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

Sarah E. Rose^{a*}, Alexandra M. Lamont^b and Nicholas Reyland^c

^aStaffordshire Centre for Psychological Research, Staffordshire University, Stoke-on-Trent, UK;

^bSchool of Psychology, Keele University, Newcastle-under-Lyme, UK;

^cRoyal Northern College of Music, Manchester, UK.

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

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Correlational studies have suggested some harmful effects of television (TV) 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, effort and performance after viewing during a problem-solving task, and comprehension of the program. The faster paced program was attended to more, but this had no impact on comprehension. Although 3-year-olds showed more attention and effort on the problem-solving task after watching the slower program, both 3- and 4-year-olds completed more problems successfully after watching the faster program. The results provide evidence to counter the 'harm' perceived in young children watching fast-paced entertainment programs as where differences were found it was the fast-paced program which appeared to have a cognitive facilitation effect.

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

Introduction

Young children watch television (TV) a lot. Three- to 4-year-old children 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, Salmon, Crawford, Campbell, & Timperio, 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, Snider, Rose, & Rippy, 2016). The research evidence is far from clear on whether, and how, TV watching can benefit young children, and the current paper addresses a piece of the puzzle by studying young children in a naturalistic environment – their home – to explore the impact of pace on behavior while viewing, and cognition and behavior directly after viewing.

Much research has focused on the impact of TV on young children's cognitive abilities, especially 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, Nordling, Yoon, Boldt, & Kochanska, 2013; Utendale & Hastings, 2010). Previous research has suggested that the amount of time a preschooler spends watching TV had a negative impact on their performance on tasks involving EF skill (Barr, Lauriceila, Zack, & Calvert, 2010; Blankson, O'Brien, Leerkes, Calkins, & Marcovitch, 2015; Nathanson, Aladé, Sharp, Rasmussen, & Christy, 2014; Nikkelen, Valkenburg, Huizinga, & Bushman, 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, Barr, Lapierre, & Piotrowski, 2014; Yang, Chen, & Wang, 2017).

One explanation for these inconsistent findings is that the outcome of watching TV depends 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, with no effect of child-directed TV. Similarly, although Nathanson et al., (2014) found a negative correlation between overall TV viewing and

EF, further analysis showed this was only the case for time spent viewing cartoons. Experimental evidence on the immediate impact of TV watching supports this, and suggests that the association is a causal one. Lillard and Peterson (2011) found that watching 11 minutes of a 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, 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 importance of an optimal range of arousal being required 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). It has been observed that features and content of the TV program being watched influence the extent of children’s attention to the screen (Calvert, Huston, Watkins, & Wright, 1982; Wright, Huston, & Ross, 1984). Preschool children exhibited greater visual attention (i.e. looking time) to faster-paced programs containing more cuts and sound effects (Alwitt, Anderson, Lorch, & Levin, 1980; Schmitt, Anderson, & Collins, 1999) and to programs which were more easily comprehensible to them (Anderson, Lorch, Field, & Sanders, 1981; Valkenburg & Vroone, 2004; Wright et al., 1984).

As well as investigating attention while viewing TV, the impact of watching TV on children’s developing attention skills has been considered. 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).

Like the impact of watching TV on EF skills, evidence 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 tended to be 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 differed both in terms of pace and content, it is unclear which of these variables may have accounted for the difference in attention found. More recent evidence suggests that pace is influential, 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, Uller, Pettifer, & Stolc, 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.

Younger children have been found to comprehend slow-paced programs better than fast-paced ones (Wright et al., 1984). However, attention does not necessarily lead to comprehension: higher levels of visual attention while viewing did not lead to enhanced comprehension of the program watched by young children (Lorch, Anderson, & Levin, 1979; Wright et al., 1984). Conversely, there is evidence that 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 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 shows that vary both in formal features (e.g. pacing) 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. However, 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 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 impact 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 has 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 focused on. Associations between behavior while watching the two differently paced programs and subsequent behavior and task performance can therefore be considered. Moreover, to allow for the investigation of individual differences, parent reports of children's temperament and home TV experiences are gathered. This is important as associations between different personality

traits and TV viewing have been suggested by a small amount of research. 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).

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 program, Postman Pat. 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 scene changes, camera angles, number of characters per episode and sound effects) has increased (Reyland, 2010). While watching, children's attention and arousal levels were observed and coded by a researcher. Directly after watching, a problem-solving game requiring a range of EF skills was introduced by the researcher and the child was observed while they engaged with this for 5 minutes. This was followed by a test of their comprehension and recall of the episode of Postman Pat that they had just watched. While children completed these tasks, their parents completed two surveys, the Child Behavior Questionnaire (Putnam & Rothbart, 2006) to assess their child's temperament (Surgency, Negative Affect & Effortful Control) and a Television Viewing Habits questionnaire.

As it has previously been found that 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). It was hypothesized that 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 the conflict in previous research between a facilitative (Cooper et al., 2009) and a harmful effect (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 has been found to improve with age (Wright et al., 1984) it was hypothesized that 4-year-olds would 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 the child'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 of the participating children attended part- or full-time nursery while five were cared for exclusively by their parents (for 3 children care arrangements were unknown). Thirty-one of the children 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 (5 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

To identify two episodes of Postman Pat which aroused similar interest levels in preschool-aged children (as rated by attention and mood while watching on a 5-point Likert scale), four 5-minute clips from different series (series 1, 1981; series 2, 1997; series 3, 2004; series 6, 2008) were shown to 16 3- and 4-year old children individually in their nursery. Two series were identified as generating equivalent responses for mood, attention and comprehension from these children: Series 2 (relatively slow-paced, average shot length 7.3 seconds) and Series 6 (relatively fast-paced, average shot length 3.4 seconds). Based on having similar plot complexity and both being unlikely to have been recently watched by the children, two episodes were selected: "Postman Pat

and the Robot” (Series 2, air date 1997) and “Flying Christmas Stocking” (Series 4, air date 2008). The programs were shown un-edited in their full 15-minute run time.

To assess post-viewing behavior, a commercially available, age-appropriate and educational game called “Block Buddies” was used. The game used skills the children were familiar with – 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.

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, five comprehension questions were asked, one relating to each image; 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. Post-testing of these questions and sequencing tasks was carried out with 16 3- and 4-year-olds who had not watched the original programs but were asked if they could guess the answers given the same materials. No child was able to correctly sequence the pictures or to correctly answer any of the questions without prompts. However, with prompts children were able to answer some questions and as this was not equivalent across the two programs (slow program: $M = 5.25$ $SD = 1.438$, fast program $M = 3.313$, $SD = 1.401$, $t(15) = 4.810$, $p < .001$) it was decided to only

score children based on their initial answer, prior to any prompts being given.

Therefore, one point was given for entirely correct sequencing and for each question answered correctly without any prompts.

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, rules regarding TV watching, 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. Two separate visits were made at similar times of day, during the morning or afternoon, as close to one week apart as possible. The same procedure was followed on both visits. One episode of Postman Pat was shown (counterbalanced in order between children) using the family television. 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. The researcher introduced the Block Buddies game 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 (the order of the piles was counterbalanced). During this the researcher made an error, placing one of the blocks in the incorrect orientation and then demonstrated recognizing and correcting this error. After this demonstration the child was encouraged to try. This was done by 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: 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 (no corrections were made by the researcher) the comprehension question relating to each picture was asked.

Coding & inter-rater reliability

Coding was carried out 'live' by the researcher. This had the advantage of the child's behavior being continuously coded even when the child moved out of shot of the camera. A coding sheet was used by the researcher to record children's behavior while viewing the TV episode, their behavior and performance on the Block Buddies task, and the comprehension tasks. Behavior while viewing was coded in nine-time segments: the

opening credits, followed by seven segments approximately 100 seconds long, and the closing credits. Behavior during each of these nine intervals was coded on separate 1-5 Likert-type scales for verbal and non-verbal attention (1= no observable attention given to program, 5= full attention given to program) and arousal (1= very passive, 5 = very active). After viewing, the child's verbal and non-verbal attention to the introduction of the Block Buddies task and during the Block Buddies task were scored on separate Likert-type scales (1= no observable attention given task, 5= full attention given to task), and effort was also scored during the Block Buddies task (1= no effort observable, 5 = full effort given to task). The number of puzzles attempted and correctly solved were also noted.

As the researcher was not blind to the age of the child nor the episode being watched, four independent raters coded each child's behavior from video recordings. Initially these raters coded mute versions of the video file so that they were blind to the experimental condition. They then re-watched with audio to code for verbal attention. The reliability of the ratings given by the four independent coders and the researcher was assessed. Reliability was high across all four independent raters and the researcher for non-verbal attention $ICC(1,1) = .82$, $CI [.76, .87]$, Cronbach's $\alpha = .95$; verbal attention $ICC(1,1) = .74$, $CI [.56, .87]$, $\alpha = .81$ and arousal $ICC(1,1) = .78$, $CI [.71, .84]$, $\alpha = .95$. 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 video camera). Verbal and non-verbal attention scores were averaged to create a score for overall attention which was used in the final analysis.

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) ANOVAs were carried out. Significant interactions were followed up using simple effect analysis in which a Bonferroni correction was used to reduce the chances of obtaining false-positive results (type I errors).

Hierarchical regressions were used to test for 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. Using this approach allowed the influence of age and gender to be controlled for so that the effects of temperament could be considered independently. 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). Parents reported a range of rules and regulations around television mainly to do with age-appropriateness and restricting access at times of day such as mealtimes. However, they also reported using TV as a reward and it being part of their daily routine.

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 were analyzed using a hierarchical multiple regression in which age in months and gender were controlled for by being entered first. 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, $\beta=-.372$, $p=.026$. All other predictors did not explain a significant proportion of the variance.

Looking at behavior during viewing (Table 1), 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 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 data from 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, with age in months and gender controlled for. 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 regression and ANOVA was also conducted 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 1 near here]

Performance on the Block Buddies task enabled a comparison of the immediate short-term effects of viewing the fast- and slow-paced program (Table 2). 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 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 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) and behavior (attention and effort) during the task predicted task success, separate multiple regression analyses were carried out for each program and each dependent variable, controlling for age and gender. There were no significant associations between the temperament variables and behaviors or success for either program¹.

[Table 2 near here]

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 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, multiple regression was used to assess the

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 programmes. This replicated the findings established from the ANOVA.

extent to which 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 ($\beta = -.1.93, p = .063$). 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. Sensitivity analysis involved the hierarchical 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 program influenced 3- and 4-year old children's attention during and directly after watching the show, behavior and performance on a task requiring EF skills directly after watching the show, and program comprehension. There was a trend for children to show higher arousal while watching the slow- compared to fast-paced program and to attend to the fast-paced program more than the slow-paced one. This is

in accordance with Alwitt et al. (1980) and Schmitt et al.'s, (1999) earlier findings that young children attend more to features such as the cuts and sound effects found more frequently in fast-paced programs. These findings suggest that visual attention in young children is malleable, rather than reflecting a more permanent attentional style or temperament trait. This interpretation is also supported by the lack of significant associations found in the current results between attention given to either program and the temperament measures of Surgency, Negative Affect and Effortful Control. 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, it has been found that 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 the slow- and fast-paced programs may have been equally comprehensible to both 3- and 4-year-old children.

In addition to paying more attention to the fast-paced program, children also tended to solve more puzzles correctly after watching the fast- compared to slow-paced program. This trend towards better success levels on the block building task for both age groups after the fast program is in accordance with Cooper et al.'s, (2009) findings

that young children made fewer errors on an attention test after watching a fast- compared to slow-paced program, suggesting a potential priming effect of watching fast-paced TV. Furthermore, Kostyrka-Allchorne et al.'s, (2017) findings that after watching a fast-paced program children shifted their attention from one toy to another more quickly may help explain why children performed better. Children may have been able to shift their attention from one brick to another, and from one possible solution to another, more swiftly, helping them to identify the correct solution more quickly and consequently to complete a greater number of puzzles within the time available. This fits with the literature on creativity and problem solving, which suggests that those who have more ideas (i.e. think more divergently) may come up with more appropriate solutions (e.g. Bijvoet-van den Berg & Hoicka, 2014; Mednick, 1962; Runco & Jaeger, 2012).

The finding that the 3- and 4-year-old children performed better on the block building task after watching the fast- compared to slow-program could be interpreted as contradictory to Lillard and Peterson's (2011) conclusion that a fast-paced program reduced performance on tasks involving EF. However, Lillard et al. (2015) had already demonstrated that the decline in performance on tasks requiring a range of EF skills was the result of program content rather than pace. Specifically, it was found that fantastical content had negative consequences for EF task performance. The programs used by Lillard et al. were either high or low in impossible events such as characters or objects appearing out of nowhere, changing shape or moving in ways that would violate gravity. Events such as these did not occur in either of the episodes of Postman Pat used in the current study. Therefore, it seems that it is the occurrence of these fantastical events that may reduce EF rather than the pace of the program. Furthermore, it seems that depending on the EF skills being tested the pace of the program may have a

facilitative effect, as found in this study and also by Cooper et al. (2009) and Kostyrka-Allchorne et al. (2017). Although Lillard et al. (2015) found no effect of pace, their EF tasks predominantly required sustained attention and following of rules (e.g. day night task, delay of gratification, head-toes-knees-shoulders). In the Block Buddies task used in our study, attention was required in terms of staying on task and visually attending to the pattern on the card that was to be replicated, but shifting of attention was also required to enable children to focus on the different blocks required to make the puzzle. Furthermore, adherence to rules and inhibitory control were not required during the block building task. Therefore, using an ecologically valid task emphasizing problem-solving skills suggests that watching fast-paced TV may not be more detrimental to children's cognitive abilities than watching slow-paced TV. In fact, it suggests that it may be beneficial. This emphasizes the complex nature of the effect of watching different types of TV on cognitive processing.

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 received higher ratings for effort made 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 slight negative effects on subsequent behavior in terms of attention and effort. 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. Therefore, taken

together these findings suggest that sustained attention in younger children may be more negatively impacted by faster-paced TV than in older children. Furthermore, this is consistent with the literature regarding the impact of TV on attention while viewing which shows that younger children may also be more negatively impacted by increased pace (Wright et al., 1984).

Pace made no difference to comprehension of the programs, with children performing at a relatively high level 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 as 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. This ability to alter attention effectively depending on the characteristics of the program being watched is further supported by 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 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). Parents' approach to regulating their child's TV viewing is consistent with qualitative research

on parents' reported practices on controlling their young children's TV watching (Dorey et al., 2010; Evans, Jordan, & Horner, 2011; Jordan, Hersey, McDivitt, & Heitzler, 2006). 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 has found associations between hyperactivity and TV viewing. However, it must be noted that although high Surgency ratings have been related to high ratings for hyperactivity (Martel, 2016), surgency is also highly correlated with extroversion (De Fruyt et al., 2006), and no associations between extraversion and amount of TV viewed has 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, the findings of this study provide a more valid insight into children's real-world behavior while watching television than previous research. 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.

In summary, this research provides a significant contribution to an area of international relevance. Internationally, young children 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). This research provides a timely and rigorous, yet ecologically valid, contribution to our understanding of the impact of pace in television on children's development. The age group selected is the one where most TV is watched in childhood (Ofcom, 2017; Rideout, 2017). The within-participant design controlled for confounding variables relating to the child and home viewing environment. The program selected allowed for content and program type to be controlled for but differences in pace to be observed. The home context in which the data was collected, the choice of program (shown in its unedited form) and the block building task all contribute to a rigorous and highly ecological design. 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, and that where there are differences it is the faster-paced programs that may have a facilitative cognitive effect.

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Table 1: 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 2: 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)