Immediate Impact of Fast/Slow Paced Television on Pre-schoolers Executive Function

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ABSTRACT

Research has provided evidence to suggest that television viewing can have negative consequences on children's cognition. In particular research has suggested the pacing of television may be a fundamental factor which undermines executive functioning (EF). A recent study which used a between groups design showed that a short exposure to a fast paced show had an immediate negative impact upon pre-schoolers EF. This study investigated this further using a within groups design. A total of 21 4 year old children participated, and undertook 3 EF tasks after watching a slow paced and fast paced television clip of the same programme on separate visits. No significant difference was found in children's performance on all 3 EF tasks and suggests that pace may not be the sole factor contributing factor to negative effects on EF. This is an under researched area and requires further investigation into possible immediate negative effects of television.

KEY WORDS:	EXECUTIVE FUNCTION (EF)	TELEVISION	PRE-SCHOOLERS

Executive Functions (EFs) is an umbrella term which refers to a number of higher order cognitive processes which are necessary for socially appropriate and goal directed behaviour (Miller & Cohen, 2001). Research suggests that EF is a multidimensional construct consisting of 3 main core EFs, which are correlated but separable in adulthood (Miyake, Friedman, Emerson, Witzki, Howerter & Wager, 2000). These core EFs include inhibition (the ability to control and inhibit which could be considered a well-learned or 'automatic' response in favour of a subdominant response), working memory (the ability to hold information in memory in order to conduct goal driven behaviour) and cognitive flexibility or attention shifting (the ability to switch the focus of attention) (Miyake et al, 2000; Lehto, Juujarvi, Kooistra & Pulkkinen, 2003; Swingler, Willoughby & Calkins, 2011).

EFs are important to study as they are crucial to our everyday lives and allow us to interact with our environment in a flexible and adaptive way, and play an important role in the learning and acquiring of both cognitive and motor skills early in life (Garon, Bryson & Smith, 2008). EF's are important to study as they have been highlighted to be one of the best predictors of life success. EFs can be associated with quality of life, school readiness, physical health and mental health (including addictions, conduct disorder, cognitive disorders, etc) (Brown & Landgraf, 2010; Davis, Marra, Najafzadeh & Liu-Ambrose, 2010; Blair & Razza, 2007; Crescioni, Ehringer, Alquist, Conlon, Baumeister, Schatschneider & Dutton, 2011; Baler & Volkow, 2006; Fairchild, Goozen, Stollery, Aiken & Savage, 2009; Diamond, 2005; Barch, 2005). Furthermore EFs predicts school success, job success, marital harmony and even public safety (Borella, Carretti & Pelegrina, 2010; Bailey, 2007, Eakin, Minde, Hetchmen, Ochs & Krane, 2004; Denson, Pederson, Friese, Hahm & Roberts, 2011). Therefore it is evident that EFs are of crucial importance to numerous aspects of our lives not only in the present but also over time.

It is important to investigate EFs early in life as research has suggested that EF is related to the prefrontal cortex, frontal lobe region of the brain, which develops rapidly between the age of 2 and 5 years old (Fuster, 2001; Diamond, 2013). There is research to suggest that attention develops within the first 6 months of life, and children can also begin to hold representations in working memory at this time which can then be manipulated at around the age of 2 years old (Diamond, DeLuca & Kelly, 1997). Following the development of working memory, response inhibition development occurs and the last EF aspect to emerge and the most complex is cognitive flexibility (Anderson, 2002; Diamond, Kirkman & Amso, 2002; Zelazo, Carter, Reznick & Frye, 1997). Research has shown that performance on EF tasks are observed between 3 – 5 years old, and by the age of 4 children can complete most EF tasks including cognitive flexibility tasks (for example, at the age of 3 children can sort according to one rule in the Dimension Change Card Sort Task (DCCS) but have difficulty changing to a new rule, however by the age of 4 they can begin to shift their attention and sort according to new rules)(Carlson & Moses, 2001; Carlson, 2005; Diamond & Taylor, 1996; Garon et al, 2008). Therefore research has shown that the pre-school years are important in the development of core aspects of EF.

Although there is vast empirical evidence to support the claim that EF is a multidimensional construct consisting of 3 main correlated but separable EFs, there has been some debate over whether or not EF can be best described as a unitary or

separable construct in childhood. A study by Wiebe, Epsy & Charak (2008) investigated EF in 3 – 6 year old children, after conducting a battery of EF tests with a large sample size (243 children involved) they concluded that a single factor model of EF could account for data and furthermore that this model was consistent across subgroups of children. However a study conducted prior to this, which studied children aged 11 – 12, found that there were 2 distinct aspects of EF; inhibition and working memory, however failed to find a third distance aspect of EF; cognitive flexibility/attention shifting, suggesting a 2 factor model (St Clair-Thompson & Gathercole, 2006). Evidence for a 2 factor model was also recently supported in research investigating pre-school children aged 3 – 5 year olds, suggesting a 2 factor model of EF was a better fit than a single or 3 factor model (Miller, Giesbrecht, Muller, McInerney & Kerns, 2012). In very recent years however, recent studies which examined EF organisation in young children and early adolescence has supported the 3 factor model, claiming that there does appear to be differentiation of EF aspects in childhood (Skogan, Zeiner, Overgaard, Orbeck, Reichborn-Kjennerud & Aase, 2014; Cassidy, 2015). These studies along with recent others in the last two decades which examine early EF development seem to suggest that there may or may not be fundamental differences in the structure and organisation of EF early in life and later in adulthood, and there is disagreement on whether EFs may not be best described as a multidimensional construct early in life or a unitary construct (Carlson, Mandell & Williama, 2004; Welsh & Pennington, 1998; Welsh, Pennington & Groisser, 1991; Wiebe, Sheffiled, Nelson, Clark, Chevalier & Espy, 2011; Swingler et al, 2011). Therefore there is a lack of consensus over the structure of EF in childhood and there appears to be increasingly mixed evidence to suggest one model over another.

While taking into consideration the role of genetics in the development of EFs, it is suggested that during the crucial period of development between the ages 3 – 5 years, EFs are also vulnerable and susceptible to influence by environmental factors (Bernier, Carlson, Deschenses, & Matte-Gange, 2012; Zelazo & Carlson, 2012; Nathanson & Fries, 2014). For example, this period of growth has been found to be dominated by sedentary behaviours, more specifically 80% of the child's waking hours is spent participating in sedentary behaviours, for example, watching television (Reilly, Jackson, Montgomery, Kelly, Slater, Grant & Paton, 2004; Vale, Silva, Santos, Soares-Miranda & Mota, 2010). The environment is an important factor during childhood which plays a significant role in children's mental growth and development (Ramirez, Christakis, Hodge, Hevner, Ramirez & Ramirez, 2013). One environmental influence which research over the years has increasing highlighted as shaping brain development and having a consequence on children's EF is television exposure (Zimmerman & Christakis, 2007; Nathanson & Fries, 2014; Nathanson, Alade, Sharp, Rasmussen & Christy, 2014).

In our ever growing society saturated with media it has been found that more children are watching television more regularly and earlier in life. For example, research has found that since the 1980's the average age of which children regularly watch television has come forward from 4 years old to 5 months old, and that by the age of 2 years old, 90% of children have been exposed to television. Furthermore the average pre-school child spends 30-40% of their waking hours engaged in the sedentary behaviour of watching television (Christakis, Ebel, Rivara & Zimmerman, 2004; Vandewater, Rideout, Wartella, Huang & Shim, 2007; Tandon, Zhou, Lozano

& Christakis, 2011; Zimmerman et al, 2007; Christakis, Ramirez & Ramirez, 2012). As television has been described as a sedentary behaviour which ultimately does not require a lot of mental or physical effort, it is tenable to suggest that the time that is spent viewing television could be using time which could be spent more wisely on activities considered more enriching to the development of the brains executive system during this crucial period of cognitive growth (AAP, 2011; Pagani, Fitzpatrick, Barnett & Dubow, 2010; Pagani, Fitzpatrick & Barnett, 2013).

It has found that television viewing can have long term negative effects on children's cognition, including not only their EF but other aspects of their function. For example, studies found that increased television exposure was associated with a decrease in vocabulary and maths skills, physical prowess, victimization by peers, weaker social skills, and also has been linked to interference with children's sleeping routines (Pagani, et al, 2013; Conners-Burrow, McKelvey & Fussell, 2011; Nathanson & Fries, 2014). Longitudinal studies have found that early television exposure has also been associated with decrease in classroom engagement and school readiness, both associated with EF (Pagani et al, 2010; Pagani et al, 2013). Therefore these studies have concluded that early exposure is not beneficial to the development of EF during the crucial period of development for prefrontal cortex growth identified as 2 – 5 years old. It may be suggested that exposure in pre-school years may undermine EF development and that exposure to television during this period predisposes children to 'passive' learning and does not encourage independent and attentive learning (Pagani et al, 2010; Pagani et al, 2013).

Recently research has also shown that there can also be immediate negative effects of television exposure as well as long term negative consequences, including a negative impact on aspects of EF including attention, working memory and inhibition, which can be displayed within experimental studies through poorer performance and less persistence in tasks after watching television (Barr, Lauricella, Zack & Calvert, 2010; Lillard & Peterson, 2011).There has been controversy for decades surrounding what factors or aspects of television exposure may contribute to the negative effects on children's function, especially the effect of television on EF (Anderson & Collins, 1998). Factors which have been highlighted include the likes of the content or genre of the show, whether it is adult or child oriented programmes, as it has been suggested that watching both fantastical and adult orientated shows at a young age can have consequences on EF (Barr, Danzinger, Hillard, Andolina & Ruskis, 2010; Barr et al, 2010). However it has also been highlighted that fast pacing was also a feature in both these studies that found a negative immediate effect of television on EF (Barr et al, 2010; Lillard et al, 2011). Therefore it may be suggested that immediate negative effects are down to pacing of television rather than their genre or orientation.

Pace of television has increased substantially over recent years due to advances in technology with television including even more audio and visual changes and special effects (Lamont, Rose & Reyland, 2014). Fast pacing of television is prevalent in children's programming, accompanied by atypical sequencing which can be described as 'nonnormative stimulation', which influences pre-school children most as research suggests that children during this age and stage of development rely on this perceptually salient stimuli to process information (Huston, Wright, Wartella, Rice, Watkins, Campbell & Potts, 1981; Wright & Huston, 1983; Nathanson et al,

2014). 'Nonnormative stimulation' has been suggested to make children continuously engage, disengage and then re engage towards different stimuli on screen and anticipate changes, like an 'attention directing adult' (Nathanson et al, 2014), and therefore these processes become reactive in nature, rather than deliberate thoughtful individual goal driven actions.

Another suggestion which has been put forward to help explain the effects of television on children's functioning is the 'overstimulation hypothesis' which also proposes that fast paced television can overwhelm children's cognitive resources and therefore can impact and effect their EF performance (Christakis, Zimmerman, DiGiuseppe & McCarthy, 2004). Television exposure during pre-school years has therefore been suggested to have profound effects on how children process information, and allocate their cognitive resources as it discourages the independent development of EF skills, such as attention shifting in context, cognitive flexibility and working memory (Nathanson et al, 2014).

Although one of the earliest studies which investigated pacing of television on children's EF found no immediate negative effects (Anderson, Levin & Lorch, 1977), recently a growing number of studies have found a significant immediate negative effect of fast paced television on children's cognition (Geist & Gibson, 2000; Lillard & Peterson, 2011). For example, a study by Geist & Gibson (2000) found that children displayed less persistence in carrying out a task after exposure to a fast paced show compared to a slow paced show. It is important to investigate further the possible negative consequences that fast paced television can have on pre-school children as research has suggested it may have not only long term but immediate negative effects on aspects of children's cognition. It is also concerning that research has suggested that pre-school children watch more than 90 minutes of television daily during this significant period of mental growth (Vandewater, et al, 2007). Therefore this current investigation explores the immediate effects of fast and slow paced television on pre-schoolers EFs.

One of the most recent studies which investigated the significance of television pacing and highlighted the immediate impact it can have on pre-schooler's EFs was conducted by Lillard & Peterson (2011). They conducted a between groups study with 4 year olds and found that those who had watched 9 minutes of a fast paced television showed poorer EF performance on a collection of EF tasks, than those who watched an educational show or those who had coloured with crayons for the same amount of time. Although the study did not state specifically what aspect each task measured, it can be assumed given the tasks used that these measured working memory (backward digit span task), self regulation (head toes knees shoulders task) and planning (tower of Hanoi task). Scores on these 3 tasks were added together to produce a composite EF score to indicate overall EF performance. However a response inhibition task (delay of gratification) was conducted also and reported separately as they suggested that this was the least correlated with the other abilities and therefore was not included in the overall EF score.

This study found that children who watched the fast paced show performed worse when EF was reported both as a composite score, and also when response inhibition was reported separately. They suggest that fast paced television is cognitively taxing and demanding for children to process, resulting in poorer performance of EF. It is

unclear what particular cognitive structural model of children's EF this study follows, other than they state that response inhibition will be looked at separately and report also a composite EF score. The current study will investigate fast paced vs. slow paced television on all 3 core areas of EF (working memory, response inhibition and cognitive flexibility). Furthermore as there is inconsistent evidence to suggest whether the structure of EF in children is separate or unitary (Weibe et al, 2008; Skogan et al, 2014), this study as well as investigating all 3 core aspects of EF, will also report a composite EF score.

As well as building on Lillard et al (2011) study by investigating all 3 core aspects of EF as well as EF overall, the current study will also address other limitations of the study. For example, the BPS published an article advising to be 'cautious' of the conclusions of this study due to methodological issues (BPS, 2011). They highlighted that the study did not test for cognitive ability before and as it was a between groups design it did not control well for individual differences. Also the nature of the shows differed and it could be suggested that this could be regarded as an extraneous variable. This study will therefore use a within groups design to control for individual differences. More over, a slow and fast paced version of the same show will be used, where the theme and storylines are broadly similar and thus controlling for extraneous variables such as the child's interest in one television show over another television show.

The hypothesis of this study is that the pacing of the television show will have an effect on children's EF when measured by a composite measure; more specifically fast pacing will have an immediate negative effect on children's EF. Lack of research on individual aspects of EF makes it difficult to predict what the outcome of pacing will have on each aspect individually and so this study sets out to explore which of the 3 aspects of EF would be affected by the pacing of television.

Method

Participants

A total of 21 child participants took part in this study, aged 4 years old. Out of the total participants, 10 were female, and 11 were male. This study used opportunity sampling; participants were recruited from private nurseries within Glasgow.

Design

This study used an experimental within groups design and a paired samples t test analysis was used in order to compare EF performance in both the slow paced and fast paced television clip conditions. The Independent Variable (IV) in this study was the video clip shown ('Fast' or 'slow' paced television clip). The Dependent Variable (DV) in this study is Executive Function Score of each participant. A score was obtained for each aspect of EF (response inhibition/working memory/cognitive flexibility) by completing the task designed to measure each aspect of EF. Furthermore a composite EF score was obtained by combining data from all 3 EF tasks. The measure was scored so that a higher score meant a higher performance on Executive Function tasks.

Materials

A letter was sent to nursery managers to seek consent to conduct research within their nurseries and to contact parents of children. Children's parents/guardians were then contacted via the nursery manager who distributed information sheets and consent forms. The documents provided to the parents described the aims of the study, explained the nature of their child's involvement, and recorded the child's date of birth and the parents written consent. Parents/guardians were also provided with debrief sheets once the investigation was completed. There were 2 performance record sheets per child to record performance on EF tasks on both visits. As responses in this study were pseudo anonymous, at the first testing session the child was given a code number, their name and number was kept on a separate sheet which was stored separately from the data and their name was removed once they had completed both testing's.

This study used a portable television DVD player where children viewed 2 age appropriate television clips across the 2 visits, from the 'Postman Pat' DVD series. The DVDs included 'Postman Pat and the Robot' (1996), which was classed as a slow paced clip, than 'Postman Pat, Flying Christmas Stocking' (2008) classed as a fast paced clip. To quantify the pacing of both these ten minute clips, each clip was viewed several times, and the number of scene changes were recorded (i.e. a complete change from one scene to another, for example move from street into post office) and the number of audio changes were recorded (i.e. where narrator or character stops talking and another starts). (See below table 1 for content analysis details within the ten minute clips used in this study). (Both of these DVDs have been used in recent research and served the purpose of distinguishing between fast and slow paced television shows (Lamont, Rose & Raylend, In Press)).

Table 1. Content Analysis of Both Fast and Slow Paced Television Clips

DVD	Number of Scene Changes (within 10 minutes)	Number of Audio changes (within 10 minutes)
Postman Pat and the Robot (1996)	23	55
Postman Pat and the Flying Christmas Stocking (2008)	50	80

EF Tasks

Response Inhibition: The tasks used in this study included, 'Simon Says' (Strommen, 1973; Carlson, 2005) In this task, children are asked to carry out some 'silly' things first of all with myself/investigator in order for the child to feel comfortable and feel familiar with the procedure of following commands (e.g. 'touch your toes/touch your nose'). The child is then asked to remain still unless they hear commands that are preceded by 'Simon Says'. Commands are expressed in a quick manner and all actions are carried out by myself/investigator regardless of whether commands are preceded by 'Simon Says'. This task consists of 10 trials (5 commands preceded/not preceded by 'Simon Says'). Performance on commands not preceded by 'Simon Says' can be taken as an index of self-control (0 = movement, 1 = no movement, children receive a mark out of 5).

Working Memory: The 'Backward Digit Span' (Davis & Pratt, 1996; Carlson, 2005) involves introducing children to a 'silly monkey' puppet and explaining that whatever is said the monkey puppet will say it backwards. A demonstration is given, where I/investigator says '1, 2' and the monkey says '2, 1', before inviting the children to try and mimic what the monkey puppet would do by saying whatever I/investigator says backwards. This task starts off with 2 digits and is then increased (up to 5 digits maximum) until children fail on 3 consecutive trials. The highest level of success is recorded (1 = failed to recall 2 digits, 2 = recalled 2 digits backwards, 3 = recall 3 digits backwards, 4 = recall 4 digits backwards, 5 = recall 5 digits backwards, children receive a mark out of 5).

Cognitive Flexibility: The 'Standard Dimensional Change Card Sort (SDCCS)' (Carlson, 2005; Frye, Zelazo & Palfai, 1995) uses cards which have both blue and red, rabbit cards and boat cards. There are 2 boxes with rectangular slots on the top and there is a red rabbit card attached to the front of 1 box and a blue boat attached to the other. Children are firstly invited to play the 'shape game' where they sort all rabbit cards into the red rabbit box and all boat cards into the blue boat box regardless of the cards colour. After 5 consecutively correct trials, children are then invited to play the 'colour game', where all red cards are put in the red rabbit box and all the blue cards are put in the blue boat box regardless of their shape. A rule is then announced before each trial, (i.e. sort according to colour/shape of card) and children are presented with a card and the card is labelled aloud (eg. Here is a blue rabbit). Following the method of Carlson (2005) and Frye et al (1995), there are 5 post-switch trails, 2 trials compatible with the old sorting rule, and 3 trials incompatible with it (where sorting by the old rule will lead to incorrect response). (If children get all 3 incompatible post-switch trials correct = 1, if they do not pass all 3 incompatible post-switch trials = 0).

Procedure

After obtaining the nursery managers/parent/guardians written consent, the child's verbal consent, and reminding the child there are no right/wrong answers, the experiment was carried out. This investigation consisted of 2 visits. On the first visit half of the children were randomly assigned to watch the slow paced DVD, while the other half of the children were assigned to watch the fast paced DVD (clip lasted for ten minutes). The children then completed 3 developmentally appropriate EFs tasks proven to be successful measures of pre-school children's EFs (including response inhibition, working memory, and cognitive flexibility) in previous research (Carlson, 2005). All 3 tasks together take ten minutes in total to complete. Within 4 weeks of the first visit, another visit was made where children watched the opposite paced DVD of what they had viewed in the first visit for the same amount of time. After the clip, children carried out the same 3 EF tasks. Performance on EF tasks was recorded on a scoring sheet at the time of testing in both visits. The children were then debriefed where they were thanked for participating and asked if they had any questions after each visit. Debrief forms were distributed to parents at the end of the second visit and the child's name was then removed from the sheet which stores their name with their id code.

Results

The descriptive statistics for overall EF of participants in each condition are displayed below, as well as individual aspects of EF (response inhibition, working memory, cognitive flexibility). Results include both the mean and SD of EF scores (see below table 2, see appendix 1 for all spss output).

Table 2. Mean and SD of EF scores in both Slow and Fast Paced Conditions

Measure		Mean	SD
Overall EF	Slow Paced Condition	7.10	2.36
	Fast Paced Condition	6.57	1.60
Response Inhibition	Slow Paced Condition	3.52	1.12
	Fast Paced Condition	3.20	.87
Working Memory	Slow Paced Condition	3.00	1.14
	Fast Paced Condition	2.86	.85
Cognitive Flexibility	Slow Paced Condition	.57	.51
	Fast Paced Condition	.52	.51

After checking data to ensure that assumptions of normality had been met, a one tailed paired samples t test was conducted and revealed that there was no significant difference in the overall EF score of participants in the slow paced television clip condition (M = 7.10, SD = 2.36) and the overall EF score in the fast paced television clip condition (M = 6.57, SD = 1.60), t (20) = 1.27, p = 0.109.The 95% confidence interval for the difference between the population means was between -0.34 and 1.38. Cohen's d = 0.28 indicating a small effect size.

Response inhibition task performance in the slow paced television clip condition (M = 3.52, SD = 1.12) was not significantly higher than the response inhibition task performance displayed in the fast paced television clip condition (M = 3.19, SD = 0.87), t (20) = 1.28, p = 0.109 (or) p = >.05. The 95% confidence interval for the difference between the population means was between -0.21 and 0.88. Cohen's d = 0.28 indicating a small effect size.

Task performance after conducting the working memory task in the slow paced television clip condition (M = 3.00, SD = 1.14) was not significantly different to working memory task performance in the fast paced television clip condition (M = 2.86, SD = 0.85), t (20) = 0.72, p = 0.240 (or) p >.05. The 95% confidence interval for the difference between the population means was between -0.27 and 0.56. Cohen's d = 0.16 indicating a small effect size.

The cognitive flexibility score of participants in the slow paced television clip condition (M = 0.57, SD = 0.51) was not significantly different than the cognitive flexibility score obtained in the fast paced television clip condition (M = 0.52, SD=0.51), t (20) = 0.44, p = .333 (or) p > .05. The 95% confidence interval for the difference between the population of means was between -0.18 and 0.27. Cohen's d = 0.10 indicating a small effect size.

The results of inferential statistics did not support the hypothesis as there was no significant effect of television pacing on children's EF; children did not perform significantly worse on EF tasks in the fast paced condition compared to the slow paced condition.

Discussion

Results of this study did not support the hypothesis of this study that the pacing of the television show will have an effect on children's EF when measured by a composite measure; more specifically fast pacing will have an immediate negative effect on children's EF. Results showed no significant difference in children's overall performance on EF task's after watching the fast paced and slow paced television clip thus did not support previous research such as Lillard & Peterson's (2011) study. Furthermore this study investigated the affects of television pacing on the 3 core aspects of EF (working memory, response inhibition and cognitive flexibility) and found that there was no significant difference in performance of each EF aspect individually after watching the slow paced show, and the fast paced show.

One possible explanation which has been put forward in past research to account for these non significant findings in similar studies is that although the clips used within these studies were considered 'fast paced', it is possible that they are not as 'fast' as what would be considered today's standard of 'fast' pacing. For example, it has been suggested that the television show 'Sesame Street', used in Anderson et al (1977), despite its increase in pace over the years, by 2000 it was still considered one of the slowest paced children's television shows to be played on air. Considering this study was conducted in the 70's the clip used would have been even slower which may therefore explain why no immediate negative effects were found on children's EF (Lillard, Li & Boguszewski, 2015; McCollum & Bryant, 2003).

As the pacing of television has increased substantially over recent years, this may help explain why there are significant findings in more recent research in the last couple of decades compared to earlier studies (Lamont, Rose & Reyland, In Press). Therefore, 'Sesame Street' may be describer in general as slower in nature compared to more popular shows that are aired on children's television channels, for example some of the most popular shows on popular channels such as 'Nikelodeon TV', which airs programmes such as 'Spongebob Squarepants', used in Lillard et al (2011) study, which consists of very rapid pacing, with several scene and audio changes which occur very frequently. However, it can be argued that this explanation cannot account for the non significant effects found within this study as Lillard et al (2011), which did find a significant effect of pacing on EF, reported that the there was on average a scene change every 11 seconds in the fast paced clip shown and therefore if this clip was used in this study it would have consisted of 54 scene changes within 10 minutes. This is similar to the amount of scene changes observed in the fast paced 'Postman Pat' clip used in this study, which consisted of 50 scene changes within a10 minute duration. Therefore the argument that the variability in scene changes of the 'fast paced' clips used within this study and Lillard's may explain the difference in findings, in this instance may be dismissed.

Another possible explanation for these non significant findings perhaps is that it may not be the pacing of television which is detrimental to children's EF but perhaps it is

the content. Although fast pace is a common feature of fantasy programmes (Goodrich, Pempek & Calvert, 2009), research has suggested that it may in fact be the 'fantastical' content of television show specifically which can have a negative impact on children's cognition rather than pacing. This could account for not only both this study and Anderson's et al (1977) non significant findings, but also could explain Lillard et al (2011) and Geist et al (2000) significant findings.

It can be highlighted that the television shows used within studies which found no significant immediate negative impact of fast paced television on children's EF, consisted of shows which were not 'fantastical' in nature and consisted of generally realistic and simple plots. However, both television shows used within the studies which did find a significant immediate negative effect on children's cognition used a fast paced show which had a 'fantastical' nature. Lillard et al (2011) study consisted of a fast paced popular fantastical cartoon about 'an animated sponge who lived under the sea' where events featured in this are likely to consist of physically impossible or unrealistic/unexpected events. It is likely that the lack of circuitry in fantastical show plots also is cognitively taxing for children to encode and depletes EF resources (Lillard et al, 2011). Furthermore the fast paced television show used in Geist et al (2000) study consisted of the 'Mighty Morphin Power Rangers', typically characterised by over exaggerated action scenes, and includes characters such as aliens, and thus again consists of unrealistic events and could be considered more cognitively effortful to process. Therefore it may be possible that it is the nature of the television show which could impact children's EF and not the pace of television.

One suggestion which has been put forward to help explain why fantastical shows may be more cognitively taxing for children to encode, is that when events violate the laws of physics, even children at a very early age can recognise that these laws have been breached and can understand that such events are 'unexpected' or 'impossible' and requires more cognitive resources to process such information (Lillard et al, 2015; Baillargeon, 1993; Baillargeon, 2002; Spelke, 1994, Shtulman & Carey, 2007). Fast pace shows are accompanied by perceptually salient features which are difficult for young children to understand and therefore process (Goodrich, et al 2009). Lillard et al (2015) also highlights the importance of Piagetian theory in explaining how children encode and process information from their environment. Piagetian theory suggests that children learn through the processes of accommodation and assimilation, and therefore when children encode unusual events and they have no previous representation this can relate to, this event cannot be assimilated to existing cognitive structures, and therefore children use the process of accommodation to encode the event, which requires more cognitive resources than assimilation.

There are a number of strengths of this study, which included building upon the key study this research is based upon (Lillard et al (2011)). This study controlled for individual differences as it used a within groups designs rather than between groups design used in previous studies. This study also based the sample size of participants on the number that was used in condition groups in Lillard et al (2011) and had a good ratio of male to female participants. Furthermore this study highlighted that there is disagreement over the structure of EF in childhood and therefore did not only measure aspects individually but also measured EF as a unitary factor in order to investigate and account for television pacing's impact on

pre-schoolers EF from both theories providing an opinion on EF structure in childhood.

The television clips used in this study, although they differed in pace, they were of the same children's television programme which is key positive aspect of this study. As the two clips shown consisted of the same programme, 'Postman Pat', both clips were therefore aimed at the same age bracket and same audience, which was relevant to the age of the participants which took part in this study. It is also important to highlight that the content of both episodes were similar in terms of the broad story line (Postman delivering parcels) with similar plot devices in both the fast and slow paced clip.

By using the same programme within this study this helped control for extraneous variables such as the child's particular interest in one television show over another television show, or other variables such as the differing genre/nature of the programmes which could arguable account for significant results in previous studies, for example Lillard et al (2011) study. In Lillard et al (2011) study, due to the design used and the varying aspects of the two television clips featured, despite finding a significant result, they could not conclude specifically what feature of the fast paced television clip shown caused the immediate negative effect on children's EF, as the clips presented to children did not only vary in pace, they also varied in genre, where the fast television clip was of a fantastical nature and the slower paced clip was not which may possibly account for results. Therefore this study built upon key aspects of the original study in order to control for extraneous variables to increase the reliability of results.

It can be highlighted that although children conducted the same 3 EF tasks in both visits, a strength of the design used in this study is that it helped to control for practice effects, whereby participants were placed in two groups, one group viewed the slow pace clip first while the other group viewed the fast paced clip first before conducting the tasks, and then in the second visit watched the opposite clip before again conducting the tasks. This helped control for the possibility that results could be influenced by the child's familiarity with the tasks.

It is also important to recognise that the tasks used within this study were chosen because not only were they developmentally appropriate for the participants within this study, they have also been identified in past research as being a successful sensitive measure of children's EF in pre-school children (Carlson, 2005). This study also specifically focused on 4 year olds as research has suggested that there is larger individual differences in children's performance on EF tasks before the age of 4, and more over, by this age children can perform relatively well on tasks of all 3 aspects of EF (Carlson et al, 2001; Carlson, 2005; Diamond et al, 1996; Garon et al, 2008).

A way in which this study could be improved upon in future research may be to conduct more than one test to measure each aspect of EF. If a number of different tasks were used in order to measure each aspect, results may be classed as more reliable and a more true reflection of executive functioning rather than basing assumptions of executive functioning on the performance of only one task. By conducted several EF tasks to measure aspects of EF, it can help to control for other

factors which may affect performance on tasks, and therefore help overcome what is often referred to as the 'task impurity problem' (Miyake et al, 2000) in order to obtain a better reflection on EF abilities. The 'task impurity problem' refers to variation in performance on tasks which can be attributed to other factors which are relevant and necessary in order to perform a task, but is not what the task sets out to directly measure. For example, performance on an EF task may not be solely attributed to EF proficiency, it may be associated with non executive abilities such as language, motor skills, and visual spatial skills which are required to understand and complete the task.

It is important for future research to investigate further the possible immediate effects that television may have upon children's executive functioning. Future research would benefit from having a large sample size of 4 year old children with a strong ratio of male to female, as it can be highlighted that although this study based its sample size on that of Lillard et al (2011) study, and no significant effect size was found within this study, the significance value for the difference in overall EF performance and performance on children on response inhibition tasks was closest to $p<.05$. Although the significance value was not less than $p>0.05$ it would be interesting to investigate whether a larger sample size would find a significant effect size as this study only compared performance of 21 children. Furthermore future research should conduct multiple developmentally appropriate EF tests in order to obtain a more reliable measure of EF performance. It would also be useful to include children from both main stream and non profit childcare organisations as well as children from private nurseries in order to increase the generalizability of results of the study to the wider population.

It is important to highlight that several aspects of television require investigation including the pace but also the nature/content of the show, in particular 'fantastical' shows. It can also be noted that the length of the television clip shown in this study was 10 minutes long, however it is common for popular children's television channels to air shows in 15 – 30 minute slots, and therefore it would be worth investigating whether or not watching fast pace television shows for this length of time would have any effect. If any immediate negative effects of television on children's EF are found in future research, it would be of value to investigate how long these 'negative effects' can last, considering the amount of exposure and time children spend participating in watching television. Parents, as well as childcare facilities, and those in authority who work with children should be more aware of the possible consequences on children's EF.

Therefore to conclude, this study made a positive contribution to our understanding of the impact of television on children's cognition, that pacing of television did not have any immediate negative impact upon children's EF. These findings are of great importance due to the role media plays in our society today. This study had a strong design and built upon the key study of which this study is based on (Lillard et al, 2011), as this study used a within groups design, the same programme in both the fast and slow paced condition, and developmentally appropriate EF tasks, which helped to control for extraneous variables which could affect children's performance. Furthermore this study measured EF as a composite measure as well as investigating the effects of television pacing on each aspect of EF individually which was not investigated in the key study. It is important to highlight that this is an under

researched area and should be further investigated as it valuable to be aware of any influences within a child's environmental which may be detrimental to their EF considering its importance and role it plays in children's everyday life, learning and development. Future research should focus on whether there are immediate negative effects of television on pre-schoolers EF taking into consideration not only the pace of television, but also the content and nature of television, in order to discover what aspects of television is implicated in the effects upon children's cognition.

References

Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. Child neuropsychology, 8(2), 71-82.

Anderson, D. R., & Collins, P. A. (1988). The Impact on Children's Education: Television's Influence on Cognitive Development. Working Paper No. 2.

Anderson, D. R., Levin, S. R., & Lorch, E. P. (1977). The effects of TV program pacing on the behavior of preschool children. Educational Technology Research and Development, 25(2), 159-166.

Bailey, C. E. (2007). Cognitive accuracy and intelligent executive function in the brain and in business. Annals of the New York Academy of Sciences, 1118(1), 122-141.

Baillargeon, R. (1993). The object concept revisited: New directions in the investigation of infants' physical knowledge. Visual perception and cognition in infancy, 23, 265-315.

Baillargeon, R. (2002). The acquisition of physical knowledge in infancy: A summary in eight lessons. Blackwell handbook of childhood cognitive development, 1, 46-83.

Baler, R. D., & Volkow, N. D. (2006). Drug addiction: the neurobiology of disrupted self-control. Trends in molecular medicine, 12(12), 559-566.

Barch, D. M. (2005). The cognitive neuroscience of schizophrenia. Annu. Rev. Clin. Psychol., 1, 321-353.

Barr, R., Lauricella, 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.

Barr, R., Danziger, C., Hilliard, M. E., Andolina, C., & Ruskis, J. (2010). Amount, content and context of infant media exposure: a parental questionnaire and diary analysis. International Journal of Early Years Education, 18(2), 107-122.

Bernier, A., Carlson, S. M., Deschênes, M., & Matte‐Gagné, C. (2012). Social factors in the development of early executive functioning: a closer look at the caregiving environment. Developmental science, 15(1), 12-24.

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. Child development, 78(2), 647-663.

BPS (2011) Does fast paced tv affect childen? Retrieved on March 30, 2015, from http://www.bps.org.uk/news/does-fast-paced-tv-affect-children

Borella, E., Carretti, B., & Pelegrina, S. (2010). The specific role of inhibition in reading comprehension in good and poor comprehenders. Journal of Learning Disabilities, 43(6), 541-552.

Brown, T. E., & Landgraf, J. M. (2010). Improvements in Executive Function Correlate with Enhanced Performance and Functioning and Health-Related Quality of Life. Postgraduate medicine, 122(5).

Carlson, S. M. (2005). Developmentally sensitive measures of executive function in preschool children. Developmental neuropsychology, 28(2), 595-616.

Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. Child development, 72(4), 1032-1053.

Carlson, S. M., Mandell, D. J., & Williams, L. (2004). Executive function and theory of mind: stability and prediction from ages 2 to 3. Developmental psychology, 40(6), 1105.

Cassidy, A. R. (2015). Executive function and psychosocial adjustment in healthy children and adolescents: A latent variable modelling investigation. Child Neuropsychology, (ahead-of-print), 1-26.

Christakis, D. A., Ramirez, J. S. B., & Ramirez, J. M. (2012). Overstimulation of newborn mice leads to behavioral differences and deficits in cognitive performance. Scientific reports, 2.

Christakis, D. A., Ebel, B. E., Rivara, F. P., & Zimmerman, F. J. (2004). Television, video, and computer game usage in children under 11 years of age. The Journal of pediatrics, 145(5), 652-656.

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.

Conners-Burrow, N. A., McKelvey, L. M., & Fussell, J. J. (2011). Social outcomes associated with media viewing habits of low-income preschool children. Early Education and Development, 22(2), 256-273.

Crescioni, A. W., Ehrlinger, J., Alquist, J. L., Conlon, K. E., Baumeister, R. F., Schatschneider, C., & Dutton, G. R. (2011). High trait self-control predicts positive health behaviors and success in weight loss. Journal of health psychology, 16(5), 750-759.

Davis, H. L., & Pratt, C. (1995). The development of children's theory of mind: The working memory explanation. Australian Journal of Psychology, 47(1), 25-31.

Davis, J. C., Marra, C. A., Najafzadeh, M., & Liu-Ambrose, T. (2010). The independent contribution of executive functions to health related quality of life in older women. BMC geriatrics, 10(1), 16.

Denson, T. F., Pedersen, W. C., Friese, M., Hahm, A., & Roberts, L. (2011). Understanding impulsive aggression: Angry rumination and reduced self-control

capacity are mechanisms underlying the provocation-aggression relationship. Personality and Social Psychology Bulletin, 37(6), 850-862.

Diamond, A. (2005). Attention-deficit disorder (attention-deficit/hyperactivity disorder without hyperactivity): A neurobiologically and behaviorally distinct disorder from attention-deficit/hyperactivity disorder (with hyperactivity). Development and psychopathology, 17(03), 807-825.

Diamond, A. (2013). Executive functions. Annual review of psychology, 64, 135.

Diamond, A., & Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to “Do as I say, not as I do”. Developmental psychobiology, (29), 315-334.

Diamond, A., Kirkham, N., & Amso, D. (2002). Conditions under which young children can hold two rules in mind and inhibit a prepotent response. Developmental psychology, 38(3), 352.

Diamond, B. J., DeLuca, J., & Kelley, S. M. (1997). Memory and executive functions in amnesic and non-amnesic patients with aneurysms of the anterior communicating artery. Brain, 120(6), 1015-1025.

Eakin, L., Minde, K., Hechtman, L., Ochs, E., Krane, E., Bouffard, R., ... & Looper, K. (2004). The marital and family functioning of adults with ADHD and their spouses. Journal of Attention Disorders, 8(1), 1-10.

Fairchild, G., van Goozen, S. H., Stollery, S. J., Aitken, M. R., Savage, J., Moore, S. C., & Goodyer, I. M. (2009). Decision making and executive function in male adolescents with early-onset or adolescence-onset conduct disorder and control subjects. Biological psychiatry, 66(2), 162-168.

Frye, D., Zelazo, P. D., & Palfai, T. (1995). Theory of mind and rule-based reasoning. Cognitive Development, 10(4), 483-527.

Fuster, J. M. (2001). The prefrontal cortex—an update: time is of the essence. Neuron, 30(2), 319-333.

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: a review using an integrative framework. Psychological bulletin, 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), 250-261.

Goodrich, S. A., Pempek, T. A., & Calvert, S. L. (2009). Formal production features of infant and toddler DVDs. Archives of Pediatrics & adolescent medicine, 163(12), 1151-1156.

Huston, A. C., Wright, J. C., Wartella, E., Rice, M. L., Watkins, B. A., Campbell, T., & Potts, R. (1981). Communicating more than content: Formal features of children's television programs. Journal of Communication, 31(3), 32-48.

Lehto, J. E., Juujärvi, P., Kooistra, L., & Pulkkinen, L. (2003). Dimensions of executive functioning: Evidence from children. British Journal of Developmental Psychology, 21(1), 59-80.

Lillard, A. S., & Peterson, J. (2011). The immediate impact of different types of television on young children's executive function. Pediatrics, 128(4), 644-649.

Lillard, A. S., Li, H., & Boguszewski, K. (2015). Television and Children's Executive Function. Advances in Child Development and Behavior, 48, 219-248

McCollum Jr, J. F., & Bryant, J. (2003). Pacing in children's television programming. Mass Communication & Society, 6(2), 115-136.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. Annual review of neuroscience, 24(1), 167-202.

Miller, M. R., Giesbrecht, G. F., Müller, U., McInerney, R. J., & Kerns, K. A. (2012). A latent variable approach to determining the structure of executive function in preschool children. Journal of Cognition and Development, 13(3), 395-423.

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. Cognitive psychology, 41(1), 49-100.

Nathanson, A. I., & Fries, P. T. (2014). Television Exposure, Sleep Time, and Neuropsychological Function Among Preschoolers. Media Psychology, 17(3), 237-261.

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.

Pagani, L. S., Fitzpatrick, C., & Barnett, T. A. (2013). Early childhood television viewing and kindergarten entry readiness. Pediatric research, 74(3), 350-355.

Pagani, L. S., Fitzpatrick, C., Barnett, T. A., & Dubow, E. (2010). Prospective associations between early childhood television exposure and academic, psychosocial, and physical well-being by middle childhood. Archives of pediatrics & adolescent medicine, 164(5), 425-431.

Ramirez, J. S. B., Christakis, D. A., Hodge, R. D., Hevner, R. F., Smith, A. F., Ramirez, T. K. M., ... & Ramirez, J. M. (2013). Decreased neurogenesis in the Dentate Gyrus following sensory non-normative overstimulation. The FASEB Journal, 27(1_MeetingAbstracts), 1124-6.

Reilly, J. J., Jackson, D. M., Montgomery, C., Kelly, L. A., Slater, C., Grant, S., & Paton, J. Y. (2004). Total energy expenditure and physical activity in young Scottish children: mixed longitudinal study. The Lancet, 363(9404), 211-212.

Shtulman, A., & Carey, S. (2007). Improbable or impossible? How children reason about the possibility of extraordinary events. Child Development, 78(3), 1015-1032.

Spelke, E. (1994). Initial knowledge: Six suggestions. Cognition, 50(1), 431-445.

St Clair-Thompson, H. L., & Gathercole, S. E. (2006). Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. The quarterly journal of experimental psychology, 59(4), 745-759.
Strommen, E. A. (1973). Verbal Self-Regulation in a Children's Game: Impulsive Errors on" Simon Says". Child Development, 849-853.

Swingler, M. M., Willoughby, M. T., & Calkins, S. D. (2011). EEG power and coherence during preschoolers' performance of an executive function battery. Developmental psychobiology, 53(8), 771-784.

Tandon, P. S., Zhou, C., Lozano, P., & Christakis, D. A. (2011). Preschoolers' total daily screen time at home and by type of child care. The Journal of pediatrics, 158(2), 297-300.

Vale, S., Silva, P., Santos, R., Soares-Miranda, L., & Mota, J. (2010). Compliance with physical activity guidelines in preschool children. Journal of sports sciences, 28(6), 603-608.

Vandewater, E. A., Rideout, V. J., Wartella, E. A., Huang, X., Lee, J. H., & Shim, M. S. (2007). Digital childhood: electronic media and technology use among infants, toddlers, and preschoolers. Pediatrics, 119(5), e1006-e1015.
Welsh, M. C., & Pennington, B. F. (1988). Assessing frontal lobe functioning in children: Views from developmental psychology. Developmental neuropsychology, 4(3), 199-230.

Welsh, M. C., Pennington, B. F., & Groisser, D. B. (1991). A normative‐developmental study of executive function: A window on prefrontal function in children. Developmental Neuropsychology, 7(2), 131-149.

Wiebe, S. A., Espy, K. A., & Charak, D. (2008). Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. Developmental Psychology, 44(2), 575.

Wiebe, S. A., Sheffield, T., Nelson, J. M., Clark, C. A., Chevalier, N., & Espy, K. A. (2011). The structure of executive function in 3-year-olds. Journal of experimental child psychology, 108(3), 436-452.

Wright, J. C., & Huston, A. C. (1983). A matter of form: Potentials of television for young viewers. American Psychologist, 38(7), 835.

Zelazo, P. D., & Carlson, S. M. (2012). Hot and cool executive function in childhood and adolescence: Development and plasticity. Child Development Perspectives, 6(4), 354-360.

Zelazo, P. D., Carter, A., Reznick, J. S., & Frye, D. (1997). Early development of executive function: A problem-solving framework. Review of general psychology, 1(2), 198.

Zimmerman, F. J., & Christakis, D. A. (2007). Associations between content types of early media exposure and subsequent attentional problems. Pediatrics, 120(5), 986-992.