*, *27*(4), 250–262.

Gröer, M., & Howell, M. (1990). Autonomic and Cardiovascular Responses of Preschool Children to Television Programs. *Journal of Child and Adolescent Psychiatric Nursing*, *3*(4), 134–138. https://doi.org/10.1111/j.1744-6171.1990.tb00460.x

Kim, S., Nordling, J. K., Yoon, J. E., Boldt, L. J., & Kochanska, G. (2013). Effortful

Control in “Hot” and “Cool” Tasks Differentially Predicts Children’s Behavior Problems and Academic Performance. *Journal of Abnormal Child Psychology*, *41*(1), 43–56. https://doi.org/10.1007/s10802-012-9661-4.Effortful

Koolstra, C. M., van Zanten, J., Lucassen, N., & Ishaak, N. (2004). The Formal Pace of Sesame Street over 26 Years. *Perceptual and Motor Skills*, *99*(1), 354–360. https://doi.org/10.2466/pms.99.1.354-360

Kostyrka-Allchorne, K., Cooper, N. R., Gossmann, A. M., Barber, K. J., & Simpson, A. (2017). Differential effects of film on preschool children’s behaviour dependent on editing pace. *Acta Paediatrica*, *106*(5), 831–836. https://doi.org/10.1111/apa.13770

Landrum, A. R., Olshansky, A., & Richards, O. (2019). Differential susceptibility to misleading flat earth arguments on youtube. *Media Psychology*, 1–30. https://doi.org/10.1080/15213269.2019.1669461

Lang, A., Zhou, S., Schwartz, N., Bolls, P. D., & Potter, R. F. (2000). The Effects of Edits on Arousal, Attention, and Memory for Television Messages: When an Edit Is an Edit Can an Edit Be Too Much? *Journal of Broadcasting & Electronic Media*, *44*(1), 94–109. https://doi.org/10.1207/s15506878jobem4401_7

Lillard, A. S., Drell, M. B., Richey, E. M., Boguszewski, K., Smith, E. D., Lillard, A. S., Drell, M. B., Richey, E. M., Boguszewski, K., & Smith, E. D. (2015). Further Examination of the Immediate Impact of Television on Children ’ s Executive Function Further Examination of the Immediate Impact of Television on Children ’ s Executive Function. *Developmental Psychology*, *51*, 792–805. https://doi.org/doi: 10.1037/a0039097

Lillard, A. S., & Peterson, J. (2011a). The immediate impact of different types of television on young children’s executive function. *Pediatrics*, *128*(4), 644–649. https://doi.org/10.1542/peds.2010-1919

Lillard, A. S., & Peterson, J. (2011b). The immediate impact of different types of television on young children's executive function. *Pediatrics*, *128*(4), 644–649. https://doi.org/10.1542/peds.2010-1919

Linebarger, D. L., Barr, R., Lapierre, M. A., & Piotrowski, J. T. (2014). Associations Between Parenting, Media Use, Cumulative Risk, and Children's Executive Functioning. *Journal of Developmental & Behavioral Pediatrics*, *35*(6), 367–377. https://doi.org/10.1097/DBP.0000000000000069

Lorch, E. P., Anderson, D. R., & Levin, S. R. (1979). The Relationship of Visual Attention to Children's Comprehension of Television. *Child Development*, *50*(3), 722–727. https://doi.org/10.1111/j.1467-8624.1979.tb02420.x

Lowe, P. J., & Durkin, K. (1999). The effect of flashback on children's understanding of television crime content. *Journal of Broadcasting & Electronic Media*, *43*(1), 83–97. https://doi.org/10.1080/08838159909364476

Marcovitch, S., & Zelazo, P. D. (2010). A hierarchical competing systems model of the emergence and early development of executive function. *Developmetnal Sceince*, *12*(1), 1–18. https://doi.org/10.1111/j.1467-7687.2008.00754.x.A

Martel, M. M. (2016). Dispositional Trait Types of ADHD in Young Children. *Journal of Attention Disorders*, *20*(1), 43–52. https://doi.org/10.1177/1087054712466915

Miller, C. J., Marks, D. J., Miller, S. R., Berwid, O. G., Kera, E. C., Santra, A., & Halperin, J. M. (2006). Brief Report: Television Viewing and Risk for Attention Problems in Preschool Children. *Journal of Pediatric Psychology*, *32*(4), 448–452. https://doi.org/10.1093/jpepsy/jsl035

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and Their Contributions to Complex "' Frontal Lobe "' Tasks : A Latent Variable Analysis.

Cogntiive Psychology, *41*, 49–100. https://doi.org/10.1006/cogp.1999.0734

Möller, A. M., Baumgartner, S. E., Kühne, R., & Peter, J. (2019). The effects of social information on the enjoyment of online videos: An eye tracking study on the role of attention. *Media Psychology*, 1–22. https://doi.org/10.1080/15213269.2019.1679647

Nathanson, A. I., Aladé, F., Sharp, M. L., Rasmussen, E. E., & Christy, K. (2014). The relation between television exposure and executive function among preschoolers. *Developmental Psychology*, *50*(5), 1497–1506. https://doi.org/10.1037/a0035714

Nikkelen, S. W. C., Valkenburg, P. M., Huizinga, M., & Bushman, B. J. (2014). Media use and ADHD-related behaviors in children and adolescents: A meta-analysis. *Developmental Psychology*, *50*(9), 2228–2241. https://doi.org/10.1037/a0037318

Ofcom. (2017). *Children and parents: Media use and attitudes report* (Issue November). http://stakeholders.ofcom.org.uk/binaries/research/media-literacy/media-use-attitudes-14/Childrens_2014_Report.pdf

Ofcom. (2019). Children and parents media use and attitudes: annex 1. In *Ofcom* (Issue January). https://doi.org/10.1021/ja035727c

Pearson, N., Salmon, J., Crawford, D., Campbell, K., & Timperio, A. (2011). Are parental concerns for child TV viewing associated with child TV viewing and the home sedentary environment? *International Journal of Behavioral Nutrition and Physical Activity*, *8*(1), 102. https://doi.org/10.1186/1479-5868-8-102

Persegani, C., Russo, P., Carucci, C., Nicolini, M., Papeschi, L. L., & Trimarchi, M. (2002). Television viewing and personality structure in children. *Personality and Individual Differences*, *32*(6), 977–990. https://doi.org/10.1016/S0191-8869(01)00102-7

Pezdek, K., & Hartman, E. F. (1983). Children's television viewing: attention and

comprehension of auditory versus visual information. *Child Development*, *54*(4), 1015–1023. https://doi.org/10.1111/j.1467-8624.1983.tb00522.x

Putnam, S. P., & Rothbart, M. K. (2006). Development of short and very short forms of the Children's Behavior Questionnaire. *Journal of Personality Assessment*, *87*(1), 103–113. http://www.tandfonline.com/doi/abs/10.1207/s15327752jpa8701_09

Putnam, Samuel P., & Stifter, C. A. (2008). Reactivity and regulation: the impact of Mary Rothbart on the study of temperament. *Infant and Child Development*, *17*(4), 311–320. https://doi.org/10.1002/icd.583

Radesky, J. S., Silverstein, M., Zuckerman, B., & Christakis, D. A. (2014). Infant Self-Regulation and Early Childhood Media Exposure. *Pediatrics*, *133*(5), e1172–e1178. https://doi.org/10.1542/peds.2013-2367

Reyland, N. (2010). A postman mans up: The changing identities of Postman Pat. In I. Inglis (Ed.), *Popular Music and Television in Britain* (pp. 213–230). Ashgate.

Reynolds, G. D., & Romano, A. C. (2016). The Development of Attention Systems and Working Memory in Infancy. *Frontiers in Systems Neuroscience*, *10*. https://doi.org/10.3389/FNSYS.2016.00015

Richards, J. E., & Anderson, D. R. (2004). Attentional inertia in children's extended looking at television. *Advances in Child Development and Behavior*, *32*, 163–212. https://doi.org/10.1016/S0065-2407(04)80007-7

Rideout, V. (2017). *The common sense census: Media use by kids age zero to eight*. Common Sense Media.

Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). *Investigations of Temperament at Three to Seven Years : The Children ' s Behavior Questionnaire*. *72*(5), 1394–1408.

Ruff, H. A., & Capozzoli, M. C. (2003). Development of attention and distractibility in

the first 4 years of life. *Developmental Psychology*, *39*(5), 877–890. https://doi.org/10.1037/0012-1649.39.5.877

Schmitt, K. L. (2001). Infants , toddlers , and television : The ecology of the home . *Zero to Three*, *22*, 17–23.

Schmitt, K. L., Anderson, D. R., & Collins, P. A. (1999). Form and content : Looking at visual features of television. *Developmental Psychology*, *35*, 1156–1167. https://doi.org/10.1037//0012-1649.35.4.1156

Sigman, A. (2007). *Remotely controlled : how television is damaging our lives - and what we can do about it*. Vermilion.

Utendale, W. T., & Hastings, P. D. (2010). Developmental Changes in the Relations Between Inhibitory Control and Externalizing Problems During Early Childhood. *Infant and Child Development*, *20*(2), 181–193. https://doi.org/10.1002/icd

Valkenburg, P. M., & Vroone, M. (2004). Developmental changes in infants' and toddlers' attention to television entertainment. *Communication Research*, *31*(3), 288–311. https://doi.org/10.1177/0093650204263435

Vittrup, B., Snider, S., Rose, K. K., & Rippy, J. (2016). Parental perceptions of the role of media and technology in their young children's lives. *Journal of Early Childhood Research*, *14*(1), 43–54. https://doi.org/10.1177/1476718X14523749

Wright, J., Huston, A., & Ross, R. (1984). Pace and continuity of television programs: Effects on children's attention and comprehension. *Developmental Psychology*, *20*(4), 653–666. http://psycnet.apa.org/journals/dev/20/4/653/

Yang, X., Chen, Z., & Wang, Z. (2017). The Relations between Television Exposure and Executive Function in Chinese Preschoolers: The Moderated Role of Parental Mediation Behaviors. *Frontiers on Psychology*. https://doi.org/10.3389/fpsyg.2017.01833

Table 1: Mean and (SD) for behavior during viewing the four clips during pilot phase

	Series 1	Series 2	Series 3	Series 6
Nonverbal	3.67	3.24	4.40	3.33
attention	(0.90)	(1.22)	(0.82)	(1.04)
Mood	2.93	2.47	2.87	2.53
	(0.70)	(0.83)	(0.92)	(0.92)

Table 2: Coding scheme for children's behavior during and after watching TV

	1	2	3	4	5
Coding of Behaviour while Watching TV					
Non-verbal Attention	**No attention given to program**. Child is engaged in another activity (or activities). Looks at the TV infrequently and for only a moment at each look.	**Minimal attention given to program.** Child is dividing their attention between the TV and another activity (or activities). Child may be fidgeting and moving. There are some sustained looks at the TV. Child looks	**Some attention given to program.** Child is likely to be involved in another activity in the room and to be dividing their attention between this activity and the TV. Child may fidget and move. Child looks at	**Good attention given to program.** Child looks at the TV most of the time. May occasionally look away for brief periods of time. Sits relatively still and facing the TV. Little attention is given to	**Full attention given to the programme.** Child consistently looks at the TV, sits still and facing the TV, may point at the TV. No attention is given to any other activity in the room, seems to be

		at the TV less than 50% of the time.	the TV more than 50% of the time.	any other activity in the room.	absorbed by the programme.
Verbal Attention	**Program unrelated talk.** Child talks about something completely unrelated to the TV content.	**More program unrelated than related talk.** Child talks about something that is related to the TV programme – e.g. what they got for Christmas while watching the Christmas Stocking. Although the	**More program related than unrelated talk.** Child talks about what is happening on the TV programme. The child's talk begins to drift away from the programme but more than 50% of the talk is directly related to	**Program related talk.** Child talks about what is happening on the TV programme but directs this talk to someone in the room. Alternatively, the child may ask a question about what is happening on the program. The talk	**Program related talk directed to TV.** Child's talk is directed to the characters in the programme, e.g. "Come on Pat!"

		programme content triggers the talk, the focus of the talk is not about the programme.	what is happening on the TV programme.	remains focused on the content of the programme and does not drift away to non-programme related talk.	
Arousal	**Very passive behaviour observed.** Child is almost completely still. They may look drowsy or like they are daydreaming.	**Relatively passive behaviour observed.** Child is relatively still but makes some occasional small movements.	**Alert, neither overly passive nor overly active behaviour observed.** Child looks alert and engaged in what they are doing. Sitting relatively still but will be making	**Relatively active behaviour observed.** Child is showing some bursts of high activity, but some of the time they may also be still or moving much less.	**Very active behaviour observed.** Child is very active and likely to be moving around the room lots.

			small movements. Alternatively, this code may be used if a child is showing a contrasting mixture of passive and active behaviour.	Child may be making consistent small movements, consistent with fidgeting.	
Coding of Behaviour during Block Buddies Task					
Overall Attention	**No attention given to task.** Child does not pay attention to the task or gives only scattered looks that	**Minimal attention to the task.** Child likely to be dividing their time between the task and an alternative activity in	**Some attention to the task.** Child may fidget and move and may be distracted by an alternative activity. Child spends	**Good attention to the task**. Child spends most of the time on task related behaviors, i.e. manipulating, looking	**Full attention given to task.** This is likely to be characterized by the child leaning in towards the blocks, casting their

	do not focus on any task object.	the room or off topic conversation with the researcher or parent.	more than 50% of the time on task. This time will be spent manipulating, looking at or talking about the task materials.	at or talking about the task materials.	eyes down and manipulating the blocks or the card.
Effort	**No effort towards goal observable.** This could involve child engaging in pretend play with the blocks, child showing reluctance to manipulate the	**Minimal effort towards goal observable.** Shows some manipulation of the blocks but this will be in a repetitive/non focused way.	**Some effort towards goal observable.** Child shows a combination of manipulation of the task materials with intent and purpose and some repetitive	**Good effort towards goal observable.** Child manipulates blocks with purpose or looks intently, e.g. by leaning in or picking up the card.	**Full effort towards goal observable.** Child appears very absorbed and focused on the task, with intense interest and prolonged manipulation of the

	blocks, saying that they could not do it or being completely off task and engaged in another activity.		non focused manipulation or off task behaviours.		materials. Shows determination and persistence.

Note: Bold headings were used by the researcher while coding the child's behavior while they were watching/carrying out the Block Buddies task. More detailed descriptions were developed afterwards to facilitate coding by the other coders.

Table 3: Mean and (SD) for behavior during viewing the fast- and slow-paced program.

	3-year-olds		4-year-olds		Both age groups	
	Slow	Fast	Slow	Fast	Slow	Fast
Mean attention	3.04	3.47	2.84	3.43	2.94	3.45
	(0.48)	(0.39)	(0.51)	(0.37)	(0.50)	(0.37)
Mean arousal	2.66	2.42	2.61	2.74	2.63	2.45
	(0.69)	(0.74)	(0.62)	(0.60)	(0.64)	(0.67)

Table 4: Mean and (SD) for behavior and performance on problem solving task directly after viewing fast- and slow-paced programs.

	3-year-olds		4-year-olds		Both age groups	
	Slow	Fast	Slow	Fast	Slow	Fast
Attention during task	4.76 (0.54)	4.43 (0.68)	4.70 (0.47)	4.80 (0.41)	4.73 (0.68)	4.61 (0.59)
Effort during task	3.57 (0.68)	3.05 (0.92)	3.85 (0.88)	3.90 (0.79)	3.70 (0.79)	3.50 (0.93)
Puzzles successfully completed	3.40 (1.67)	3.90 (1.55)	5.20 (2.04)	5.70 (1.53)	4.30 (2.05)	4.80 (1.77)