AN INVESTIGATION OF THE EFFECTS OF BACKGROUND TELEVISION ON ATTENTION, PERFORMANCE, LEARNING AND EXECUTIVE FUNCTIONING IN PRESCHOOLERS

by

© Lynn M. Frizzell

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Abstract

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Given the omnipresence of television in children's lives, it is important to know what effect it may have on attention, executive functioning (EF) and learning. This study investigated effects of background television (BTV) on attention to, and memory for, storybook details, a puzzle strategy, and performance on an EF task in 108 preschoolers during an adult-child interaction. Parents reported children's BTV exposure and screen media use and rated their everyday EF. Results showed BTV reduced attention to all tasks but only on more challenging tasks was performance also affected. BTV interfered with encoding such that delayed but not immediate story recall was diminished. On the easier puzzle task, scores were equal across BTV conditions. On the EF task, children were slower, more variable, less accurate and less able to detect errors with BTV present. Very few children learned any BTV programming content, and nothing without performance cost. These results align with a limited capacity theory of attention and EF, and suggest that children can maintain performance when task demands and distractor salience combined do not overtax cognitive resources. Children with higher EF managed BTV better, though they too scored lower in its presence, suggesting EF becomes depleted when taxed. Parent reports revealed clusters of factors that correlated with EF. Specifically, in homes where BTV was more frequently on, children also watched more TV, used more devices and more often had a bedroom TV. These children were also judged by their parents as less distracted by BTV, even though they had lower EF according to task scores and parents' own ratings on a standardized measure. BTV practices may reflect parenting styles. Parents who limit BTV may provide more of the kind of structure, such as rules and routines, that scaffolds EF development and the transition from other- to self-regulated. BTV interfered with stable, sustained, focused and shared attention on the kinds of tasks that require the most attention and effort and thus are most likely to drive cognitive development. Shared viewing of high quality children's programming can be a part of the optimal caregiving environment, but BTV should not be.

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Chapter 1: Introduction

Maintaining attention in the presence of distraction is essential to learning and problem solving (Garon, Bryson, & Smith, 2008; Kannass, Colombo, & Wyss, 2010). Today, however, young children are growing up, playing and learning surrounded by many potential sources of distraction. One such source is television (TV). Despite the proliferation of computers, video games, tablets and smart phones, TV continues to "reign supreme" (Rideout, 2013, p. 17), especially among preschoolers (Rideout, 2017; Wartella, Rideout, Lauricella, & Connell, 2014). In fact, these many alternate platforms provide children with new ways to watch. In this media-saturated environment, the demands on children's attention can be intense and the potential impact on their executive functioning and learning is unknown.

Exposure to TV

In many homes, young children are exposed to TV, or similar video screen media, for six hours every day (Lapierre, Piotrowski, & Linebarger, 2012;Vandewater et al., 2005; 2007). In a third to a half, or more, of homes with young children, a TV is on "most" or "all of the time," regardless whether anyone is watching (Masur, Flynn, & Olsen, 2015; Rideout, 2017). On average, preschoolers spend about 2.5 hours per day directly engaged with screen media (Fitzpatrick, Pagani, & Barnett, 2012; Vandewater et al., 2005). Children with bedroom TVs tend to watch more, and more than a third of preschoolers have one (Rideout, 2013). About 22% of parents report using TV to get their preschoolers to sleep (Vandewater et al., 2007) and TV is a part of many families' mealtimes (Fiese & Schwartz, 2008). Watching TV is very much a "default" primary activity (Vandewater et al., 2005). It is also such a common secondary activity that is has become the backdrop to children's play and social interactions, potentially providing a constant source of distraction from the learning opportunities these activities provide (Masur & Flynn, 2008; Masur et al., 2015). In fact, TV is often included as an indicator in studies on the effects of household chaos on developmental outcomes (Martin, Razza, & Brooks-Gunn, 2012; Vernon-Feagans, Garrett-Peters, & Willoughby, 2016). Yet, few parents express concern or enact rules to govern TV watching (i.e. foreground TV) or background TV exposure, believing TV to be mostly beneficial (Bentley, Turner, & Jago, 2016; Bleakley, Jordan, & Hennesy, 2013; De Decker et al., 2012; Vaala, 2014). However, evidence also shows that parents who believe TV to be harmful do restrict children's access (Rideout, 2013). Research in the field makes a distinction between foreground and background TV, which may be blurred when TV is always on, but, most simply, background TV (BTV) refers to programming that is not the current primary focus of the child's attention, either because the child is doing something else or the content is not intended for, or comprehensible to, the child (e.g., adult programming). BTV becomes foreground when it gets and holds the child's attention, potentially displacing the original activity (Courage & Setliff, 2010).

Learning from TV

Parents cite various reasons for allowing TV in their homes and a main one is their belief in the educational and enriching value of the programming (De Decker et al., 2013; Rideout, 2014; Vaala, Bleakley, & Jordan, 2013). Many believe that exposure to children's programming, whether as foreground or background, stimulates the development of attention, the ability to focus, creativity, and helps children to learn and to acquire social and emotional skills (Valla, 2014). However, evidence to date suggests the effects of TV watching and BTV exposure on attention, attention control, and learning are more mixed and complex than straightforward (Kostyrka-Allchorne, Cooper, & Simpson, 2017). Certainly, parents are right about the educational potential of TV and video. Well-designed educational programming like *Sesame Street*, *Dora the Explorer* and *Blue's Clues* has been associated with positive short- and long-term outcomes like word learning and pro-social behaviour among preschoolers (Mares & Pan 2013; Richert, Robb, & Smith, 2011; Schmidt & Anderson, 2007), and improved executive functioning (Linebarger, 2015), though, even for some of these exemplary programs results are mixed (Nathanson, Aladé, Sharp, Rasmussen, & Christy, 2014). A wealth of evidence-based development work goes into the production of effective programs like *Sesame Street* (Baydar, Kağitçibaşi, Küntay, & Gökşen, 2008; Kearney & Levine, 2015; Mares & Pan, 2013). Unfortunately, most programming is not developed this way, or for this purpose, and the educational claims of some programs have not been supported and sometimes contradicted (Robb, Richert, & Wartella, 2009; Richert, Robb, Fender, & Wartella, 2010). For example, Richert et al. (2011) showed that children under 2 years of age failed to learn words from video programming expressly designed to teach vocabulary. Often the goal is simply entertainment and profit. Furthermore, much of what children are exposed to when the “TV is always on” may not be appropriate (Vandewater et al., 2005). Potential educational benefit is greatest when parents watch with their children and scaffold the content (Kirkorian, Wartella, & Anderson, 2008; Strouse, O’Doherty, Troseth, 2013), but such co-viewing is not the norm (Saxbe, Graesch & Alvik, 2011; Wartella et al., 2014), and, certainly, this potential benefit is likely lost when programming is in the background while the child is otherwise engaged. Children learn better in the context of play and social interaction than they do from TV, displaying a so-called “video deficit” (Anderson & Hanson, 2010; Anderson & Pempek, 2005; Barr, 2010; Courage & Howe, 2010; Courage & Setliff, 2010).

Attention, Learning and TV Exposure

The fact that TV programming can get and hold children’s attention makes it an effective tool for education and a potentially powerful distractor from other learning opportunities (Courage & Setliff, 2010). Many studies show that although children will maintain activities in the presence of TV (Lorch, Anderson, & Levin, 1979; Schmitt, Woolf, & Anderson, 2003) it can also displace and diminish the quality of children’s engagement in play (Courage, Murphy, Goulding, & Setliff, 2010; Schmidt, Pempek, Kirkorian, Lund, & Anderson, 2008; Vandewater, Bickham, & Lee, 2006) and interactions with parents and siblings (Courage et al., 2010; Kirkorian, Pempek, Murphy, Schmidt, & Anderson 2009; Pempek, Kirkorian, & Anderson, 2014; Vandewater et al., 2006). It has also been shown that preschoolers exposed to incomprehensible (Kannass & Colombo, 2007) and comprehensible (Kannass et al., 2010) BTV exhibited poorer attention and performance on play-based tasks than those not exposed. These findings are of great concern because it is in the context of play and social interaction where young children learn.

Attention, Executive Function and TV Exposure

Play and social interactions are also vital to the development and practice of the voluntary control of attention, which is integral to all aspects of executive functioning (Bodrova, Leong, & Akhutina, 2011; Diamond, 2011; Garon et al., 2008; Smith & Pellegrini, 2008). Executive functions (EF) are adaptive, goal-directed behaviours that allow children to use attention to override habits, and resist temptations and distractions and to use information held in mind to adjust behaviour to changing task demands (Diamond, Barnett, Thomas, & Munro, 2007; Garon et al., 2008; Zelazo, 2015). Executive attention is a voluntary, top-down, component of attention that develops significantly through the preschool years (Colombo, 2001; Courage, Reynolds, & Richards, 2006; Ruff & Rothbart, 2001). Maturation of executive attention enables the volitional dispatch of limited attentional resources to a selected task and the ability to ignore distraction, which are crucial to EF performance (Garon et al., 2008; Gopher, Armony, & Greenspan, 2000). Exposure to TV and processing its content while engaging in other activities adds to cognitive load and taxes attention and EF resources and thus may interfere with the opportunity to practice EF skills that the activities may provide. Thus, again, the concern is raised that TV exposure, by interfering with practice, play and adult-child interactions, may impede the development of critical attention and EF skills

(Diamond et al., 2007) associated with better cognitive, academic, social, emotional, mental and physical health outcomes (Moffitt et al., 2011).

Abundant evidence indicates concern is warranted. Many reports correlate higher TV exposure with poorer cognitive skills, including attention (Christakis, Zimmerman, DiGiuseppe, & McCarty, 2004; Martin et al., 2012), executive functioning (Barr, Lauricella, Zack, & Calvert, 2010; Lillard & Peterson, 2011;Nathanson et al., 2014; Linebarger, Barr, Lapierre, & Piotrowski, 2014), theory of mind (i.e., understanding that other’s thoughts may differ from one’s own) performance (Nathanson, Sharp, Aladé, Rasmussen, & Christy, 2013), vocabulary and language (Bittman, Rutherford, Brown, & Unsworth, 2011; Zimmerman, Christakis, & Meltzoff, 2007; Christakis et al., 2009; Tomopolous et al., 2010), school readiness (Fitzpatrick, Barnett, & Pagani, 2012; Pagani, Fitzpatrick & Barnett, 2013; Wright et al., 2001), and academic achievement (Anderson et al., 2001; Hancox, Milne, & Poulton, 2005; Wright et al., 2001). In addition, TV exposure has been associated with problems with aggression (Bushman & Huesmann, 2006; Manganello & Taylor, 2009), obesity (Hawkins & Law, 2006) and sleep (Cespedes et al., 2014; Thompson & Christakis, 2005). Of course, as extensively reviewed by Kostryka-Allchorne et al., (2017) there are many studies that do not find such associations (e.g., Foster & Watkins, 2010) and many that report TV effects that vary, not just with the amount of exposure, but with program content (child- or adult-directed; entertainment or educational; violent or not) (Zimmerman & Christakis, 2007) viewing context (i.e., parent co-viewing), family socioeconomic status (SES) (Zimmerman & Christakis, 2005), parenting style (Linebarger et al., 2014), and child-specific characteristics such as age first exposed to TV (Nathanson et al., 2014), gender (Anderson et al., 2001), and temperament (Thompson, Adair, & Bentley, 2013). Further research is needed to help clarify the factors, their interactions, and the mechanisms underlying the relationship between TV exposure and children's development.

The Current Study

The primary goal of this study was to further explore the potential effects of BTV exposure on children's attention, learning and EF. It is important to know whether and to what extent BTV interferes with young children's depth of attention, information processing and learning during play and social interactions. If BTV interferes significantly with attention and EF in the short term, then the cumulative effect of chronic exposure, as would be the case in homes where the TV is always on, could be substantial. An environment that creates a constant demand for "multitasking" has the potential to modify brain circuitry such that attentional switching may be enhanced but sustained and focused attention are weakened (Courage, Bakhtiar, Fitzpatrick, Kenny, & Brandeau, 2015; Rothbart & Posner, 2015). Insofar as basic attention skills are foundational to EF, problems with attention development would in turn undermine EF development. Alternatively, it is also valuable to know whether today's children, given their extensive experience with TV, and other screen media, have developed strategies to reduce the cognitive load or to effectively filter out distraction or to efficiently divide their attention and multitask without significant performance cost (Armstrong & Greenberg, 1990). Certainly, given the "new electronic world" the acquisition of effective multitasking skills could be highly adaptive (Courage et al., 2015; Courage & Howe, 2010). These questions are investigated in the present study. What follows is a review of the literature on the current understanding of the organization, measurement and development of attention, attention control, executive functioning, and the central importance of these processes to learning and development in the media rich context of children's lives.

Chapter 2: Literature Review

The review will examine the organization and development of attention and its role in executive functioning and learning as well as the activities that support the development of attention, EF and learning – namely, social interaction and play. An overview of current findings on the effects of BTV on attention, EF, learning and learning contexts, will be presented.

Attention

The ability to maintain attention on a selected task in the presence of competing stimuli is crucial to learning and problem solving (Garon et al., 2008; Kannass et al., 2010). Yet, some level of distractibility is also adaptive, as we must remain responsive to our surroundings (Ruff & Rothbart, 2001). Children must develop the ability to maintain and control attention and persist in tasks that may not be of their choosing or intrinsically interesting and to be flexible enough to redirect attention as priorities demand (Ruff & Rothbart, 2001). The fundamentals of these attentional skills develop significantly, and with a great deal of individual variability, along with the underlying neural architecture, over the first five years of a child's life.

What most, if not all, models of attention have in common is the premise that attention resources are limited and that to *pay attention* essentially means to choose or select task-relevant stimuli from among competing inputs and to resist task-irrelevant information (Cowan et al., 2005; Ruff & Rothbart, 2001). Thus, as defined by Kahneman (1973), *distraction* is the processing of task-irrelevant information, which restricts available processing capacity, potentially impairing task performance. Once a target has been selected, attention must then be effortfully sustained for further processing to take place. As Courage et al. (2015) describe it, attention is a finite resource that fuels virtually all cognitive activity. Essentially, the construct of selective attention is based on the fact that the perceptual world presents too much information for a limited capacity system to process (Broadbent, 1958; Huang-Pollack, Carr, & Nigg, 2002). Differences between individuals over the course of development are evident in the effort required and in the speed and efficiency with which limited attentional resources are allocated to the selection and sustained processing of task-relevant stimuli and these differences depend on genes and experience (Posner & Rothbart, 2009; Rothbart & Posner, 2015).

While we attend to and process information from environmental stimuli that we feel, hear and see, the most studied and readily observable form of attention in infants and young children is visual attention, as indicated by where and for how long they look (Aslin, 2007). The construct of visual attention is not unitary but encompasses several isolable but interacting processes. There are many conceptualizations of the construct of attention but most models are quite similar, differing mainly in how component processes are divided and named (Raz & Buhle, 2006). The attention networks model of Rothbart and Posner (2015; Posner & Rothbart, 2007) served as an organizing framework for the current study.

The Attention Networks Model

Rothbart and Posner's widely accepted model (Cuevas & Bell, 2014; Hrabok, Kerns, & Muller, 2007; Mackie, Van Dam, & Fan, 2013; Raz & Buhl, 2006; Zelazo et al., 2013), which evolved from the seminal work of Posner and Peterson (1990; Peterson & Posner, 2012) and Ruff and Rothbart (2001), characterizes the construct of visual attention as composed of three networks – *alerting, orienting* and *executive*. The term "networks" reflects how each attentional process can be distinguished behaviourally and is subserved by anatomically distinct neural networks and neurotransmitter systems (Posner & Peterson, 1990). Furthermore, each is associated with different genes (Posner & Rothbart, 2009) and developmental trajectories (Ruff & Rothbart, 2001; Ruff & Capozzoli, 2003). While the networks have been described as independent (Fan, McCandliss, Sommer, Raz, & Posner, 2002) the more accurate descriptor is isolable (MacLeod et al., 2010) as there is cross communication among networks, enabled by bidirectional connections (Colombo, 2001). This neural connectivity is refined throughout development, increasing the functional integration and efficiency of the visual attention system. Rothbart and Posner (2015) also assert that while the visual attention system is anatomically separate from other sensory modalities, attention in all modalities involves the same brain areas.

Alerting network. The alerting network is responsible for the state of arousal and for attaining and maintaining a state of readiness for stimulus input and processing. It involves parietal cortex, right frontal lobe and the norepinephrine pathways originating in the midbrain locus coeruleus (Posner & Rothbart, 2007). Its main function is to support and enhance cognitive processes (Hrabok et al., 2007). In a variation on the Eriksen Flanker Task (Eriksen & Eriksen, 1973), namely, the Attention Networks Task (ANT), subjects are presented an array of five arrows (or fish in the child version) on a screen and are required to press a left or right key to indicate the direction of the central arrow which faces the same direction as the flanking arrows on congruent trials and the opposite on incongruent trials. The efficiency of the alerting network is indicated by the difference in reaction times between temporally cued and no-cue trials. Fast and accurate responses require a state of readiness (i.e., phasic alertness) and the continuous performance demands of the task require sustained (i.e., tonic) alertness (Peterson & Posner, 2012; Posner & Peterson, 1990). Arousal level is important to recruiting and focusing attention and at optimum can maximize attention, information processing, learning and performance. This "bottom-up" enhancement of arousal, by the release of norepinephrine from locus coeruleus, is one mechanism by which alertness can be improved and task performance enhanced. This mechanism may explain occasions where performance is better on more demanding (i.e., arousing) tasks or in the presence of distraction (Ruff & Capozzoli, 2003).

Orienting network. The orienting network is responsible for the selection of a target for information processing, which involves attentional engagement, disengagement and switching processes. Orienting can be elicited exogenously by salient (or arousing) features of environmental stimuli or guided endogenously by voluntary effort (i.e., executive attention). It is the involuntary pull on orienting that underlies distractibility and the effort of voluntary orienting that explains resistance to distraction (Rothbart & Posner, 2015). The underlying anatomy includes the brainstem pulvinar and superior colliculus, the temporoparietal and superior parietal cortices, and the frontal eye fields. The orienting network is modulated by acetylcholine from basal forebrain (Peterson & Posner, 2012; Posner & Rothbart, 2009). In the laboratory, the orienting network can be tested with spatially cued target search tasks, like the ANT. The difference in accuracy and reaction time on spatially cued versus centrally cued trials yields a measure of efficiency.

Executive attention network. The executive attention network is "top-down", volitional, endogenously driven and can be observed in sustained effort, resistance to distraction and flexible switching of attention as tasks demand. The executive attention network is integral to the attentional control evident in executive processes like resolving conflict among response options, inhibition of task-inappropriate responses, error detection or self-monitoring, and the planning and pursuit of goal-directed behaviours (Hrabok et al., 2007; Mackie et al., 2013; McDermott, Perez-Edgar, & Fox, 2007). Subserving the executive attention network is the anterior cingulate gyrus and the prefrontal cortex. It is modulated by dopamine from the ventral tegmental area (Peterson & Posner, 2012; Posner & Rothbart, 2009). This frontal network regulates primary sensory areas in order to enhance task relevant information and to inhibit irrelevant, thus controlling what gets processed. The efficiency of the executive attention network can be tested by the speed and accuracy of performance on Stroop-like tasks that require the resolution of conflict and the inhibition of a prepotent response (e.g., saying "night" to a picture of a dark starry sky) in favour of task-defined correct response (i.e., say "day" when shown the night sky), or on the ANT by comparing performance on congruent (i.e., central target aligned with flankers) and incongruent (i.e., target opposes flankers) trials.

There are many such tasks used to measure executive attention network efficiency (Garon et al., 2008; Zelazo et al., 2013). These same tasks are used to measure the set of skills collectively called executive function (EF) because executive attention is central to these functions. Cuevas and Bell (2014) have shown that attentional efficiency at 5 months of age predicts EF skill at ages 2, 3 and 4 years, reflecting the continuity of the role of the attention system through the EF skill set and through a period of significant EF maturation. The development of volitional, sustained, selective attention supports EF performance. With an increasingly integrated attention system serving as the foundation, component EF processes emerge (Garon et al., 2008).

Executive Function

Executive function, or EF, refers to the set of top-down processes that manage attention in order to coordinate and regulate goal-directed behavior (Clark et al., 2016; Diamond, 2013; Zelazo, 2015). The term EF is used interchangeably with cognitive control (Diamond, 2013; Mackie et al., 2013; Zelazo & Carlson, 2012) and executive control (Diamond, 2013; Clark et al., 2016). Like executive attention, EF involves the anterior cingulate and prefrontal cortex and it regulates cognition, emotion and behaviour by modulating the activation and inhibition of other cortical and subcortical areas (Friedman & Miyake, 2017; Garon et al., 2008). There are several theoretical frameworks that describe the set of skills that make up EF. Most models agree that EF applies to the control of cognition, sometimes considered separately from emotional control (Diamond et al., 2007). Some make the distinction between emotionally neutral cognitive EF and emotionally or motivationally significant EF (i.e., involves reward); referring to these as cool and hot EF, respectively (Zelazo & Carlson, 2012). EF includes three main skills, specifically, working memory, inhibition and set shifting/mental flexibility (Diamond et al., 2007; Zelazo & Carlson, 2012). When mature, these skills are separable in that they can be measured by different EF tests, activate different neural pathways as shown in image analyses, and show distinguishable developmental trajectories. Yet, results of different EF tests, meant to isolate the various functions, usually correlate, and image analyses of brain activation patterns reveal significant anatomical overlap (Mackie et al., 2013). As separable components, the three core functions emerge gradually over the preschool years, though they remain correlated into adulthood (Zelazo et al., 2013). According to the integrative framework proposed by Garon et al. (2008), based on their comprehensive review and a model first proposed by Miyake et al. (2000), this shared variance reflects the fundamental role of executive attention in all EF skills (see also Baddley, 1986; Mackie et al., 2013; Posner & Rothbart, 2009; Zelazo, 2015). As Zelazo (2015) states, "EF skills are attentional skills or ways of using attention" (p. 56). It must be noted, however, that there is some debate about the source of shared variance. Some have proposed that inhibition or working memory may be the shared process, (while some equate inhibition [Diamond, 2013] or working memory [Engle, 2002] with executive attention, thus adding no clarity). Still others simply designate an EF component called "common EF" (Friedman & Miyake, 2017). Clearly, there is much still to learn about the structure and development of EF. To date, as with the attention networks model, the best-fit models of EF recognize three core functions that are isolable yet integrated, as is necessary to achieve coordinated control (Garon et al., 2008; Mackie et al., 2013; Miyake et al., 2000).

Current conceptualizations of EF also recognize its hierarchical structure (Garon, Smith, & Bryson, 2014; Hendry et al., 2016). EF is supported by the attention system and contributes to self-regulation (SR). SR includes cognitive control (i.e., EF), and emotional control (Bell & Deater-Deckard, 2007; Berger, Kofman, Livneh, & Henik, 2007), which together produce organized, goal-directed behaviour. More complex EF skills develop later, building on simpler ones. The core components of EF support higher-order cognitive functions like planning, reasoning and problem solving. Furthermore, just as executive attention (i.e., attentional control) is central to EF (i.e., cognitive control), it is also central to emotional control and thus to overall SR (Bell & Deater-Deckard, 2007; Berger et al., 2007). Because the attentional resources that subserve EF are limited, so too is EF, or cognitive control, capacity. Likewise limited are emotional control and, ultimately, self-regulatory capacity. EF is effortful, and demanding tasks can exhaust cognitive control capacity (Diamond, 2013; Kaplan & Berman, 2010; Muraven & Baumeister, 2000), a process that has been referred to as EF depletion (Kaplan & Berman, 2010; Lillard, Drell, Richey, Boguszewski, & Smith, 2015; Powell & Carey, 2017). The hierarchical nature of EF also applies within the set as working memory enables inhibition, inhibition facilitates working memory, and both are necessary for mental flexibility (Diamond, 2013; Garon et al., 2014). It is the interaction of all three processes that enable flexible behavior, but what do the component processes do?

Inhibition. Response inhibition, or simply inhibition, refers to the ability to deliberately inhibit or resist dominant, automatic or prepotent responses in favour of more task-relevant or situationally appropriate responses. Inhibition suppresses attention to distractors and thus helps to select and prioritize relevant information for processing. Thus, EF tasks and daily activities that create conflict, distraction or interference make demands on inhibition. Suppressing the urge to read the word "green" rather than reporting to the experimenter the blue colour it's printed in, or waiting to take your turn in a game, both require inhibition.

Working memory. The function of working memory (WM) is to maintain attention on, hold in mind, and actively manipulate current goals and task-relevant information, and to protect it from distraction and interference. Most EF laboratory tasks, and daily activities, make demands on WM because goals and task rules must be held in mind to guide ongoing behaviour. Repeating back a list of words in reverse order to an experimenter or remembering where you have already looked when playing hide and seek both depend on WM. Some make a distinction between simple "holding in mind" and complex WM where manipulation and updating of the information is required, distinguishing short-term memory from working memory (Garon et al., 2008).

Mental flexibility. Set shifting, or mental flexibility, is the ability to attend to or monitor what is currently relevant and irrelevant and to shift attention between task sets, stimulus features, problem solving strategies, or perspectives, in order to respond appropriately to changing task demands, rules or contexts (Perone, Almy, & Zelazo, 2017). For example, when an EF task requires cards or items to be sorted by color and then on the next trial by shape instead, this requires a recognition of a change in what is now task-relevant and, thus, a mental shift to maintain performance. Similarly, listing novel uses for a hammer requires flexible thinking, as does trying another way to solve a math problem.

In sum, the attention system operates as three basic processes – alerting, orienting and executive attention. Likewise, EF comprises the three cores skills of inhibition, working memory and set shifting which "correspond to various forms of goal-directed modulation of attention" (Zelazo, 2015, p. 58). EF depends on the attention system and both are shaped by experience.

The Development of Attention and EF

The development of attention supports executive functioning. Basic attention skills emerge – alerting then orienting then executive attention – and become more integrated and refined as neural connections develop. Attention development is characterized by more than quantitative increases in speed and efficiency. There is a qualitative transformation from attentional control that is primarily stimulus-driven, involuntary, automatic, relatively effortless or reactive, and which is driven by the orienting network, to attention that is, by contrast, self-driven, volitional, effortful, proactive and reflective, and controlled by the executive attention network (Fisher, Thiessen, Godwin, Kloos, & Dickerson, 2013; Kaplan & Berman, 2010; Rothbart & Posner, 2015). There is a gradual developmental shift from the dominance of exogenous control of attention in the first year to more endogenous control in late infancy and beyond. This shift signals the emergence of executive control of attention and of EF. The transformation is evident in the difference between the infant who focuses on that which gets its attention and for as long as nothing more salient comes along, and the child, ready for school, who is much more able to select what to attend to and to hold attention and to resist distractors in order to pursue a goal. These changes reflect the increasingly refined connectivity and integration within and among brain areas responsible for each attention network and executive function (Perone et al., 2018). The importance of this shift is highlighted by the suggestion that the "failure of the transition to occur can contribute to childhood pathologies (e.g., ADHD) that depend on the executive attention network" (Rothbart & Posner, 2015, p. 58).

Given the significant, though gradual, shift in how the attention system functions before and after the emergence of voluntary control, some researchers conceptualize attention development as a two-part process. Ruff and Rothbart (2001) describe it as a move between attention subsystems; from the *orienting-investigative system* to the *anterior attention system* or *system of higher controls*. In this model, the three attention networks are organized into two systems, dominant at different stages of development. The alerting and orienting functions are the earlier developing processes. They dominate infant attention early on, via the orienting-investigative system, but give way to the ascendancy of the executive control system (i.e., system of higher controls) throughout the toddler and preschool years as the underlying neural structures develop and the infant gains skills, knowledge and experience (Hrabok et al., 2007). Cohen (1972) also describes a two-part model of *attention getting* and *attention holding* processes. In this model attention getting is observed as a visual orienting response to stimuli and combines the processes of alerting and orienting (or selecting). Attention holding is observed as sustained, focused, attention that emerges with executive control and is necessary for information processing and mature goal-directed behaviour (Courage & Setliff, 2010).

Attention development in the first year. The first year of visual attention development can be divided into several phases marked by periods of transition (Colombo, 2001). From birth to about 2 months infants are minimally alert and exhibit reactive attention and orienting and problems with disengagement of attention, or what is called obligatory looking. Due to this "sticky attention," infants exhibit longer look durations than they do a little later on. They look longer at larger versus finer patterns, higher contrast, curves versus straight lines, and prefer face-like patterns and novelty (Colombo, 2001; Richards, 2005; Ruff & Rothbart, 2001). Age 2-3 months marks a transition to attaining and maintaining longer periods of alertness and an improvement in vision. At around 4 months infants show the first rudimentary signs of attention control as they develop the ability to disengage from a stimulus, and this is evident in their now shorter looks. Also, infants are now able to engage in eye contact with a caregiver, marking an important social developmental milestone. From about 3 to 9 months, vision matures rapidly attaining adult-like acuity and binocularity. Look duration continues to decrease likely because infants are learning more quickly about simple objects while remaining exogenously responsive to more complex objects and to novelty, which causes them to shift their attention frequently. At this stage, look duration indicates the speed and efficiency of information processing and the increasing coordination of attention and memory processes, and reflects individual differences (Colombo, 2001; Hendry et al., 2016). Clark et al., (2016, p. 12) describe these early abilities to orient and inhibit looking as the "precursors to cognitive control" and it has been shown that 5-month-old "short lookers" exhibit greater cognitive abilities (e.g., memory, language) and higher EF at 2, 3 and 4 years of age than "long lookers" (Cuevas & Bell, 2014). By 5-6 months infants can reach and grasp for objects and by 9 months are able to manipulate objects, allowing them to explore through touch that which they see (Ruff & Rothbart, 2001). Measures of EF that capitalize on these new abilities can now be used. On a search task, for example, 5-6-month-olds can find a hidden object after a short delay, exhibiting the ability to "hold in mind", a precursor to working memory (Garon et al., 2008). On another task, the A-not-B, younger infants perseverate but 8-9-month-olds can inhibit a reach for a previously rewarded "A" location, in favour of the new hiding place, "B." By 11 months they can inhibit a direct reach and instead reach around a transparent barrier to get a toy. At this age, infants are also able to comply with a parental "don't touch" prohibition (Clark et al., 2016; Hughes, 2011). With the budding ability to hold information in mind and to inhibit distractions, look duration begins to increase again around 8 months, indicative of more focused attention on more complex stimuli (Colombo, 2001; Courage et al., 2006). During periods of sustained, focused, attention, information processing and learning take place. While it is dominant, the rapidly maturing orienting-investigative system supports a great deal of learning about objects and places. After about 6 months of age, and most evident at age 9-12 months, the transition of dominance to the second system begins as endogenous (i.e., volitional) control of attention emerges, and with it, the intentionality of behavior (Ruff & Rothbart, 2001). Socially, this time also marks the onset of joint attention, observed as the child shifting gaze between parent (or other social partner) and object, or pointing to direct the partner's attention. Such episodes of shared attention are critical to social and cognitive development and learning (Mundy & Newell, 2007).

The emergence of attentional control. In year two, infants make great advances in the development of the second attention system. They also make great cognitive strides in memory, language, self-awareness and symbolic representation, to name a few (Ruff & Rothbart, 2001). Studies show an increase with age in look duration to complex stimuli such as television programming (Anderson & Levin, 1976; Courage et al., 2006) and toys (Ruff & Lawson, 1990), likely because of greater understanding of programming content (Anderson & Pempek, 2005; Pempek et al., 2010) and a growing ability to engage in more sophisticated symbolic play (Schmidt et al., 2008). This pattern of increasingly focused and sustained attention continues throughout the preschool years, and beyond, along with decreases in distractibility (Kannass, Oakes, & Shaddy, 2006; Ruff & Capozzoli, 2003), reflecting greater executive control of attention. Illustrating integration and continuity from attention to EF development, Johansson, Marciszko, Brocki, and Bohlin, (2016) found that sustained attention and simple EF skills measured at 12 months were correlated and predicted more complex EF skills at 36 months.

Executive attention as the foundation of EF. Since EF emerges as executive attention is maturing, the measurement of executive attention and EF are essentially equivalent in early development. At this time, EF is a unitary structure, not yet clearly dissociable into WM, inhibition and set shifting components (Wiebe et al., 2011). Indeed, as mentioned, the same tasks are used to measure executive attention and EF. However, no task provides a pure measure of an attention network or EF process because they are integrated, acting in unity and diversity (Best & Miller, 2010; Miyake et al., 2000). Furthermore, any task recruits other perceptual, cognitive and motor response processes that also affect task performance. It is difficult, in infants and young children, to detect the "faint signal" of EF above the noise of other rudimentary and rapidly developing abilities (Espy et al., 2016). Because of this task impurity problem, much of what is understood about the development of executive attention and EF has been gleaned from multiple studies and batteries of tasks subjected to factor analysis. Task batteries usually include sets of tasks, each set meant to tap a separate core process (e.g., working memory tasks), with test results correlating into diverse clusters, while more moderate correlations among the sets reveals the unity that emerges from interaction and shared processes (e.g., executive attention). From this line of analysis it is currently thought that EF emerges as a unitary structure (single cluster), with tasks highly correlated (Wiebe et al., 2011). Throughout the preschool years results on sets of tasks begin to diverge into separate clusters while correlations between clusters decrease. By the end of this period, best-fit models reveal the three separable, yet moderately correlated, core EF clusters (Garon et al., 2008, 2014). Throughout childhood, adolescence and adulthood these skills become more refined, yet integrated, like their underlying neural correlates.

Measuring the emergence of the components of EF. While factor analysis of EF batteries informs the understanding of the structure of EF throughout development, much has also been learned about the emergence of EF processes through the analysis of performance, across a range of ages, on commonly used tasks such as A-not-B, Flanker (including the ANT), and the Dimensional Change Card Sort (DCCS) tasks. For example, as mentioned, 8-month-olds can succeed on early measures of simple inhibition like prohibition and A-not-B tasks. Significant improvement on such tasks characterizes the toddler years (Hughes, 2011). Throughout the second year, children show little evidence of being able to solve more complex inhibition tasks that require conflict resolution

(Posner & Rothbart, 2007). On a spatial conflict task, where a target appears on a screen opposite a matching key and the correct response requires overcoming the prepotency to press the key on the same side, children at 24 months were able to perform above chance though 30- and 36-month-olds were faster, more accurate and less likely to perseverate (Gerardi-Caulton, 2000). Significant improvement in memory and on simple conflict resolution tasks is evident throughout year three. More difficult conflict tasks, such as a variation on the Simon Says game that requires the child to complete an action ordered by a toy bear but not by the elephant, are very difficult for children under 40 months but performance improves markedly over the fourth year (Jones, Rothbart, & Posner, 2003). On the Toolbox version of the Flanker Task, which tests executive attention and conflict inhibition and is designed so 3-year-olds can pass it, there was steady improvement on speed and accuracy across the 3- to 15-year-old age range tested (Zelazo et al., 2013). On a complex version of the ANT (including invalid cues) improvements were evident in speed, accuracy, conflict resolution and on alerting, orienting and executive attention networks, across the 6- to 12-year age range tested, as were interactions among the networks, indicative of growing integration of the underlying neural correlates (Pozuelos, Castillo, Fuentes, Paz-Alonso, & Rueda, 2014). Improvement in inhibition, including conflict resolution, is most dramatic through the preschool years with more gradual improvement thereafter and through to adulthood (Best & Miller, 2010; Hughes, 2011).

While infants as young as 5 months have been shown to hold items in mind over short delays, its not until some time after 2 years of age that they pass a task like Spin the Pots where they must remember under which of eight visually distinguishable pots each of six stickers has been hidden and where they have already looked as they search. Two-year-olds do not do well, 3-year-olds do much better and 4-year-olds can reach ceiling (Hendry et al., 2016). Working memory, requiring updating, emerges in the preschool years but undergoes the most improvement from then into adolescence (Best & Miller, 2010).

On the DCCS task, children must sort cards (e.g., red and blue circles and squares) by one rule (e.g., by colour or shape) through several trials, building a prepotent response, and then switch to sort on the other dimension. This requires inhibition, working memory and set shifting (i.e., mental flexibility). Many 2-year-olds cannot reliably sort cards by colour or shape, failing to hold the rules in mind (Clark et al., 2016). Three-year-olds can meet the WM demands and flexibly follow a same dimension rule change (e.g., circles into red box, then circles into blue box), but not until 4 years of age can children reliably succeed on dimensional change post-switch trials where they sort first by shape then by colour (Best & Miller, 2010; Clark et al., 2016). Using more and more complex sets of rules in the DCCS, (e.g., if star on card, sort by colour, no star sort by shape, followed by switch trials) reveals continued development of mental flexibility throughout the school-aged years and into adulthood (Hughes, 2011).

Regardless of when EF abilities emerge, many studies show that they improve into adulthood. More challenging versions of EF tasks reveal improvements in speed and accuracy with fewer errors of commission and omission, reflecting less impulsivity, greater sustained attention, and fewer lapses in attention. Also evident is greater error detection and correction (e.g., slower RT after an error), reflecting contributions from the later developing skills of self-monitoring and metacognition (Best & Miller, 2010;

Hughes, 2011). EF development through adolescence and adulthood is characterized by the integration of core skills into higher order EF skills like planning, strategizing, and self-monitoring and reflects the growing influence of metacognition.

The fundamental development of attention and attentional control is accomplished in early childhood, but maturation of executive control spans a protracted period through childhood, adolescence and into adulthood, just like the underlying neural architecture which does not fully mature until early adulthood (Berger et al., 2007; Rothbart & Posner, 2001). There are great individual differences in EF, attributable to genetics and experience (Diamond, 2011; Rothbart & Posner, 2001) and within such an extended period of plasticity there is ample opportunity for the influence of experience (Hughes & Devine, 2017).

Supports to Attention and EF Development

Focused, sustained, controlled attention and EF are critical to learning, and to all aspects of development, and because these do not develop automatically, it is important to understand and promote experiences that foster these skills and to limit those that undermine them (Centre on the Developing Child at Harvard University, 2011; Hughes & Devine, 2017). Positive parental and other social partner interactions, parental scaffolding, language exposure, household structure, and practice through play, predict EF development. Notably, for the current study, each of these factors can be influenced by BTV.

Responsive social interaction. Through social interactions with parents and others, children learn, develop and practice attentional control and EF skills (Bodrova et al., 2011; Diamond, 2011; Smith & Pellegrini, 2008). Wertsch, McNamee, McLane, and Budwig (1980) proposed that, over the course of development, the nature of parent-child interactions in problem-solving contexts evolves from parent-directed to child-directed. They observed this progression in a puzzle-matching task where children, at 4.5 compared to 2.5 years of age, required less parental guidance to successfully learn and implement the model referencing strategy. They observed responsive parents adjust their help in accordance with children's abilities. This behaviour, as described by Vygotsky, is called scaffolding – when more expert social partners provide developmentally appropriate help that is contingent on the child's level of need (Hughes & Devine, 2017; Wertsch et al., 1980). Such autonomy-supportive scaffolding, in which parents help children to focus and sustain their attention on task-relevant information, guide their strategy use, and elaborate on their actions and ideas during daily activities, play and shared problem-solving (e.g., "try looking at the other puzzle"), without controlling them, fosters attention and EF skills so that they generalize from other-regulated to self-regulated (Bernier, Carlson, & Whipple, 2010; Cuevas et al., 2014; Hammond, Müller, Carpendale, Bibok, & Liebermann-Finestone, 2012; Hendry et al., 2016; Hughes & Devine, 2017; Hughes & Ensor, 2009).

Effective use of scaffolding is just one of several indicators of the quality of parenting and the caregiving environment that predict EF development (Carlson, 2009; Vernon-Feagans et al., 2016). Experiencing a secure attachment, which comes from positive, sensitive and predictable parental responsiveness (assessed from observational ratings of parent-child interactions), gives children confidence to explore and play and practice their EF skills (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012). Mind-minded language, in which parents label states of mind, boosts children's metacognition and reflection skills, which further promotes independent executive functioning (Bernier et al., 2010). Language in general, which depends on verbal interaction (e.g., object naming, conversation, story reading) with parents and others (Zimmerman et al., 2016), is critical to EF, because it enables mental representation of goals, task demands and plans and provides children with the verbal and mental tools, including private speech, to guide their thoughts and actions (Berk, 2018; Carlson, 2009).

Play. Play provides another very important context in which children practice the EF skills that parents and teachers scaffold for them (Diamond, 2011). In social play children must, for example, decide and remember who will be mommy, daddy and baby, and negotiate rules of play and stay in character – all of which requires focused, sustained and joint attention, as well as inhibition, WM and mental flexibility (Bodrova, et al., 2011; Diamond, 2011). In social or independent play, imagining and enacting scenarios actively engages and exercises attention and EF skills and provides practice for the language skills that boost EF (Berk, 2018).

The caregiving environment. Structured, ordered, predictable environments that parents (and teachers) create, and which children can recreate in the context of play scenarios, also predict EF maturity. When parents enact household rituals, routines and rules they provide a model for observational learning and an external source of regulation that scaffolds the development of children's endogenous regulation (Hughes & Ensor, 2009). By contrast, the construct of household chaos, which describes environments high in background noise (e.g., BTV) and low in structure and routine, predicts a lack of EF development (Carlson, 2009; Hughes & Ensor, 2009; Martin et al., 2012; Vernon-Feagans et al., 2016). Noisy, chaotic, unpredictable homes can also increase stress, which has been shown to adversely affect prefrontal cortex development in young children (Blair & Raver, 2015). Chronic noise, distraction and a lack of routine (e.g., regular bedtime story; no TV at mealtimes) can interfere with the quantity and quality of social interactions and thus with benefits reaped from parental responsiveness, scaffolding, modeling, verbal interactions and play. It is by these mechanisms that poverty and lower SES are linked to EF. Anything that interferes with the quantity and quality of parent-child interaction or that disorganizes the environment has the potential to diminish the development of attention and EF skills and the learning that depends on them. Chronic exposure to BTV has that potential.

Research on BTV and Attention, EF, Learning and Learning Contexts

Attending to TV. Observational studies show that when TV is on children attend to it but frequently maintain other activities. In one study in which children were video-recorded at home over 10 days, 2- and 5-year olds, respectively, watched, 41% and 58% of the time the TV was on and engaged in secondary activities for 61% and 51% of that time (Schmitt et al., 2003). Lorch and Castle (1997) proposed that TV captures children's attention, but with experience they become strategic, "schema-guided" viewers using what they know about programming features (e.g., music change signifies scene change) to monitor content aurally and tactically allocate visual attention, while continuing other activities (Anderson & Kirkorian, 2006; Lorch et al., 1979; Hawkins, Pingree, Bruce, & Tapper, 1997; Hawkins et al., 2005). These studies show children are inclined, and use their TV knowledge and attentional skill, to multitask. But, does this divided attention come without cost?

Managing distractors and divided attention. Decades of research using various paradigms and types of distractors show that dividing attention usually comes at the cost of poorer performance (Armstrong & Greenberg, 1990; Courage et al., 2015; de Fockert, 2013; Lavie, 2010; Forster & Lavie, 2011; Ninio & Kahneman, 1974). Some exceptions have been found. Well-practiced tasks (primary or secondary) make less demand on cognitive capacity rendering dual tasks more manageable (Courage et al., 2015; Schumacher et al., 2001). Sometimes, a distracting situation boosts arousal or effort, producing a mobilization or funneling of attention toward the primary task, enhancing performance (Dixon et al., 2012; Hagen, 1967; Higgins & Turnure, 1984; Maccoby & Hagen, 1965; Ruff & Cappozoli, 2003; Ruff & Rothbart, 2001; Zukier & Hagen, 1978). Distractibility is also reduced during very engaging tasks or with uninteresting distractors (Courage & Setliff, 2010; Dixon et al., 2012). Based on this research, BTV would be expected to reduce attention to and performance on primary activities, particularly if it is engaging programming, unless children's experience with BTV has made it a well-practiced task requiring few resources, or it acts to arouse or motivate greater effort. What does the research show?

Many correlational studies, as referenced in the introduction, suggest greater TV experience is associated negatively with attention, EF and task performance (Christakis et al., 2004; Zimmerman & Christakis, 2005). While there are studies reporting no such negative associations, reports of positive correlations were specific to TV content (e.g., educational) and not amount of experience per se (Kostryka-Allchorne et al., 2017). Thus correlational evidence does not support the idea that experience with TV fosters a skill set to successfully divide attention.

BTV effects on older children and adolescents. In experimental studies with older participants, BTV reduced reading, math and problem solving performance in college students (Armstrong, Boiarsky, & Mares, 1991; Armstrong & Chung, 2000; Armstrong & Greenberg, 1990; Furnham, Gunter, & Peterson, 1994; Popoola, 2008). On a simple vigilance task, BTV rendered 10-year-olds slower and less accurate (Bellieni et al., 2010). With BTV, school-aged children and adolescents were distracted from homework, took significantly longer to do it and showed poorer performance once completed (Beentjes and Van der Voort, 1997; Pool, Van der Voort, Beentjes, and Koolstra, 2000; Pool, Koolstra, and Van der Voort, 2003a, 2003b). For young children, experimental studies show that BTV can interfere with their work too – the business of play and social interaction.

Effect of BTV on play. Vandewater et al. (2006), using 24-hr time use diaries from 1712 children aged birth to 12 years, found that TV predicted reduced play and social interaction at all ages. For 3-5 year-olds, every hour of TV predicted a 20% decrease in time with parents, 40% for siblings, and a 9% decrease in time at play. This finding has been supported by a number of experimental studies. Setliff and Courage (2011) observed 6- and 12-month old infants play with toys for 10 minutes with and without adult- and infant-directed BTV. Courage et al. (2010) conducted a very similar study with 6- and 18-month old infants using only infant-directed BTV. In both studies, infants looked more to toys than TV, whether or not the TV was on. However, during BTV, regardless of content, look lengths to toys decreased and attention shifts increased. Setliff & Courage (2011) also observed a decrease in the duration of episodes of focused attention on toys, suggesting more superficial engagement. Schmidt et al., (2008) observed 12-, 24-, and 36-month-olds play with toys with and without adult-directed BTV. Though children took fewer than one brief look (< a few seconds) per minute to the TV, while TV was on they played less overall, showed shorter play episodes, indicative of less complex play, and less focused attention on toys. Taken together, these studies indicate that BTV disrupted toy play, even when children did not appear to pay it much attention. BTV, by eliciting repeated looks, interfered with children's sustain focused attention, likely interrupting imagined play scenarios and thus the quality of play. Others have observed that when preschoolers were distracted from a play scenario (e.g., play partner's brief absence), they return to it at a more superficial level (DiLalla & Watson, 1988).

Effect of BTV on parent-child interaction. Courage et al. (2010) also observed the parents and found that when BTV was on, parents spoke to and played less with their infants, regardless of program content. Several other studies have reported similar effects on parent-child interaction. Tanimura, Okuna, and Kyoshima (2007) observed parents make fewer and shorter utterances to their 7-24-month-olds during toy play in the presence of child-directed BTV. Pempek et al. (2014) observed similar decreases in quantity and quality (i.e., fewer new words/minute) of parent speech during play with 12-, 24-, and 36-month-olds with adult-directed BTV. Kirkorian et al. (2009) observed the same children and parents in free play and found adult-directed BTV reduced verbal communication from parents and children, lessened shared play, and decreased parental responsiveness to children's bids for attention – key ingredients for the joint attention and scaffolding that support learning.

Pempek, Demers, Hanson, Kirkorian, and Anderson (2011) and Lavigne, Hanson, and Anderson (2015), with 12- and 18-month olds, conducted very similar studies to assess parent-child interaction before, during and after exposure to videos designed to promote parent-child interaction (e.g., Sesame Beginnings). Contrary to purpose, results showed an overall reduction in quantity and quality of interactions (e.g., playing, reading) and parent speech (Lavigne et al., 2015) during the video. However, Lavigne et al. did report an increase in speech quality (i.e., labelling) during and after the video and Pempek at al. observed a small but significant increase in interaction following the video. Thus, while demonstrating the educational potential (for parents in this case) of well-designed content in the context of co-viewing, these results add to the evidence that BTV is distracting and displaces parent-child interaction. No studies have looked at the effect of BTV on parent-child interaction with preschoolers older than 3 years.

Nathanson and Rasmussen (2011), who included toddlers and preschoolers (ages 16-72 months), noted significantly less mother-child communication and maternal responsiveness in the context of child-directed TV co-viewing (i.e., foreground TV) as compared to the much richer communication observed during co-play and shared reading. Thus, while co-viewing may be better than viewing alone, as children frequently do, this study suggests shared TV may not foster the same quality of communication as co-play and reading together. When TV displaces or diminishes these activities it reduces the inherent learning opportunities. But how does it affect the actual learning?

BTV effects on learning and performance. A handful of studies have specifically investigated the effect of TV distraction on learning and performance on play-based tasks in young children. In one example, Dixon, Salley, and Clements (2006) showed that for 21-month-olds child-directed BTV interfered with the learning of a modeled sequence (e.g., build a rattle) and that other environmental distractors (i.e., stranger enters) reduced word learning. They suggested that distractors reduce attention to the word-learning event or to cues provided by a social partner (i.e., joint attention) so that the word and/or referent was not sufficiently processed and encoded. By this mechanism, BTV interference with parent-child interactions can reduce word learning and in turn EF development, which is bolstered by language.

In earlier work that investigated learning *from* TV, Lorch et al. (1979), and Sanchez, Lorch, Milich, and Welsh (1999) investigated the effect of toys, as the distractors, on how well preschoolers, 4-6 years, learned program content. In both studies, children looked less to TV, the primary task here, when toys were present but recalled just as much program detail as children without toys. Lorch et al., (1979) credited this to children's effective strategy for dividing attention by monitoring the soundtrack and looking up from toy play to catch important visual TV content. While this may seem a successful multitasking strategy, all that can be said is that toys did not interfere with learning from TV, but whether TV interfered with the quality of and learning from toy play was not measured. This is an important question. Given the studies just reviewed, it is likely that children in these studies engaged in lesser quality play in order to learn TV content.

Wyss, Kannass, and Haden (2013) investigated the effect of BTV on attention and task performance in toddlers. A video of random segments of Sesame Street, thus incomprehensible content, served as distractor. Looking was coded and performance on three play-based tasks (puzzle; categorize toys; find hidden toys) was scored. Compared to the no BTV group, the BTV group looked less to the tasks and had lower composite task scores, thus exhibiting poorer attention, problem solving and memory. In a similar study, Kannass and Colombo (2007) tested 3.5- and 4-year-old preschoolers on four timed tasks (build Lego house, colour picture, select cards and do puzzle, to match models/pictures). The distractor video of random Sesame Street segments in Spanish was incomprehensible and it reduced children's on-task attention and task scores. In a follow-up study, Kannass et al. (2010) used the same tasks and incomprehensible distractor and added a comprehensible distractor (Sesame Street, English, proper sequence). There was no distraction-free condition. Children looked off task more and had lower scores with the comprehensible, than the incomprehensible, distractor. Also, while they showed some habituation to the incomprehensible distractor, off-task attention increased with the comprehensible one. Lorch and Castle (1997) reported a similar finding from a study in which 5-year-olds watched Sesame Street, as the primary task, while playing a game (i.e., strike key when buzzer sounds), as a secondary task. When BTV was comprehensible (versus foreign language), children looked more to the TV and slowed their reaction times. Altogether, these findings suggest that child-directed BTV, as a continuous and comprehensible distractor, may be particularly engaging and disruptive to children's attention and performance.

Effect of BTV on EF. Researchers have only very recently begun to look at the effect of TV on children's EF specifically. Barr et al. (2010) found that children exposed to more adult-directed or general household, but not child-directed, BTV at 1 and 4 years, as reported by parents, had lower EF at age 4 on behavioural and parent-reported measures. Similarly, Linebarger et al. (2014) found greater BTV exposure was associated with lower parent-reported EF in preschoolers at demographic risk. Nathanson et al., (2014) also found higher parent-reported BTV exposure predicted lower scores on EF tasks in 3-6 year olds. As with all correlational studies, the direction of these effects is not known. It could be that children at risk for lower EF get exposed to more TV. Radesky, Silverstein, Zuckerman and Christakis (2014) investigated that interpretation and found that 9-month-olds with lower parent-reported self-regulation (e.g., self-soothing) watched more TV by age 2 years, though they speculated that the effect is likely bidirectional such that lower EF leads to more TV (e.g., child preference; parent coping tool) which disrupts the practice opportunities of play and parental interaction, further limiting EF development.

To date there have been no experimental studies looking at the effect of BTV per se, on EF. The few experiments done looked at the immediate effects of TV exposure on *subsequent* EF performance, not performance concurrent with BTV. Mainly these results agree with the correlational findings. For example, in a series of experiments, Lillard and colleagues (Lillard, Drell, et al., 2015; Lillard, Li, & Boguszewski, 2015; Lillard & Peterson, 2011) assigned preschoolers, aged 4-6 years, to various conditions of educational TV, entertainment TV, reading, drawing or playing. They varied the pace (i.e., rate of scene changes) and fantastical content of TV programs. They found that fantastical programs, more than pace, whether educational or entertainment, impaired children's subsequent performance on various EF tasks. They hypothesized that the fantastical content, for which children had no established mental schema, often coming at a fast pace, taxed children's cognitive processing resources and temporarily depleted their EF abilities. This speculation was supported in another study showing preschoolers exhibited poorer EF (i.e., Go/No-Go) and higher PFC activity (i.e., functional near-infrared spectroscopy), after watching a video of a fantastical game, though not after playing that same game (Li, Subrahmanyam, Bai, & Xie, 2018). Furthermore, children who played the game rated it less fantastical than those who simply watched it being played on video. The conclusion was that interactivity made the game more realistic and thus less cognitively taxing, as evident in the brain imaging. In contrast, a more recent study showed younger children (i.e., 2-3 years) who watched educational or entertainment programs maintained subsequent EF performance (e.g., Spin Pots), while those who played with an educational iPad app *increased* their subsequent EF scores over baseline (Huber, Yeates, Meyer, Fleckhammer, & Kaufman, 2018). Like Li et al. (2018), Huber et al. suggested that meaningful engagement in interactive activities, like their app, and like drawing, reading and playing, do not distract and deplete EF in the way that non-interactive and difficult to process TV (or app) content might.

Summary. Considerable correlational and experimental evidence shows that BTV of varying content and comprehensibility can negatively affect sustained, effortful attention, EF, task performance, and learning in infants and preschoolers directly, and indirectly by interfering with the development and practice opportunities afforded by play and parent-child interaction. The accumulation of negative experiences, as likely happens when TV is frequently on, may interfere with optimal attention and EF development. The current study will add to this literature as an experimental investigation of the effect of comprehensible, child-directed BTV programming – typical of that which children are exposed to and that parents often consider as enrichment – on concurrent attention, EF, learning and performance on different kinds of tasks, in preschoolers, in the context of an adult-child interaction. In addition, the study aims to explore the role of age, EF maturity and prior experience with TV at home.

Chapter 3: Goals and Hypotheses

Given young children's extensive home exposure to TV and screen media, and the extent to which TV has become the backdrop to their play and social activities, it is necessary to understand the effect this exposure may have on the learning opportunities these activities provide. Thus, the purpose of the study was to test the effect of child-directed BTV programming on preschoolers' attention, EF, learning and performance during play-based tasks.

One goal was to examine the effect of BTV on children's ability to attend to, perform, and learn from, tasks in the context of an adult-child interaction. A second goal was to investigate BTV effects on their ability to perform on a standard laboratory measure of EF (i.e., Flanker Task), presented like a game on an iPad.

Specifically, the study investigated the following research questions:

1. *How does the presence of BTV affect preschool children's attention during different types of play-based activities with an adult?*

2. *What impact does BTV have on learning of the information provided during the activities?*

3. *How does BTV affect preschool children's performance on a behavioural measure of executive function (i.e., Flanker Task)?*

4. *Do children learn BTV program content as they engage in a play-based activity?*

5. *Do the effects of BTV on attention and task performance vary as a function of maturity of preschoolers' EF, measured behaviorally and by parent report?*

6. *Do preschool children's attention, task performance and executive function vary with BTV exposure at home?*

In order to investigate these research questions (RQs) children learned and performed several tasks while, in TV-on conditions, a children's program played in the background. Thus, a distraction paradigm was employed. Preschoolers were studied because ages 3 to 5 years is a time of rapid development in executive control of attention and a time when greater demand is placed on children's attention and emerging executive functioning as they are increasingly expected to engage in more challenging tasks, and not necessarily of their choosing (Ruff & Rothbart, 2001). This is also the age group to whom much TV and video programming is specifically targeted and for whom TV "reigns supreme" (Rideout, 2013, p. 17). Thus, commercially available child-directed programs were used. As a natural context where children engage in adult-child learning interactions, childcare centres were chosen, also affording convenience for parents and comfort for children.

To investigate BTV effects on attention, learning and performance, children completed Story and Puzzle Tasks. Each task had two phases – a learning phase (i.e., hear the story; learn matching strategy) and a testing phase (story recall; match puzzle). Children were assigned to one of three conditions: TV-off – for learning & testing phases; TV-on – for learning & testing; or TV-on/off – TV on for learning, off for testing, thus permitting between-group comparisons (see Appendix A). To examine BTV effects on EF, children completed a Flanker Task. Each child performed *both* TV-on and TV-off blocks of trials, thus serving as their own controls.

As a standard behavioural measure of visual attention, children's looks were quantified during Story and Puzzle learning. The effect of BTV on attention was assessed by comparing looks on- and off-task across TV conditions. Task score comparisons across TV conditions also revealed BTV effects on attention, as well as performance, learning and EF.

All children completed a standard behavioural measure of EF without TV. Parents completed a standardized parent-reported measure of EF and a questionnaire about their child's home media experience. These measures were used to examine how BTV distraction, as indicated by task performance, varied with age, maturity of EF and screen media experience.

It was expected that BTV would attract children's attention (RQ1). The extent to which BTV distracted children from tasks and interfered with task performance was expected to vary with age, EF (RQ5), and possibly with screen media experience (RQ6).

TV-on and TV-on/off groups were expected to exhibit more off-task looking than the TV-off group (RQ1). Children were also expected to take longer to complete tasks in TV-on and TV-on/off conditions because looks to TV would interrupt task engagement, necessitating re-engagement (RQ1). Looking, as an indicator of the focus of visual attention, was expected to correlate with Story and Puzzle Task performance (RQ2). Those who looked off-task more were expected to miss information during learning phases and thus exhibit poorer test performance (RQ2). The TV-off group was predicted to outperform TV-on and TV-on/off groups on Story and Puzzle Tasks. Furthermore, while children in TV-on and TV-on/off conditions were both exposed to BTV during learning, the TV-on/off group was tested without BTV, thus it was a possibility that they would out-perform the TV-on group.

On the Flanker Task (RQ3) it was predicted that BTV would distract children and diminish performance. Specifically, children were expected to be slower, miss more trials, make more mistakes and be less able to resolve conflict and detect errors. It was also anticipated that if children attended the TV sufficiently to learn program (i.e., *Arthur*) details, it would be at the cost of Flanker Task performance (RQ4).

Children were expected to exhibit individual and developmental variability in attention and management of BTV. Older children and those with greater EF skill, as measured by BRIEF-P and Day-Night, were expected to display greater resistance to distraction, evident as less off-task looking and better task performance (RQ5).

The various measures of EF – Flanker, Day-Night, and BRIEF-P – may or may not correlate. On one hand, at this age, EF is largely a unitary structure (Garon et al., 2008), however, given the Flanker Task is a non-verbal measure, Day-Night a verbal measure, and the BRIEF-P a parental assessment of everyday EF, a lack of correlation among measures is possible, as reported by others (Toplak, West, & Stanovich, 2013).

The potential role of TV and screen media experience is not clear (RQ6). If greater exposure is associated with less than optimal attention and EF development, then poorer on-task looking and task performance would be expected, and the bulk of research favours this hypothesis. However, if children with screen media experience develop strategies for coping with distraction, they may outperform the inexperienced in TV-on conditions. Since some research indicates boys play more video games than girls (Rideout, 2013), even at this young age, gender was also examined, though differences were not otherwise expected. Whatever effect, if any, greater media experience has on attention, learning and performance in the presence of BTV, may be more evident in boys.

Chapter 4: Method

Participants

Children aged 3, 4 and 5 years were recruited from eight childcare centres in St. John's and three surrounding communities. Centres distributed a study brochure and parent consent forms and consent was obtained for 129 children, with 108 in the final sample. Excluded children were older than 72 months (n=1), younger than 36 months (n=1), left the centre before they could participate (n=5), refused to participate (n=10) or had incomplete data (n=4). For two of the final 108, a video malfunction meant some tasks could not be timed and looking could not be coded. On the Flanker Task the sample size was reduced to 105 because data for two 3-year-old boys was lost to an iPad malfunction while one 4-year-old boy completed only one task block. Children ranged in age from 36.24 to 71.92 months, with a Mean (*SD*) age of 54.19 (10.22) months. There were equal numbers of boys and girls and of 3, 4 and 5-year olds. Upon completed participation, packages were sent home containing a certificate of appreciation, Sesame Street© stickers, and the media, demographic and BRIEF-P questionnaires.

Materials

TV programming. For background TV, two popular children's programs were chosen. *The Backyardigans: Tale of the Mighty Knights* played for TV-on conditions in Story and Puzzle Tasks and *Arthur* played during the Flanker Task TV-on block. Commonsense Media, a children's media advocacy group, rated both as positive for young children and their experts gave *The Backyardigans* 4/5 stars (Kho, 2008) and *Arthur* a 5/5 rating (Wallace, 2004) for developmental appropriateness.

Story Task. This task is based on one developed by Simcock and Dooley (2007) and incorporates tests of immediate and delayed verbal recall as well as delayed non–verbal recall (i.e., the Oscar Task). Children were read a story written for this study, ensuring its novelty to all. The story depicted a Kid K-Nex© "Oscar the Grouch" toy, as shown in Figure 1, falling from his garbage can into pieces and being reassembled by a child in a particular series of steps (an ordered actions sequence). The story (see Appendix B) illustrated and described the order in which Oscar was reassembled and a rationale was given for that order (e.g., "first she puts on Oscar's legs so he can stand up"). Two versions of the story were created to feature girl and boy actors.

Figure 1. Story Task – storybook and Kid K-Nex© Oscar toy.

Puzzle Task. Modeled on a task developed by Wertsch et al. (1980), this was presented as the "matching puzzles" game. The task included two sets of identical puzzles

(Figure 2). The train puzzle included three small differently coloured wheels (red, blue, yellow) and the truck puzzle carried a load of six differently coloured boxes (orange, yellow, white, dark blue, light blue and purple). The small wheels of the train were the same size and shape and therefore could fit interchangeably. Likewise, the six cargo box pieces in the truck puzzle could fit interchangeably in the truck. As a result, children had to learn and employ the strategy of referencing the model puzzle in order to match their puzzle – they could not rely on fit. The truck puzzle also included two extra "distractor" pieces (red and green) that did not match pieces in the model.

Figure 2. Puzzle Task.

Flanker Task. This is a computerized test of attention and EF, adapted for this study (Eriksen & Eriksen, 1974; McDermott et al., 2007; Rothbart, Sheese, Rueda, & Posner, 2011; Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005; Zelazo et al., 2013). The Flanker paradigm combines a continuous performance task with a conflict resolution task and tests vigilance, persistence, sustained attention, selective attention (i.e., resistance to distraction), the inhibition component of EF (McDermott et al., 2007) and error detection (Checa, Castellanos, Abundis-Gutiérrez, & Rueda, 2014; McDermott et al., 2007).

The Flanker Task was designed like a game and presented on an iPad. An array of cartoon fish (Figure 3) is presented and the task is to press the arrow on the touch screen corresponding to the direction the central fish is "swimming." On congruent trials the central fish is flanked by fish facing the same direction but opposes the flankers on incongruent trials. The opposite-facing flankers create distraction and response conflict. A correct response on incongruent trials requires the resolution of conflict from the competing flankers and the inhibition of any impulse to respond to the more numerous flankers rather than the single central target. The difference in performance between congruent and incongruent trials reflects the ability to ignore distractors and resolve conflict, and thus of the efficiency of executive attention (Rueda et al., 2005; Rothbart et al., 2011). While children as young as 4 years have been successfully tested with similar computerized tests of executive attention, it is challenging (Rueda et al., 2005). The Flanker Task developed for this study used large fish with spacing between them in order to promote a focus on the central fish, reduce conflict, and thus make the test easier for the youngest children while trying to avoid ceiling effects for the oldest (Eriksen & Eriksen, 1974; Lindqvist & Thorell, 2009, McDermott et al., 2007).

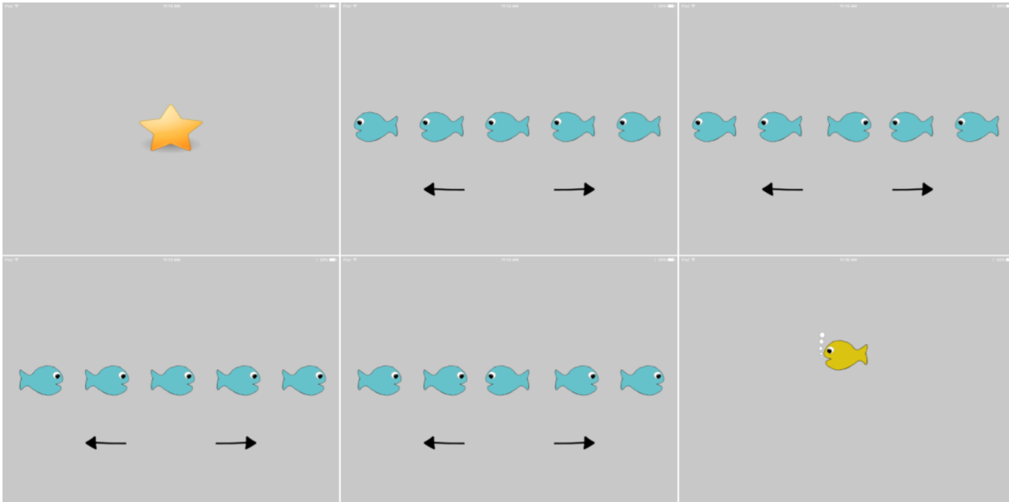

Figure 3. Six iPad screen shots from Flanker Task showing fixation probe star, the four trial types and a still shot from the animated task finale.

Day-Night Task. Day-Night is a widely used measure of EF, appropriate for children aged 3 years and up (Garon et al., 2008; Montgomery & Koeltzow, 2010). The task requires them to hold a rule in mind, control interference, and inhibit a pre-potent response in favour of a less practiced one. Children must respond "day" to a depiction of a starry night sky and "night" to a picture of the sun.

BRIEF-P. The *Behavior Rating Inventory of Executive Function – Preschool Version* is a parent-completed, standardized assessment of preschool children's everyday EF behaviours (Appendix C) (Gioia, Espy, & Isquith, 2003). The 63 items yield scores on five scales: Inhibit; Shift: Emotional Control; Working Memory and Plan/Organize. The five scales form three broader indices of Inhibitory Self-Control (Inhibit + Emotion Control), Flexibility (Shift + Emotional Control) and Emergent Metacognition (Working

Memory + Plan/Organize). The sum of the five scales yields an overall Global Composite Score. BRIEF-P results are assessed against a set of norms for children ages 2 years, 0 months to 5 years, 11 months. Parents complete the questionnaire by answering "never", "sometimes" or "often" to the question, "During the past six months how often has each of the following behaviours been a *problem*?" Thus, higher scores indicate *more problematic* behaviour (Sherman & Brooks, 2010). The form takes about 10 minutes to complete.

Media and demographics questionnaire. This questionnaire was designed to collect information on family demographics and child TV viewing habits, exposure and screen media experience (Appendix D). Parents were asked to indicate how many hours on weekdays and weekends their children typically used TV and other screen media. As an indicator of children's BTV exposure parents were asked to indicate how frequently TV was on in the home even if no one was watching and whether or not children had a bedroom TV. Numbers of media devices with which children had experience was also requested. Parents were asked to indicate their level of education.

Procedure

Children were tested at their childcare centres in a separate room as available (e.g., observation room, lunch room). For 51% of children experiments took place over two days, with the remainder completing all tasks in one session, as required to accommodate the centre's schedule. Story and Puzzle Tasks were done first, in counterbalanced order. Flanker and Day-Night tasks were completed next, also counterbalanced. Day-Night, completed without TV, served as a standard EF measure.

As illustrated in Figure 4, children sat at a child-sized table with an experimenter (E1) seated to the child's left. Tasks were placed on the table in front of the child. A laptop computer served as "TV." The TV was placed on another surface (as available; desk, counter) in front and to the right of the child at an approximate distance of two metres and a 30° angle and elevated at about the same angle so the child had to look up from the task to see it. A video camera stood on a tripod approximately one metre from the table opposite the child. A second experimenter (E2) was seated to operate the laptop and camera. E2 was friendly but interacted minimally with the child during tasks.

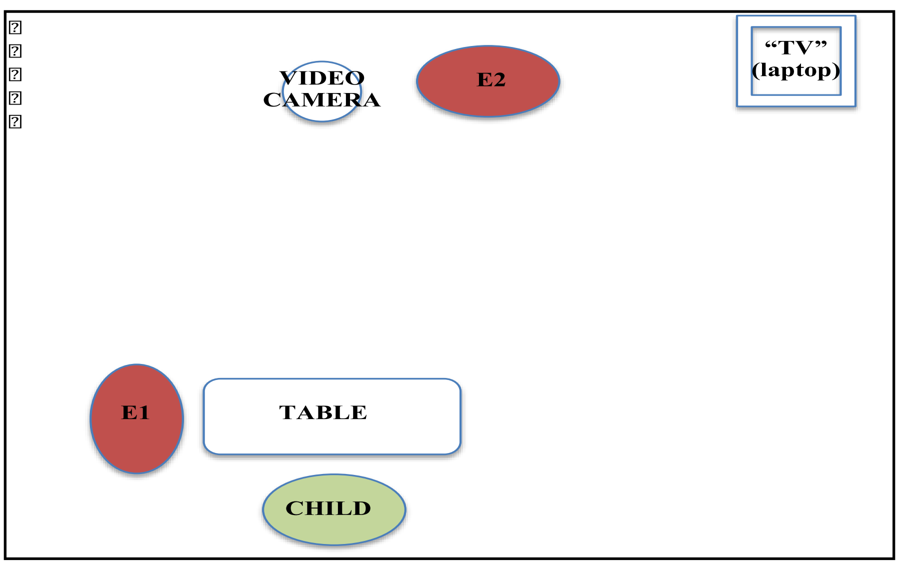

Figure 4. Schematic of the experimental set–up.

Looking. Children were video-recorded during the learning phases of Story and Puzzle Tasks to permit scoring and coding of direction, frequency and duration of looks, as an indicator of attention and distractibility. Direction was coded by target, that is, to the book or puzzle, experimenter (E1), TV, or elsewhere. Looks to the book or puzzle, and to E1, were combined for an "on-task" measure, while looks to TV or elsewhere (including E2) were combined as an "off-task" measure. For the Story Task, looking was coded from the time E1 read the first word of page two to the final word. For the Puzzle Task, looking was coded from when the child picked up the first piece until s/he placed the last piece, during the learning phase only. The *proportion* of looks directed at each target was calculated, and used as the measure for comparison across groups, in order to account for individual differences in task duration (i.e. looking time). Looking was not coded during story or puzzle testing phases, or during Oscar or Flanker tasks.

Children were given no instruction with regards to attending to the TV, but were reengaged to the assigned task when they had looked at the TV (or elsewhere off-task) for 15 seconds. Studies show that looks of this duration indicate maximal engagement with programming and, at this time point, children are least likely to spontaneously return to the primary task without redirection (Anderson, Choi, & Lorch, 1987; Hawkins et al., 1997). On Story and Puzzle tasks children were redirected to the task upon 15 seconds of off-task looking. On the Flanker Task trials children had five seconds to respond, thus were redirected after three consecutive missed trials.

Story Task. A few minutes was spent with each child on page one, discussing the depicted Sesame Street characters, as a way to put children at ease and to get them talking and ready to answer questions. *During* the reading, children were asked five questions (immediate verbal recall) on story details in order to keep them engaged and to assess attention, comprehension and learning. Immediate recall questions were asked within 15 seconds of the content detail being read. Correct answers were acknowledged, or provided when children responded incorrectly. At the end of the story, children were asked eight questions (delayed verbal recall) to test learning and retention. Immediate recall measures comprehension, short term memory and encoding, while delayed recall reflects the quality of encoding as well as consolidation to and retrieval from long term memory (Bauer, Van Abbema, & de Haan, 1999; Bauer, Larkina, & Doydum, 2012; Dixon et al., 2012). Four delayed questions were repeats of immediate questions and four were new, thus permitting a comparison of the effect of BTV on retention of information to which children did and did not have their attention specifically drawn. Directing preschoolers' attention to stimuli is known to boost memory (Kannass et al., 2010). Upon completion of the questions, children were presented with the actual Oscar toy and, as an ordered actions sequence imitation task (Bauer et al., 2012; Dixon et al., 2012), were asked to put Oscar back together (they were presented the body piece to start) as the child in the story had done (delayed non-verbal recall). As determined by group assignment, children completed *learning* (story reading) and *testing* (content questions and Oscar assembly) phases in either a TV-on or TV-off condition. In the TV-on/off group, children completed story learning with the TV on and testing with the TV off. Performance on the Oscar Task (delayed non-verbal recall) was scored as the number of correctly sequenced pairs of parts (of four: legs to body, then head; head then arms; arms then Slimey worm into Oscar's hand; Slimey in hand then Oscar and Slimey into trash can). This type of elicited imitation task, like verbal recall, is considered a measure of declarative memory and performance can reflect encoding, consolidation or retrieval (Bauer, Wenner, Dropik, & Wewerka, 2000; Dixon et al., 2012). The duration to complete the assembly was also measured. The Story Task, complete with Oscar assembly, was intended to test children's learning and recall of content details and of the action sequence depicted in the story.

Children were also scored on story reading time. While the Story Task was guided by E1, progress could be slowed by children's off-task behaviour, quantified by off-task looking. As detailed above, when off-task looks reached 15 seconds, children were directed back to the story. Progress could also be slowed when children were engaged and asked questions, which was evident as on-task looking. E1 responded simply to questions and comments but aimed to keep the story moving. Any time spent in conversation beyond that, or on interruptions, was deducted. Story Task reading and looking time were equivalent, as both were counted from the reading of word one on page two to the final word. The Story Task took less than 10 minutes to complete.

Puzzle Task. This task was presented as the "matching puzzles" game. Children were shown how sets of puzzles were identical, with all the same pieces in the same places. During the learning phase, first train puzzle then truck, the puzzle was disassembled and the child was invited to work with E1 to reassemble the puzzle to match the model. Children were instructed to reference the model ("look at my puzzle") to ensure the puzzles matched ("can we make your puzzle look just like my puzzle, so all the coloured boxes are in the same places?"). Children were helped as needed to complete the train then truck puzzle. It was ensured that children understood (i.e., agreed) that puzzles matched before proceeding from the train to truck puzzle, and then from learning to testing with the truck puzzle. During the testing phase, children were asked to try the matching puzzles game again (with truck puzzle only) without help, and were reminded to make their truck look just like the model (i.e., "this time you can do it all by yourself, don't forget to make your puzzle look just like my puzzle!"). Children were also presented with the two extra "distractor" pieces during the testing phase and were instructed "there are more pieces than you need to make your puzzle match mine, so you may leave two pieces on the table." As determined by group assignment, children completed the learning and testing phases in either TV-on or TV-off conditions. In the TV-on/off group, children completed puzzle learning with the TV on and puzzle testing with the TV off. Children were scored on time to complete the truck puzzle in learning and in testing phases and on the number of correctly placed pieces in the testing phase. It was also recorded whether or not children 1. placed a distractor piece in the puzzle (regardless of whether they later corrected the error) and 2. used the referencing strategy during testing. This task requires sustained attention and is considered to be a test of EF because successful completion requires the referencing strategy. The Puzzle Task took about five minutes to complete.

Flanker Task. Prior to starting the Flanker Task, children were tested for their understanding of "middle." Each was presented with four pictures depicting rows of three and five kittens and puppies and was asked to point to the middle kitten or puppy. All children demonstrated an understanding of middle. The Flanker Task was then presented on an iPad as the fish game. Children were instructed to press the arrow to show which way the middle fish was "swimming." They completed 10 practice trials and two blocks of 40 test trials each. During practice and one of the test blocks, the TV was off.

On each trial, a warning fixation probe (star shape) appeared at the centre of the screen and preceded the presentation of the fish array by 500, 1000 or 1500 msec (fixed, random order). Children had 5000 msec to respond before the trial timed out, except on practice trials where they had unlimited time. Correct responses were followed by auditory feedback in the form of a "whoohoo" sound. A low tone followed incorrect responses and timed-out trials. The inter-trial interval was 800 msec. Each block of 40 trials had 10 congruent trials with all fish facing right, 10 congruent all left, 10 incongruent with centre fish right, and 10 incongruent with centre fish left. At the end of each of the two trial blocks, children were rewarded with a short animation of a fish "dancing", changing size and colours, and blowing bubbles.

The Flanker Task yielded several measures. Each trial generated a *reaction time* and *accuracy* score, thus overall accuracy and mean reaction times over blocks of trials were compared across groups (i.e., age, gender, TV condition). Errors of commission and omission (i.e., timed-out trials) were counted and compared across groups. Errors of commission indicate the inability to suppress the impulse to respond to the distractor fish and therefore reflect distractibility and impulsivity. Errors of omission reflect lapses of attentional control. Additionally, *variability in reaction times,* as measured by the standard deviation of reaction times (RTSD), was compared across groups as an indicator of attentional fluctuation and distractibility, where greater variability indicated less consistently focused attention (Adólfsdóttir, Sørensen, & Lundervold, 2008; Epstein et al., 2011; Goméz-Guerrero et al., 2011; Isbell, Calkins, Swingler, & Leerkes, 2018).

The difference in performance on congruent and incongruent trials reflects the conflict effect. Conflict resolution is the ability to inhibit a response to more numerous incongruent flankers and instead indicate the direction of the single central target. Given reports that accuracy scores are more sensitive than RTs in young children (Adólfsdóttir et al., 2008; Diamond & Kirkham, 2005), accuracy on congruent versus incongruent trials was used as a measure of conflict resolution.

Another aspect of EF that emerges in the preschool years is *error detection* (Jones et al., 2003). Error detection reflects self-monitoring and is evident when children slow their responding after an error (McDermott et al., 2007). Thus, RTs on trials following errors were compared to RTs following correct trials in TV-on and TV-off blocks.

As stated, children completed Flanker trials with and without BTV. In order to determine whether children could learn content from BTV while doing the TV-on block, they were asked six questions about the *Arthur* program. Children were first given the opportunity to answer by free recall and failing that, were offered three multiple-choice options. Thus children had recall, recognition and combined total incidental learning scores. Answers to questions could be learned from the auditory track without looking to the TV. In this way, TV distraction, whether visual or aural, as measured by incidental learning could be examined. Four outcomes were possible. Incidental learning (i.e., score above chance) with no cost to Flanker performance would suggest some ability to multitask, while incidental learning at the cost of Flanker performance would indicate BTV distraction and that learning from BTV comes at the cost of primary task performance. No incidental learning (i.e., scores at chance level) with no cost to Flanker performance would indicate effective ignoring of the TV. No incidental learning *and* poorer Flanker Task performance would suggest interference from BTV, an inability to ignore BTV, and an inability to multitask with no educational benefit from the programming. The Flanker Task took about 10 minutes to complete.

Day-Night Task. Children were presented this task as the silly game. They were shown 16 cards, eight each day and night, in a fixed random order. They were explained the task, ensuring they understood to say the opposite, and were tested on a practice set of four cards until they achieved 100% accuracy on a set. If children made more than four consecutive errors during testing, they were reminded to "say the opposite." Accuracy was scored out of 16 with a half credit (.05) given for self-corrections (i.e., "day…no night!"). Day-Night was given to all children without BTV and took about 5 minutes to complete.

Design and analysis. For Story and Puzzle Tasks, children were randomly assigned to one of three conditions balanced for age and gender. In the TV-off condition children were exposed to BTV only as they entered the room, then it was turned off and remained off. In the TV-on condition, BTV was on throughout learning *and* testing phases of the tasks. In the TV-on/off condition, BTV was on during learning but off during testing. Comparison between TV-off and TV-on groups permitted examination of BTV effects on the entire episode of task learning and testing. The TV-on/off condition was added to permit examination of BTV effects on the learning phase only, isolated from the testing phase, where the testing conditions for TV-off and TV-on/off groups were equal (i.e., without TV). Thus, TV-off and TV-on groups experienced different learning and testing conditions; TV-off and TV-on/off experienced different learning, but equal testing, conditions and TV-on and TV-on/off groups experienced equal learning, but different testing, conditions.

The same children completed two blocks of the Flanker Task. All children completed one TV-on block and one TV-off block. Whether TV was on during block 1 (Order 1) or 2 (Order 2) was counterbalanced.

According to Wilson VanVoorhis & Morgan (2007), analysis of variance requires a minimum of 30 subjects per experimental condition. It was expected 36 participants per condition for Story and Puzzle tasks would suffice for a medium sized effect (Cohen's d = .50 or partial eta-squared (η_p^2) = .06, power of .80, and a significance level of .05).

For all analyses SPSS version 24 was used. Significance was evaluated at the $p < .05$ level. Adjustments were not applied to alpha levels because it was expected that the acute effect of BTV on an episode of learning may not be substantial and thus a Type 2 error was considered more likely than a Type 1. Also, given children's extensive and chronic exposure to BTV, and the body of evidence to support the hypothesis that BTV is likely to be distracting and detrimental to performance, a Type 2 error was considered more serious than a Type 1 error (Feise, 2002; O'Keefe, 2003; Rothman, 1990). That is, to advise parents that BTV interferes with attention, learning and/or executive function when it does not is considered of lesser consequence than failing to advise them that it does. Also, the chance of Type 1 error was lessened by the fact that only the analyses necessary to answer the a priori research questions were conducted (O'Keefe, 2003). Partial eta-squared (η_p^2) effect sizes are presented and benchmarked against Cohen's (1969, pp. 278-280) criteria of small ($\eta_p^2 \geq .01$), medium ($\eta_p^2 \geq .06$) and large ($\eta_p^2 \geq .14$), (Richardson, 2011). Effect sizes of correlations are commonly assessed against Cohen's criteria of small (r =.10 -.30), medium (r =.30 -.50) and large (r >.50) (Durlack, 2009; Hemphill, 2003). Unless otherwise noted, marginal means and standard errors are presented.

In all analyses, age was treated as a categorical variable. It is known that attention and EF processes undergo considerable development over the preschool years, such that older preschoolers differ qualitatively and substantially from younger preschoolers. These qualitative differences, which may emerge as curvilinear effects or age group differences, were as much of interest as linear changes.

Ethics approval

This study was approval by the Interdisciplinary Committee for Ethics in Human Research (ICEHR) at Memorial University. All researchers obtained Criminal Records Screening Certificates (i.e., Certificate of Conduct) from the Royal Newfoundland Constabulary and Certificates of Clearance from Child Youth and Family Services.

Chapter 5: Results

Results are organized by the six research questions presented in Chapter 3. First, the subject sample and group assignment are described.

Participants

As shown in Table 1, the three TV conditions in which children completed Story and Puzzle Tasks were matched on age, $F(2, 105) = .01$, $p = .99$, $\eta_p^2 < .001$, and EF maturity, as measured by the Day-Night Task, $F(2, 102) = .41$, $p = .67$, $\eta_p^2 = .008$. Likewise, on the Flanker Task, where children completed both TV-off and TV-on blocks of trials, mean ages did not differ, $F(1, 103) = .28$, $p = .60$, $\eta_p^2 = .00$, between order conditions.

Questionnaires

The media and demographics questionnaire was completed by 73% (79/108) of parents and 70% also completed the BRIEF-P. Most respondents, the majority of whom were mothers (72/79), had a postsecondary degree (70.90%) or diploma or certificate (21.50%), while fewer had some post secondary (6.30%) or high school (1.30%) education. Most children (72.15%) had at least one sibling. Those with completed questionnaires (M = 52.99 months, SD = 10.00), were younger, $F(1, 106) = 4.22$, $p = .04$, than those without (M = 57.47 months, SD = 10.27), but an ANOVA, controlling for age, showed no group difference on the standard measure of executive functioning (EF), that is, the Day-Night Task, $F(1, 99) = .35$, $p = .55$, $\eta_p^2 = .004$. A χ^2 cross-tabulation showed the groups matched on gender composition, $\chi^2(1) = .42$, $p = .67$.

Table 1

Distribution of Children by Age and Gender to TV Conditions for Story and Puzzle Tasks

Age group (years)	Gender	TV conditions			
		TV-off	TV-on	TV-on/off	All
3	Boys	6	6	6	
	Girls	6	6	6	
4	Boys	5	5	5	
	Girls	7	7	7	
5	Boys	6	7	8	
	Girls	6	5	4	
Mean (SD) age (mos)		54.12 (10.38)	54.05 (10.52)	54.40 (10.04)	54.19 (10.22)
Day-Night Mean (SE)		11.68 (.67)	11.67 (.66)	10.94 (.65)	11.34 (.36)

Research Question 1: How Does the Presence of BTV Affect Preschool Children's Attention During Different Types of Play-based Activities with an Adult?

The direction and duration of looks were coded as an indicator of where children directed their attention as they were read the story and taught to match puzzles. Since it was expected that older children would be more attentive and faster than younger, and that BTV would distract and slow children down, differences in looking duration (i.e., story or puzzle learning times) across age and TV groups were anticipated. With puzzle and story looking durations as outcome measures, which are also proxy measures of completion time for each of these tasks, two 3 (TV conditions) x 3 (age groups) x 2 (genders) ANOVAs were conducted. There were no gender differences in total looking time in story, $F(1, 89) = .08$, $p = .78$, $\eta_p^2 = .001$, or puzzle, $F(1, 89) = 1.81$, $p = .18$, $\eta_p^2 = .02$, tasks. Contrary to expectation, neither story, $F(2, 89) = .06$, $p = .95$, $\eta_p^2 = .001$, nor puzzle, $F(2, 89) = .72$, $p = .49$, $\eta_p^2 = .02$, looking durations differed across TV conditions. There was, however, the expected age difference in story, $F(2, 89) = 18.76$, $p < .001$, $\eta_p^2 = .30$, and puzzle, $F(2, 89) = 26.37$, $p < .001$, $\eta_p^2 = .37$, looking durations. It took longer to read the story with 3 (*M* = 286.78 seconds, *SE* = 5.26) than 4-year-olds (*M* = 263.68, *SE* = 5.37, *p* = .003), who took longer than 5-year-olds (*M* = 240.86, *SE* = 5.37, *p* = .003). Likewise, 3-year-olds were slower (*M* = 181.56 seconds, *SE* = 8.14) to learn the puzzle than 4-year-olds (*M* = 152.44, *SE* = 8.45, *p* = .02), who took longer than 5-year-olds (*M* = 97.94, *SE* = 8.35, *p* < .001). Thus, younger children accrued more looking time. To account for this age difference, *proportions* of story reading and puzzle learning time spent looking at 1. book or puzzle, 2. experimenter (E1), 3. TV, and 4. elsewhere, were calculated. Means and standard errors are shown in Tables 2 and 3. Since an exploration of puzzle looking proportions found the three most extreme outlying scores were all in the TV on/off group, they were removed from analyses.

Looking was coded by one observer and a 20% subsample by a second coder who was uninformed of the study's research questions. Videos were focused on the child and were coded without audio and thus the TV could not be seen or heard by coders. Inter-rater reliability (IRR) was tested using intra-class correlation (ICC) estimates with 95% confidence intervals based on a single-rating, absolute-agreement, 2-way random-effects model. IRR, on the proportion of task time looking to each target, was found to be excellent for book, ICC = .995, 95% CI [.987, .998], $F(21) = 367.62$, $p < .001$, E1, ICC = .94, 95% CI [.84, .98], $F(21) = 36.22$, $p < .001$, and TV, ICC = .996, 95% CI [.99, .999], $F(21) = 609.30$, $p < .001$, and moderate for looks elsewhere, ICC = .65, 95% CI [.29, .84], $F(21) = 5.51$, $p < .001$.

Effect of BTV on looking during Story Task. To investigate for effects of age, gender and BTV on the proportion of looking at each target (i.e., direction) during adult-child interactions, a 3 (TV conditions) x 3 (age groups) x 2 (genders) x 4 (look directions) mixed ANOVA analysis was conducted, with look direction as the within subject variable. Mauchly's test indicated a violation of the assumption of sphericity, $\chi^2(5) = 146.82$, $p < .001$, so degrees of freedom were corrected using Greenhouse-Geisser estimates ($\varepsilon = 0.62$). Results (Table 2) revealed a main effect of look direction, $F(1.87, 166.34) = 991.61$, $p < .001$, $\eta_p^2 = .92$, because children looked most at the book, less at E1 and TV, and least, elsewhere. There were no main effects of TV condition, age group or gender, nor interactions involving age and gender. However, a significant look direction by TV condition interaction was found, $F(3.74, 166.34) = 10.18$, $p = .001$, $\eta_p^2 = .19$).

Table 2

Mean (SE) Proportion of Story Task Time Looking to Targets by Age and TV Groups

TV condition	Age group (years)	Looking target			
		Book	Experimenter	TV	Elsewhere
TV-off	3	.77 (.04)	.16 (.03)	.02 (.03)	.06 (.01)
	4	.88 (.04)	.12 (.03)	.01 (.03)	.04 (.01)
	5	.82 (.04)	.12 (.03)	.02 (.03)	.04 (.01)
		.81 (.02)	**.13 (.02)**	**.02 (.02)**	**.05 (.01)**
TV-on	3	.80 (.04)	.06 (.03)	.09(.03)	.05 (.01)
	4	.72 (.04)	.10 (.03)	.15 (.03)	.04 (.01)
	5	.75(.04)	.08 (.03)	.15 (.03)	.02 (.01)
		.75 (.02)	**.08 (.02)**	**.13 (.02)**	**.04 (.01)**
TV-on/off	3	.66 (.04)	.08 (.03)	.23 (.03)	.02 (.01)
	4	.71 (.04)	.10 (.03)	.16 (.03)	.03 (.01)
	5	.76 (.04)	.06 (.03)	.15 (.03)	.02 (.01)
		.71 (.02)	**.08 (.02)**	**.18 (.02)**	**.02 (.01)**
	Total	**.76 (.01)**	**.10 (.01)**	**.11 (.01)**	**.04 (.00)**

Univariate analyses examined the simple main effects of BTV for each look direction and on the combined *on-task* (book and E1) and *off-task* (TV and elsewhere) looking variables. Age and gender were excluded from these analyses. Significant differences across TV conditions for looks to the book, $F(2, 104) = 4.39$, $p = .02$, $\eta_p^2 = .08$, E1, $F(2, 104) = 4.58$, $p = .01$, $\eta_p^2 = .08$, TV, $F(2, 104) = 23.52$, $p < .001$, $\eta_p^2 = .31$, and elsewhere, $F(2, 104) = 3.88$, $p = .02$, $\eta_p^2 = .07$, revealed that children were significantly distracted by BTV, with a large effect size. Specifically, pairwise comparisons showed, as depicted in Figure 5, the TV-off group looked more to the book than did the TV-on/off group ($p = .004$) and more to E1 than TV-on or TV-on/off groups (both *ps* = .01). Similarly, the TV-off group was significantly, $F(2, 104) = 15.99$, p = .001, $\eta_p^2 = .24$, more *on-task* than either BTV group (*ps* < .001). Both BTV groups looked more to TV than did the TV-off group (both *p*s <. 000) and while the TV-on/off group looked more to TV than the TV-on group ($p = .02$), they were similar in overall *off-task* looking ($p = .10$). Thus, while total looking time (i.e., story reading time) was the same across TV conditions, how looks were allocated within that time was affected by BTV. The TV-off group distributed most looks between book and E1 while TV-on and TV-on/off groups shifted visual attention between book and TV.

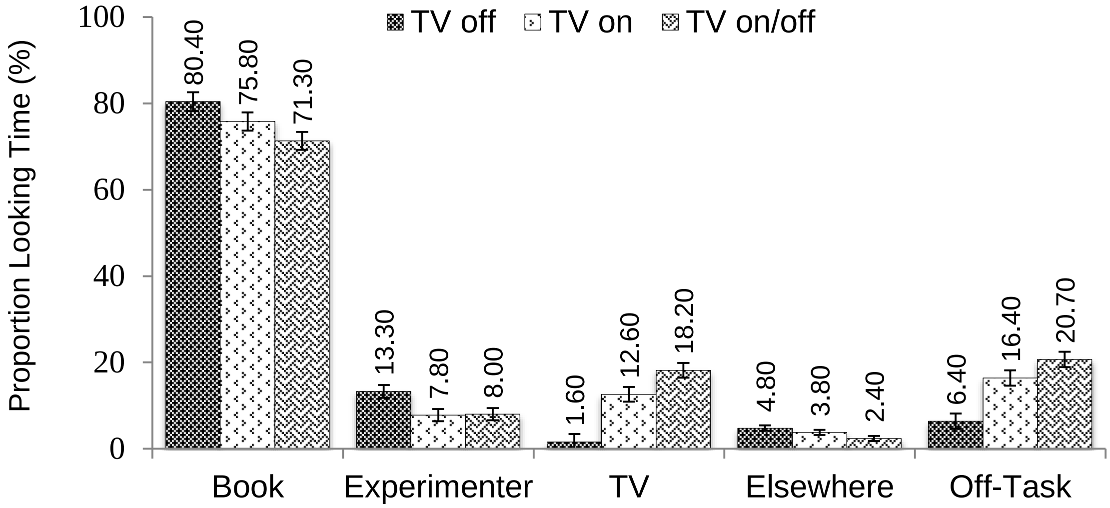

Figure 5. Mean (SE) proportion (%) of story reading time looking to targets, by TV condition.

Effect of BTV on looking during the Puzzle Task. As above, a 3 (TV conditions) x 3 (age groups) x 2 (genders) x 4 (look directions) mixed ANOVA analysis was conducted. Given a violation of the sphericity assumption, $\chi^2(5) = 486.14$, $p < .001$, degrees of freedom were corrected with Greenhouse-Geisser estimates ($\varepsilon = 0.35$). Results (Table 3) revealed a large main effect of look direction, $F(1.05, 90.46) = 5049.65$, p < .001, $\eta_p^2 = .98$, because children looked mostly at the puzzle ($M = .94$, $SE = .01$), much less at TV ($M = .05$, $SE = .01$), E1 ($M = .005$, $SE = .001$) or elsewhere ($M = .004$, $SE = .001$). There were no main effects of TV condition, age group or gender, nor any interactions with age and gender. However, a significant interaction between look direction and TV condition was found, $F(2.10, 90.46) = 12.78$, $p < .001$, $\eta_p^2 = .23$. Univariate analyses, excluding age and gender, showed a significant difference across TV conditions for looks to the puzzle, $F(2, 101) = 15.16$, $p < .001$, $\eta_p^2 = .23$, and TV, $F(2, 101) = 14.50$, $p < .001$, $\eta_p^2 = .22$. Pairwise comparisons showed the TV-off group looked more to the puzzle and less to TV than did the TV-on ($p = .05$, $p = .04$, respectively) and TV-on/off (both *ps* < .001) groups. Thus, children were significantly distracted by BTV, with a large effect size. Differences in looking were not expected between the two BTV groups, yet, the TV-on/off group looked less to the puzzle and more to TV than did the TV-on group (both *p*s = .001). Children in the TV-off group stayed focused on the puzzle while those exposed to BTV were distracted.

Summary. Although BTV distraction did not add significantly to the time to complete story reading or puzzle learning, it did affect how children distributed their looks within that time. During both tasks, children exposed to BTV spent more time looking off-task. It is noteworthy that off-task looking was much lower in the Puzzle than Story Task across ages and conditions, indicating the Puzzle Task may have been more engaging. While younger children took longer than older to complete tasks, how they distributed looks among targets within that time did not differ. That is, contrary to expectation, there was no age difference in attention or in the effect of BTV on looking. The lack of gender differences was not unexpected. Though they do not differ significantly in age, gender composition, or in scores on the Day-Night EF task, the TV-on/off group was more off-task during puzzle learning than the TV-on group. This difference was not expected.

Table 3

Mean (SE) Proportion of Puzzle Task Time Looking to Targets by Age and TV Groups

TV Condition	Age Group	Looking Target			
		Puzzle	Experimenter	TV	Elsewhere
TV-off	3	.98 (.02)	.01 (.00)	.01 (.02)	.01 (.00)
	4	.99 (.02)	.01 (.00)	.00 (.02)	.00 (.00)
	5	1.00 (.02)	.00 (.00)	.00 (.02)	.00 (.00)
		.99 (.01)	**.01 (.00)**	**.00 (.01)**	**.00 (.00)**
TV-on	3	.96 (.02)	.00 (.00)	.03 (.02)	.00 (.00)
	4	.95 (.02)	.00 (.00)	.04 (.02)	.00 (.00)
	5	.94 (.02)	.01 (.00)	.05 (.02)	.00 (.00)
		.95 (.01)	**.01 (.00)**	**.04 (.01)**	**.00 (.00)**
TV-on/off	3	.86 (.02)	.01 (.00)	.12 (.02)	.01 (.00)
	4	.89 (.03)	.01 (.00)	.10 (.03)	.01 (.00)
	5	.92 (.02)	.00 (.00)	.08 (.02)	.00 (.00)
		.89 (.01)	**.01 (.00)**	**.10 (.01)**	**.00 (.00)**
Total		**.94 (.01)**	**.05 (.01)**	**.005 (.001)**	**.004 (.001)**

Research Question 2: What Impact Does BTV have on Learning of the Information Provided During the Activities?

Effect of BTV on story learning and retention. To investigate the effect of BTV on children's response to content questions asked *during* (immediate verbal recall) and *after* the story (delayed verbal recall), a 3 (TV conditions) x 3 (age groups) x 2 (genders) x 2 (verbal recall conditions) mixed ANOVA was conducted with verbal recall as a repeated measure. Results showed a significant main effect of age group, $F(2, 90) = 28.76$, $p < .001$, $\eta_p^2 = .39$, in which 5-year-olds (M = 82.5%, SE = 3.07) recalled more (p = .01) than 4-year-olds (M = 71.41, SE =3.04) who outperformed (p = .001) 3-year-olds (M = 50.57, SE = 2.99). There were no main effects of TV condition, $F(2, 90) = 2.66$, $p = .08$, $\eta_p^2 = .06$, gender, $F(1, 90) = .13$ $p =.72$, $\eta_p^2 = .001$, or verbal recall condition, $F(1, 90) = 3.04$, $p =.09$, $\eta_p^2 = .03$. There was, however, an interaction between TV and verbal recall conditions, which was marginally significant, $F(2, 90) = 3.08$, $p = .05$, $\eta_p^2 = .06$, with a medium-sized effect. Further univariate analyses showed, as illustrated in Figure 6, no difference across TV conditions, $F(2, 99) = .71$, $p = .50$, $\eta_p^2 = .01$, on recall *during* the story (i.e., immediate recall). However, BTV significantly reduced recall *after* the story, $F(2, 99) = 4.66$, $p =.01$, $\eta_p^2 = .09$. This effect size is well within medium range ($.06 \leq \eta_p^2 < .14$). Pairwise comparisons showed the TV-off group retained significantly more story detail than TV-on (p =.03) and TV-on/off (p =.004) groups. TV-on and TV-on/off groups did not differ (p = .45). Thus, children were able to respond to content questions immediately, regardless of BTV, but were unable to retain that information for recall after the story ended. Furthermore, children in the TV-on/off group, who learned the story *with* BTV but were tested for delayed recall *without* it, were not able to recall as much as the TV-off group and no more than the TV-on group who continued to be exposed to BTV during testing. This indicates that it was BTV exposure *during the learning phase* that disrupted retention, and not that continued distraction simply interfered with performance, as could have been the case for the TV-on group. There were no other interactions.

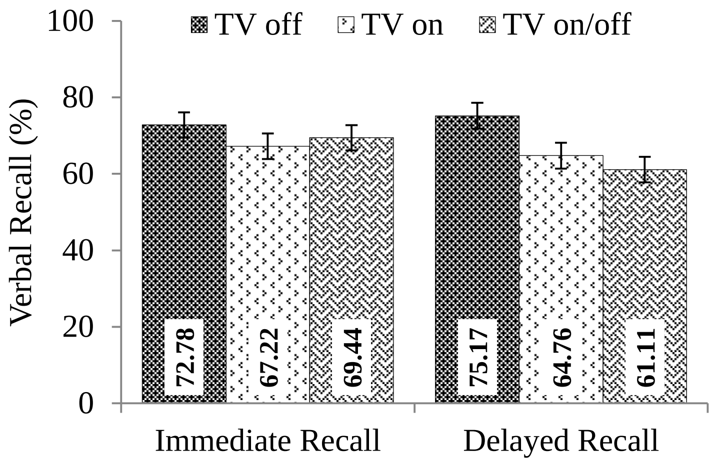

Figure 6. Mean (SE) verbal recall by TV condition.

Results on the delayed non-verbal recall test – the Oscar assembly task – showed the effect of BTV differed by age group. A 3 (TV conditions) x 3 (age groups) x 2 (genders) ANOVA revealed a significant main effect of age group, $F(2, 90) = 15.28$, $p = .001$, $\eta_p^2 = .25$, but no main effects for TV condition, $F(2, 90) = .1.41$, $p = .25$, $\eta_p^2 = .03$, or gender, $F(1, 90) = .06$, $p = .81$, $\eta_p^2 = .001$. There was a significant TV condition by age group interaction, $F(4, 90) = 2.60$, $p = .04$, $\eta_p^2 = .10$. Further analysis of the interaction showed a significant difference between TV conditions for 4-year-olds, $F(2, 33) = 4.61$, $p = .02$, $\eta_p^2 = .22$, but not for 3- , $F(2, 33) = .84$, $p = .44$, $\eta_p^2 = .05$, or 5-year-olds, $F(2, 33) = .15$, $p = .87$, $\eta_p^2 = .01$. Pairwise comparisons showed that among 4-year-olds, the TV-off group outperformed TV-on ($p = .01$) and TV-on/off groups ($p = .02$). The two BTV groups did not differ ($p = .76$). No effect of BTV was evident among 5-year-olds who performed similarly across TV conditions, while 3-year-olds performed relatively poorly in all conditions.

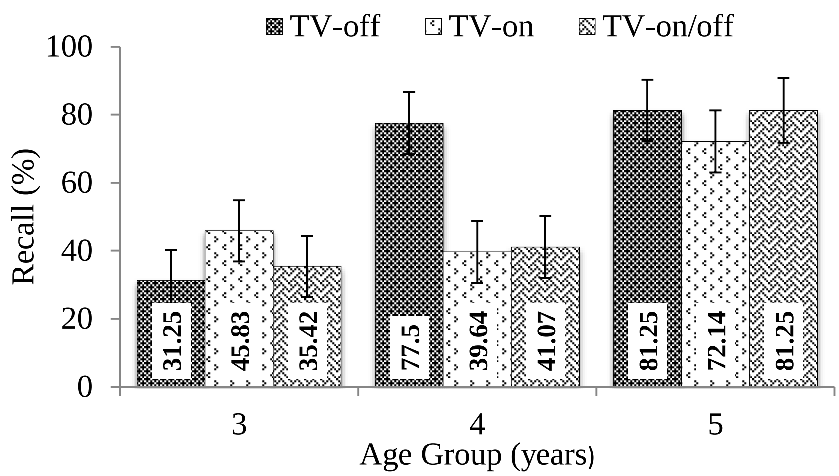

Figure 7. Mean (SE) delayed non-verbal recall (Oscar Task) by age and TV condition.

Recall of repeated versus new story content questions. Of the eight post-story questions, four were repeats from the five asked during the story and four were new. A 2 (question types) x 3 (TV conditions) x 3 (age groups) mixed ANOVA analysis was conducted with question type (repeated or new) as the within subject factor. Repeated questions (*M* = 76.04, *SE* = 2.11) were better recalled, $F(1, 99) = 53.16$, $p < .001$, $\eta_p^2 = .35$, than new (*M* = 57.99, *SE* = 2.50). The absence of any interactions shows this was true across TV and age groups. Children showed better recall for story details that they had previously been quizzed on than for content they had not been compelled to attend to and process. However, as reported with all eight questions, the TV-off group outperformed both BTV groups on recall of the subset of repeated questions, indicating that even having their attention explicitly directed to story details did not help the BTV groups retain as much information as the TV-off group.

Story Task attention and performance. Insofar as looking indicates the target of attention and that attention is important to performance, looking should correlate with performance. Partial correlations, controlling for age, showed the proportion of time looking at the book negatively correlated with how long it took to read the book, *r*(104) = -.33, *p* = .001, showing that attending to the book speeded up reading. The proportion of time looking at the book also correlated positively with immediate, *r*(104) = .20, *p* = .04, and delayed, *r*(104) = .41, p < .001,verbal recall and delayed non-verbal, *r*(104) = .31, *p* =.001, recall. Maintaining attention on the book improved learning and recall. Interestingly, however, the correlation between the off-task proportion of looking and recall *during* the story was not significant, *r*(104) = -.15, *p* = .14, though off-task looking correlated negatively with recall *after* the story, *r*(104) = -.30, *p* = .002, and with Oscar scores, *r*(104) = -.28, *p* = .004. Visual attention to the story was important to verbal and non-verbal *delayed* recall, but not *immediate* verbal recall. This aligns with the reported effects of TV condition. Delayed verbal recall, and, for 4-year-olds, delayed non-verbal recall, were lower in the two BTV conditions than in the TV-off condition, while immediate verbal recall was equal across TV conditions.

Effect of BTV on Puzzle Task learning and performance. On the Puzzle Task, children were scored for: 1) accuracy, 2) strategy use, and 3) avoidance of distractor pieces. To accurately place puzzle pieces, which differed only by colour, not shape, children had to employ the strategy of referencing the model. ANOVA results confirmed that the 74 children who used the strategy (*M* = 94.60, *SE* = 2.69) had a higher percentage accuracy, $F(1, 106) = 174.40$, $p < .001$, $\eta_p^2 = .62$, than the 34 non-users (*M* = 31.37, *SE* =

3.96). Likewise, the 61 children who avoided placing the distractor pieces into the puzzle (M = 96.72, SE = 3.55) outperformed, $F(1, 106) = 88.28$, $p < .001$, $\eta_p^2 = .45$, the 47 who did not (M = 46.10, SE = 4.05). To examine BTV effects on accuracy**,** a 3 (TV conditions) x 3 (age groups) x 2 (genders) ANOVA was conducted. There was an effect of age, $F(2, 90) = 10.35$, $p < .001$, $\eta_p^2 = .19$, such that 4- (M = 77.54, SE = 5.92, p = .01) and 5- (M = 92.82, SE = 5.98, $p < .001$) year-olds were more accurate than 3-year-olds (M = 55.09, SE = 5.84), while 4- and 5-year-olds did not significantly differ (p = .07). Puzzle accuracy did not differ across TV-off (M = 70.27, SE = 5.86), TV-on (M = 79.46, SE = 5.89), and TV-on/off (M = 75.73, SE = 5.98), conditions, $F(2, 90) = .62$, $p = .54$, $\eta_p^2 = .01$. Thus there was no effect of BTV on puzzle accuracy, There was also no effect of gender, $F(1, 90) = .22$, $p = .64$, $\eta_p^2 = .002$.

A χ^2 cross tabulation analysis tested whether BTV affected strategy use and avoidance of distractor pieces. Results (Table 4) showed the same pattern as with accuracy. Older children were more likely to successfully use the referencing strategy, $\chi^2(2, N=108) = 16.57$, $p < .001$, and ignore distractor pieces, $\chi^2(2, N=108) = 18.38$, $p < .001$. Boys and girls did not differ on strategy use, $\chi^2(1, N=108) =1.55$, $p = .21$, or avoidance of distractor pieces, $\chi^2(1, N=108) = .04$, $p = .85$.

Table 4

Proportions of Children in Each Age Group Employing Puzzle Task Strategies

	Age Group (years)		
	3	4	5
Used Strategy (%)	47.22	66.67	91.67
Avoided Distractors (%)	30.56	58.33	80.56

As presented in Table 5, there were no significant differences across TV conditions for strategy use, χ^2 (2, N=108) = .60, p = .74, or avoiding distractor pieces, χ^2(2, N=108) = 3.24, p = .20. Thus, while developmental differences were clear, BTV had no effect on Puzzle Task performance.

Table 5

Proportions of Children in each TV Condition Employing Puzzle Task Strategies

	TV Conditions		
	TV-off	TV-on	TV-on/off
Used Strategy (%)	69.44	72.22	63.89
Avoided Distractors (%)	44.44	63.89	61.11

Puzzle Task attention and performance. Maintaining visual attention on the Puzzle Task would be expected to improve performance. Partial correlations, controlling for age, confirmed that as the proportion of looks directed to the puzzle increased, learning time decreased, $r(104) = -.45$, $p < .001$, while off-task TV looking increased learning time, $r(104) = .41$, $p < .001$. Also, children who took longer to learn puzzle matching (whether due to distraction or greater need for strategy instruction) had lower task scores, $r(104) = -.29$, $p = .003$. However, neither on-task, $r(104) = .003$, $p = .98$, nor off-task, $r(104) = .004$, $p = .97$, looking correlated with puzzle scores suggesting TV distraction slowed learning but did not diminish it. It is noteworthy that the children set the pace for the Puzzle Task and there was no time limit, unlike story reading where the pace and duration were set by the reader (i.e., E1).

Summary. BTV had no effect on Puzzle Task performance. In the Story Task, BTV also had no significant effect on immediate recall of story details. However, children exposed to BTV during story *learning* retained fewer details for later recall and this was true for children *tested* with BTV present (i.e., TV-on group) and without it (i.e., TV-on/off group). Children retained less information when learned in the presence of BTV. Furthermore, even when delayed recall questions were repeats of earlier questions, exposure to BTV reduced retention. This pattern of results suggests that BTV distraction interfered with encoding during the learning phase but not retrieval during testing. While delayed non-verbal recall measured by the Oscar Task correlated negatively with off-task looking, suggesting that focused attention during reading was important for this task too, comparison across TV conditions showed BTV significantly reduced recall among 4-year-olds only. This was the only interaction between BTV and age. There was a main effect of age such that older children completed all tasks more quickly and accurately. There were no gender effects. It is noteworthy that scores on the Puzzle versus Story Task were generally higher, suggesting it may have been easier or more engaging. The role of EF maturity in these effects will be explored in research question 5.

Research Question 3: How Does BTV Affect Preschool Children's Performance on a Behavioural Measure of Executive Function?

Successful Flanker Task performance requires the executive abilities to consistently sustain selective attention, resist distraction, resolve conflict, and inhibit dominant responses. To analyse the effect of BTV on Flanker Task performance, a 2 (TV conditions) x 3 (age groups) x 2 (genders) x 2 (orders) mixed ANOVA analysis was conducted with TV condition as the within-subject factor. Comparisons were made on: 1) accuracy (percent correct); 2) errors of commission; 3) errors of omission (timed-out before a response); 4) reaction times (RT); and 5) variability in reaction times (RTSD). Results revealed main effects for TV condition and age group on all measures but no main gender or order effects. There were TV condition x age group interactions on error counts and RT variability, TV x order interactions on omission errors and RTSD and a TV x order x gender interaction on omissions.

Effect of BTV on Flanker Task performance. As illustrated in Figure 8, BTV significantly reduced accuracy, $F(1, 93) = 59.78$, $p < .001$, $\eta_p^2 = .39$. Although children made *fewer* errors of commission, $F(1, 93) = 7.99$, $p = .01$, $\eta_p^2 = .08$, in the TV-on block, this was more than offset by *more* errors of omission, $F(1, 93) = 87.35$, $p < .001$, $\eta_p^2 = .48$. Furthermore, as Figure 9 shows, with BTV, RTs slowed, $F(1, 93) = 70.95$, $p < .001$,

η_p^2 = .43, and RT variability, indicative of inattention, increased, $F(1, 93) = 58.18$, $p <$ .001, η_p^2 = .39). Effect sizes on accuracy, omissions, RTs and RTSD were all large ($\eta_p^2 \geq$ .14).

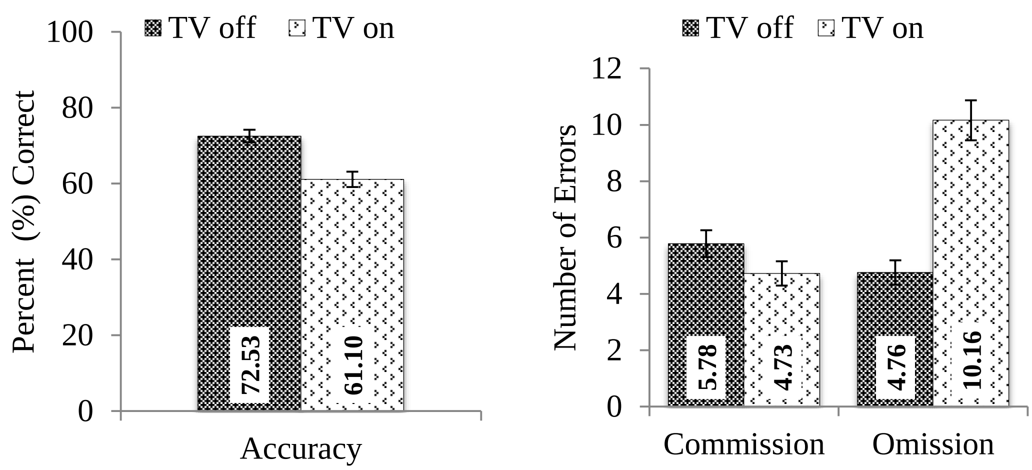

Figure 8. Mean (SE) accuracy and errors, in TV-off and TV-on conditions.

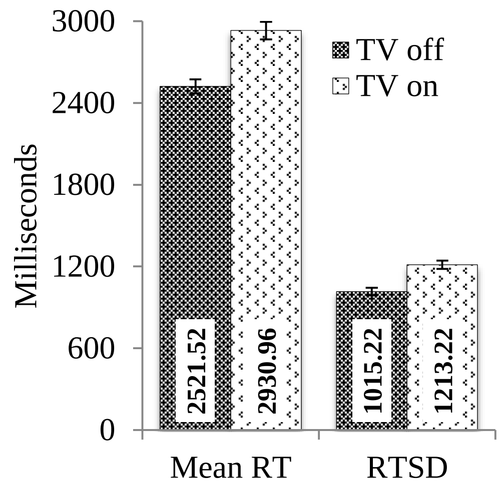

Figure 9. Mean (SE) Reaction Time (RT) and Reaction Time Variability (RTSD) by TV condition.

Effect of age on Flanker Task performance. As presented in Table 6, accuracy improved with age, $F(2, 93) = 39.83$, $p < .001$, $\eta_p^2 = .46$. In fact, 3-year-olds, on average, did not perform above chance (≥ 60%). A one-sample t-test showed accuracy of 60% (but not 55%) was greater than chance, $t(34) = 2.70$, $p = .01$. Older children made fewer errors of commission, $F(2, 93) = 15.54$, $p < .001$, $\eta_p^2 = .25$, and omission, $F(2, 93) = 24.88$, $p < .001$, $\eta_p^2 = .35$. RTs were faster, $F(2, 93) = 41.26$, $p < .001$, $\eta_p^2 = .47$, and less variable, $F(2, 93) = 16.07$, $p < .001$, $\eta_p^2 = .26$, as children got older. Pairwise comparisons revealed steady improvement from 3 to 4 to 5 years of age on all measures except RTSD, where 3- and 4-year-olds did not differ ($p = .20$), but were both more variable than 5-year-olds ($p < .001$). All effect sizes were large.

Table 6

Mean (SE) Scores on Flanker Task, by Age Group

	Age Group (years)		
	3	4	5
Accuracy (%)	49.17 (3.01)	65.37 (2.92)	85.91 (2.84)
Errors of Commission	8.03 (.74)	5.38 (.72)	2.37 (.70)
Errors of Omission	11.62 (.92)	7.98 (.89)	2.78 (.87)
Mean RT (ms)	3267.11 (95.08)	2816.97 (92.21)	2094.64 (89.90)
RTSD (ms)	1257.26 (46.71)	1173.98 (45.30)	911.41 (44.17)

Interaction effects. There were significant TV condition x age group interactions on errors of commission, $F(2, 93) = 3.33$, $p = .04$, $\eta_p^2 = .07$, and omission, $F(2, 93) = 3.48$, $p = .04$, $\eta_p^2 = .07$. As shown in Figure 10, while 3- and 4-year-olds committed significantly *fewer* errors with BTV than without, 5-year-olds did not change. All ages made more omission errors instead.

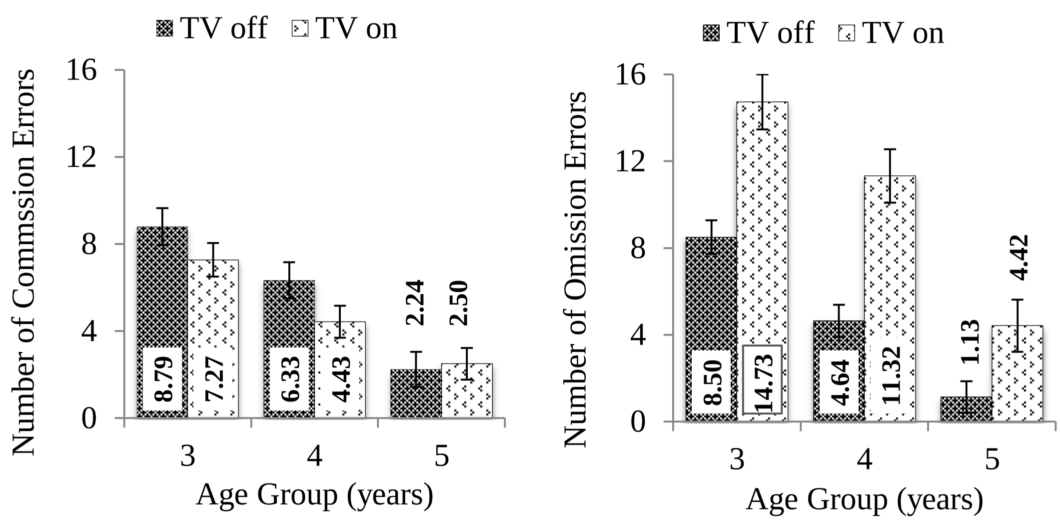

Figure 10. Mean (SE) errors of commission and omission in TV-off and TV-on blocks of the Flanker Task, by age group.

On the RTSD measure, a significant TV x age group interaction, $F(2, 93) = 4.91$, $p = .01$, $\eta_p^2 = .10$, suggested that while 5-year-olds showed lower RT variability overall, they also showed a greater increase from TV-off to TV-on blocks (Figure 11). This is likely because 3- and 4-year-olds performed with such high variability without TV, they were already closer to ceiling.

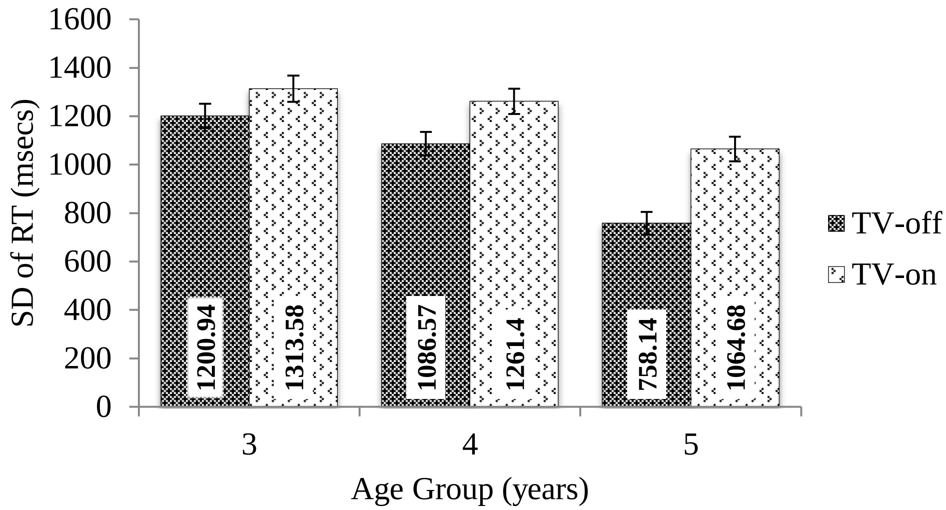

Figure 11. Mean (SE) variability of RTs (RTSD), in TV-off and TV-on blocks of the Flanker Task, by age group.

The effect of BTV varied by order. A TV x order effect, $F(1, 93) = 5.28$, $p = .02$, $\eta_p^2 = .05$, showed the increase in RT variability with BTV was even greater when the TV block was second. For omission errors, significant TV x order, $F(1, 93) = 4.81$, $p = .03$, $\eta_p^2 = .05$, and TV x order x gender interactions, $F(1, 93) = 6.05$, $p < .02$, $\eta_p^2 = .06$, were found. Mean omissions numbered 8.78 (SE =1.05) when the TV-on block was first but 11.53 (SE = .97) when it came second. As in Figure 12, both boys and girls found it hard to maintain Flanker Task performance with BTV, but for girls, the effect was smaller when the TV-on block came first (Order 1). In Order 2, girls performed like the boys. Both boys and girls showed a depleted ability to manage BTV when it came in a second round of the Flanker Task. Altogether, these results show BTV is a significant distractor for all ages, with costs to all performance measures – accuracy, speed and consistency.

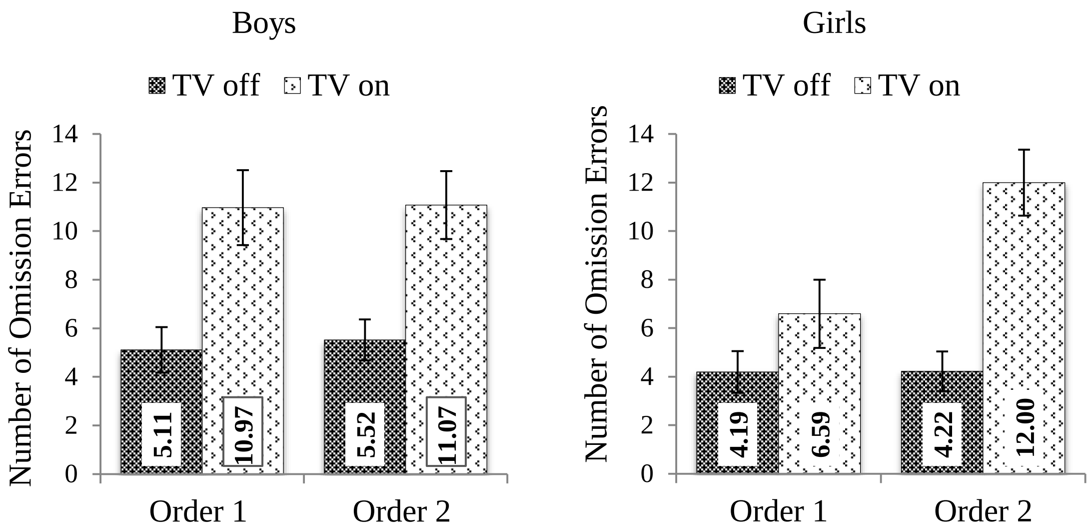

Figure 12. Effect of TV, by order of presentation, on errors of omission in boys and girls.

Conflict resolution. The difference in accuracy on congruent versus incongruent Flanker Task trials reflects conflict resolution. Since children completed both TV-off and TV-on blocks of Flanker trials (40 per block), including congruent (n=20) and incongruent trials in each block, four within-subject trial conditions were created: 1. congruent-no TV, 2. incongruent-no TV, 3. congruent-TV, or 4. incongruent-TV.

A 4 (trial conditions) x 3 (age groups) mixed ANOVA was conducted with trial condition as the within subject factor and accuracy as outcome measure. Since a preliminary analysis revealed no main effects of gender or order, these were excluded. Mauchly's test indicated, $\chi^2(5) = 35.87$, $p < .001$, a Greenhouse-Geisser correction was needed ($\varepsilon = 0.86$). Results (Figure 13) revealed main effects for trial condition, $F(2.57, 261.89) = 54.55$, $p < .001$, $\eta_p^2 = .35$, and age group, $F(2, 102) = 41.49$, $p = .001$, $\eta_p^2 = .45$, both large effects, as well as a trial condition x age group interaction, $F(5.14, 261.89) = 5.30$, $p < .001$, $\eta_p^2 = .09$.

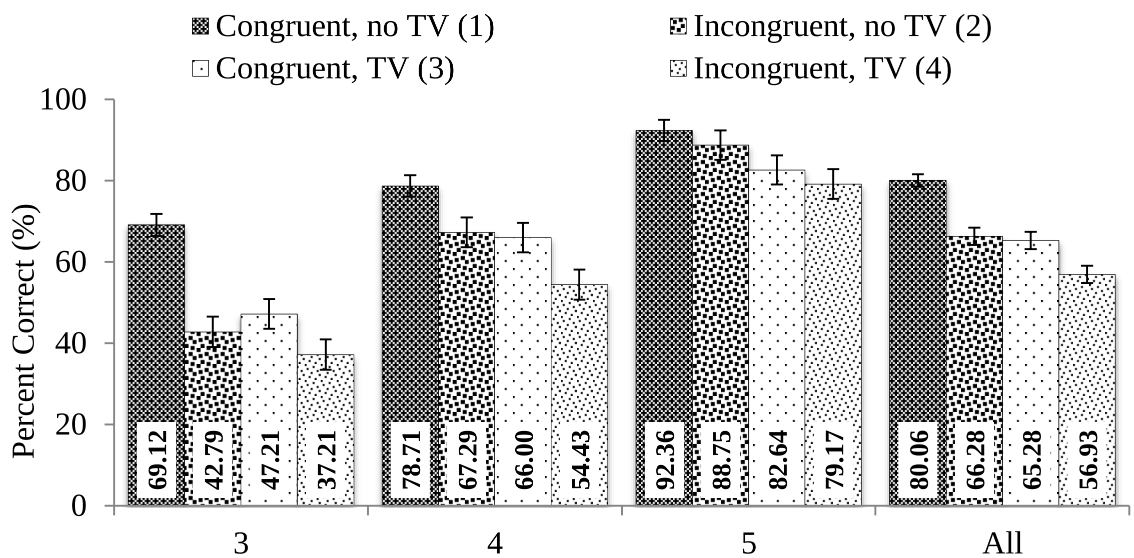

Figure 13. Flanker Task mean (SE) accuracy in each trial condition by age group (years), and overall.

Pairwise comparisons showed, overall, accuracy in condition 1 (congruent, no TV) was greater ($p < .001$) than in 2 (incongruent, no TV) and, accuracy in condition 3 (congruent, TV) was greater ($p < .001$) than in 4 (incongruent, TV). Thus, there was a significant conflict effect in TV-on and TV-off conditions. Accuracy was greatest with no distractors (condition 1) and lowest in condition 4 where performance dropped below chance (<60%).

The main effect of age showed 5-year-olds were significantly more accurate than 4-year-olds ($p < .001$) who outperformed 3-year-olds ($p < .001$). With any distractor, (TV, incongruency, or both), accuracy of 3-year-olds dropped to chance. Four-year-olds could resolve conflict *or* manage BTV, but could not do both. Five-year-olds, however, maintained above-chance accuracy in all conditions. The trial condition x age group interaction, examined with separate repeated measures ANOVAs for each age group, showed how 5-year-olds differed. For them, accuracy in trial condition 3 was significantly lower than in 2 ($p = .004$), suggesting they managed incongruency better than BTV. In fact, the difference between congruent and incongruent trials did not attain statistical significance with TV-off ($p = .07$) or TV-on ($p = .12$). Thus, 5-year-olds were able to resolve conflict with or without BTV. This difference could not be assessed with the younger children because of floor effects.

Error detection. In speeded reaction time tests like the Flanker Task, the EF skill to recognize and correct errors is evident in the slowing of RTs on trials following an error. It was expected that BTV would interfere with this skill. Since children completed TV-off and TV-on blocks, and RTs on any given trial (excluding the first) followed a correct response or error (omission or commission), four within-subject response conditions were created: 1. post-correct, TV-off, 2. post-error, TV-off, 3. post-correct, TV-on and 4. post-error, TV-on. To compare RTs across response conditions, a mixed 4 (response conditions) x 3 (age groups) ANOVA was conducted. Four 4-year-olds and seven 5-year-olds made no errors and were excluded. A preliminary analysis revealed no main effects of gender or order so these were excluded. Mauchly's test indicated, $\chi^2(5) = 18.15$, $p = .003$, a Greenhouse-Geisser correction was needed ($\varepsilon = 0.88$). Results revealed main effects for response condition, $F(2.63, 239.49) = 24.38$ $p < .001$, $\eta_p^2 = .21$, and age group, $F(2, 91) = 26.87$, $p = .001$, $\eta_p^2 = .37$, and no interaction, $F(5.26, 239.49) = .89$, $p = .49$, $\eta_p^2 = .02$. Speeding of RTs with age was reported (Table 6). Figure 14 illustrates the effect of BTV on error detection. Pairwise comparisons showed RTs in condition 2 (post-error, TV-off) were significantly slower ($p = .03$) than in condition 1 (post-correct, TV-off) but equal ($p = .75$) in conditions 3 (post-correct, TV-on) and 4 (post-error, TV-on). Thus, there was post-error slowing without TV, but no such corrective action with BTV. While younger children were slower, the lack of interaction ($p = .49$) shows post-error slowing, and BTV interference with error detection, occurred across age groups.

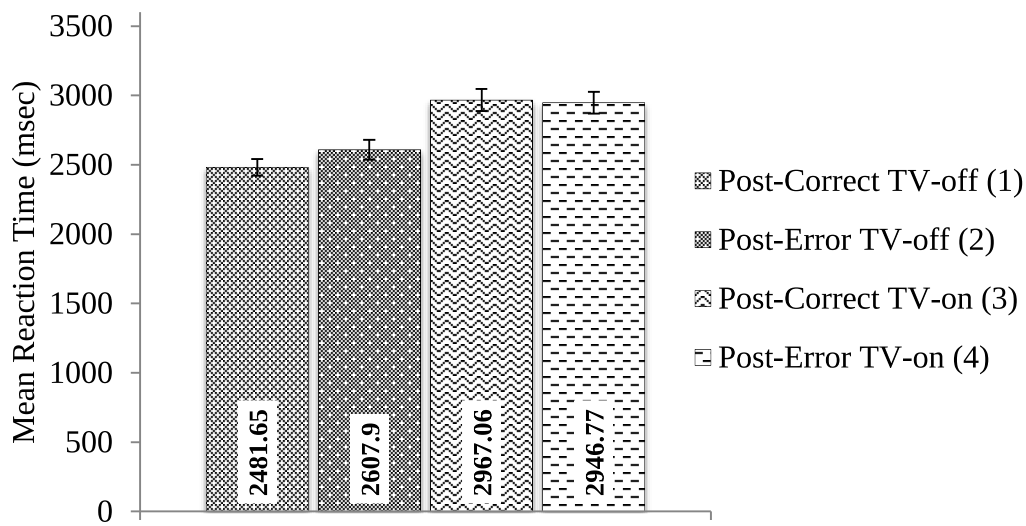

Figure 14. Mean (SE) RTs following correct responses or errors, with and without BTV.

Summary. In summary, BTV had a significantly detrimental effect on EF performance as evident on all measures of Flanker Task performance. BTV decreased response speed and accuracy and increased errors and inattention (RTSD; errors of omission) at all ages. The effect of BTV on variability and lapses of attention was even greater with BTV in the second trial block, suggesting EF was becoming depleted. Girls were better able to resist BTV in the first block, showing a much smaller increase in omissions, but when the TV-on block came second, girls and boys made equal omissions. No other gender or order effects were seen.

Overall, conflict effects were evident in both TV-off and TV-on conditions, showing, as expected, that incongruency, like BTV, was a significant distractor. However, effects varied by age. For 3-year-olds, BTV, incongruency, or both, reduced accuracy to chance. While 4-year-olds maintained above-chance accuracy with BTV or incongruency, they could not do so with both. Thus BTV effects on conflict resolution could not be assessed for younger children. Only 5-year-olds performed above chance in all trial conditions and while BTV reduced their accuracy, it did not affect their EF ability to resolve conflict.

Error detection was evident as post-error slowing of RTs when the TV was off, but not when it was on. Thus children were not able to detect, or correct for, their errors in the presence of BTV. This effect on EF was equal across age groups and genders.

Research Question 4: Do Children Learn BTV Program Content as they Engage in a Play-based Activity?

During the Flanker Task TV-on block, the program "Arthur" played in the background. Upon completion of the task, children were asked six program content questions as a measure of incidental learning. Children were offered three response options. Given six questions with three response options each, two correct by chance would be expected. Only 44% of children correctly answered three or more questions. However, to perform statistically greater than chance, children would have to answer five out of six questions correctly, exact binomial p (two-tailed) = .04. Only six children, with a mean age of 65.46 months, recalled that much. Children did not learn television content while engaged in another task and indeed the six who did, did so by compromising their performance. Paired sample t-tests comparing Flanker Task measures on TV-on and TV-off blocks, showed that these six children, like children overall, slowed their RTs, $t(5) = 3.87$, p =. 01, made more omission errors, $t(4) = 3.65$, $p = .02$, and responded with greater RT variability, $t(5) = 4.36$, $p = .01$. Thus, they learned program details at the cost of their response speed and consistency and by missing trials.

Summary. Children did not learn from the TV while engaged in the Flanker Task. Incidental learning from the TV was possible for very few and not without primary task performance cost. Furthermore, when TV was on in the background and *nothing* was learned from it, as was the case for the vast majority, it interfered with every measure of Flanker Task performance. These data suggest children could not ignore BTV, nor could they multitask and certainly show that BTV should not be regarded as a form of enrichment.

Research Question 5. Do the Effects of BTV on Attention and Task Performance Vary as a Function of Maturity of Preschoolers' EF?

Children with higher EF were expected to better maintain attention and task performance in BTV conditions. To test this question, EF measures were used, rather than age groups, as indicators of EF maturity. The Day-Night task served as a behavioural measure, and the BRIEF-P was used as a standardized, parent-reported measure.

EF measured by Day-Night. Day-Night (DN) scores were obtained for 105 children. Three refused to complete the task. Children willing but unable to do the task were given a score of zero and included in the analysis. Scores ranged from 0 to the maximum of 16 with a mean of 11.34 (*SE* = .36). A 3 (age groups) x 2 (genders) ANOVA demonstrated a significant effect of age, $F(2, 99) = 7.26$, $p = .001$, $\eta_p^2 = .18$, such that 5-years-olds scored (*M* = 13.26, *SE* = .62) higher than 4- (*M* = 10.45, *SE* = .62, *p* = .001) and 3-year-olds (*M* = 10.30, *SE* = .63, *p* = .001), who did not differ (*p* = .88). As expected, EF (DN) increased with age and was equal, $F(1, 102) = 2.15$, $p = .15$, $\eta_p^2 = .02$, between boys and girls. Age and gender were excluded from further analyses.

EF (DN), BTV, looking and performance on Puzzle and Story Tasks. To analyse whether, and how, BTV effects on attention and performance varied as a function of EF as measured by Day-Night (DN), regression analyses were performed for continuous outcome variables and binary logistical regression analyses were conducted for the categorical outcomes. If EF (DN) was important to performance it would show as a significant predictor and if the effects of BTV on attention and performance *varied* with EF (DN), it would be evident as a TV condition by EF (DN) interaction.

Linear regression analyses were conducted for story and puzzle performance measures with TV condition (dummy coded with TV-off as the initial comparison group) and EF (DN) as predictors in the first block (i.e., model 1) and the TV condition by EF (DN) interaction terms added in the second block (i.e., model 2). In addition, binary logistic regressions were used to assess the effect of EF (DN), and its interaction, if any, with TV condition, on children's use of the puzzle referencing strategy and avoidance of distractor pieces. Results showed that EF (DN) was not a significant predictor of on-task looking during story reading, b = .002, SE = .003, t(101) = .63, p = .53, nor during puzzle learning, b = -.002, SE = .002, t(101) = -.90, p = .37, and this was true across TV conditions (i.e., there were no interactions, ps > .05; ΔR^2 = .01 for story reading; ΔR^2 = .003 for puzzle). This finding aligns with the earlier suggestion that looking may not always reflect attentional control in conditions where children can monitor content aurally. EF (DN) also did not significantly predict delayed non-verbal (Oscar) recall, b = 1.32, SE = .91, t(101) = 1.45, p = .15. It was found, however, that children with higher EF (DN) performed significantly better on immediate verbal recall of story details, b = 1.78, SE = .57, t(101) = 3.10, p = .003, and on the puzzle task, b = 2.75, SE = .90, t(101) = 3.07, p = .003, and were more likely to use the referencing strategy, b = .16, SE = .06, Wald χ^2(1, N=105) = 7.26, p = .01, OR = 1.17, and to avoid placing distractor pieces, b = .16, SE = .06, Wald χ^2(1, N=105) = 7.15, p = .01, OR = 1.17, but none of these effects varied across TV conditions (p > .05 for all interactions; ΔR^2 = .02 for immediate recall; ΔR^2 = .003 for puzzle score). Thus, for each additional correct response on Day-Night, children were 1.17 times more likely to use the referencing strategy or avoid distractor pieces, but this did not interact with BTV. In contrast, for delayed verbal recall, EF (DN) interacted with BTV exposure, as illustrated in Figure 15. With the EF (DN) by TV condition interaction terms included, the regression model accounted for an additional 6% of the variance in delayed recall, $F(5, 99) = 6.07$, $p < .001$, $R^2 = .24$. While EF (DN) did not predict recall when the TV was off, $b = -.24$, $t(99) = -.21$, $p = .83$, it did predict recall in the TV-on condition, $b = 1.97$, $t(99) = 2.70$, $p = .01$, where the TV was on during learning *and* testing, and was marginally predictive in the TV-on/off condition, $b = .82$, $t(99) = 1.70$, $p = .09$, where children learned with the TV on but were tested without it. Thus, EF (DN) was increasingly important as the level of BTV distraction increased from TV-off to TV-on/off to TV-on conditions. In other words, EF (DN) modified the effect of BTV such that children with higher versus lower EF were better able to manage its potentially negative effects on the learning and retention of story details. When the TV was off, children's delayed story recall was the same regardless of their level of EF. While the BTV effect on delayed recall had not varied with age, it did vary with EF (DN) maturity. These results suggest that on more difficult tasks, in increasingly cognitively challenging conditions, children engage their maturing EF and those with more mature EF perform better as a result.

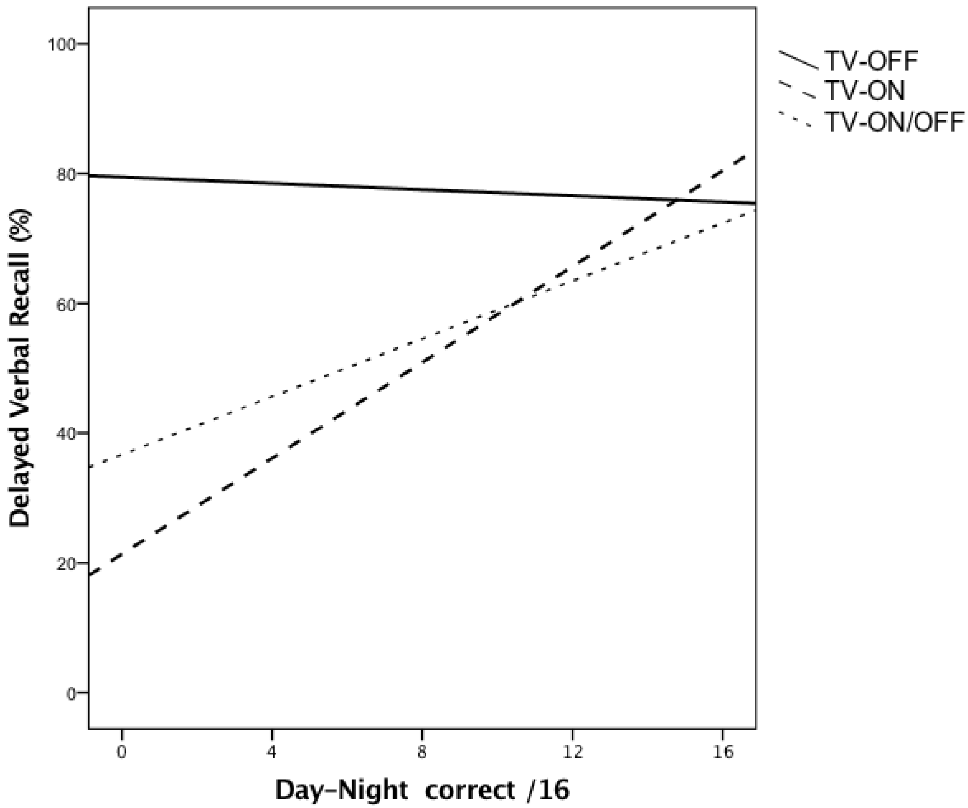

Figure 15. Delayed verbal recall increased with EF (DN) in TV-on and TV-on/off groups, but not in the TV-off group.

EF (DN), BTV and Flanker Task Performance. To test whether BTV effects on Flanker Task accuracy varied with EF (DN), a mixed 2 (TV conditions) x 2 (orders) ANOVA with EF (DN) as a covariate, was performed. As illustrated in Figure 16, children with higher EF had higher Flanker Task accuracy, $F(1, 98) = 24.50$, $p < .001$, $\eta_p^2 = .20$, and the lack of interaction, $F(1, 98) = 2.06$, $p = .16$, $\eta_p^2 = .02$, shows this was equally true in TV-off and TV-on blocks. While Figure 16 hints that children with the highest EF may be able to attain nearly equal performance in TV-on and TV-off conditions when the TV is on in first block, though not in a second block of trials, the three-way interaction was not significant, $F(1, 98) = .82$, $p = .37$, $\eta_p^2 = .01$. On this challenging task, EF mattered in all trial conditions.

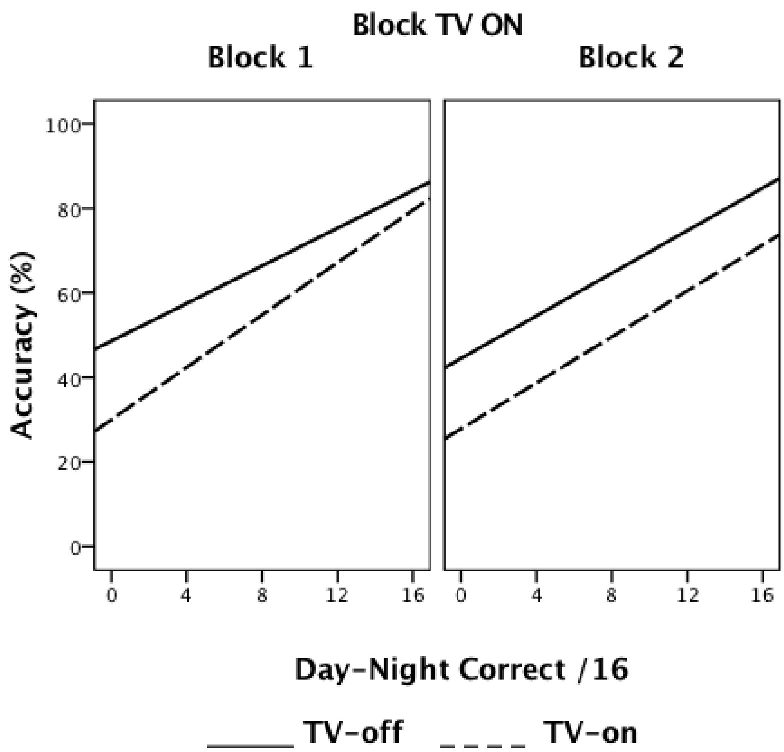

Figure 16. Accuracy increased with EF (DN) in both TV-off and TV-on conditions, whether TV was on in the first or second block of Flanker Task trials.

Summary. Day-Night scores varied with age but not gender, as expected. Children with higher EF (DN) had higher Story Task immediate and delayed verbal recall. They also scored higher on the Puzzle Task because they used the puzzle strategy more and placed fewer distractor pieces. Flanker Task accuracy also increased with EF (DN). The detrimental effect of BTV on on-task looking (RQ1) during Puzzle and Story Tasks did not vary with EF (DN). In contrast, children with lower EF (DN) exhibited lower delayed verbal recall with exposure to BTV, although those with higher EF (DN) retained more of the details learned during the Story Task. Children with the highest EF also appear, though the effect was not statistically significant, to maintain higher Flanker Task accuracy with BTV, when the TV block was first. When the TV block was second, however, here was no difference between children with higher and lower EF in how BTV affected their Flanker Task accuracy. On more challenging tasks (i.e., delayed verbal recall and Flanker) and in distracting conditions (i.e., BTV; extra puzzle pieces) EF maturity, as measured by Day-Night, is important to performance.

EF measured by BRIEF-P. The BRIEF-P was completed with acceptable consistency for 75 of 108 children. On this parental assessment of everyday EF, higher scores indicate more problematic functioning. Table 7 displays Mean (*SD*) T-scores on the five EF scales, three indices, and the Global Executive Composite (GEC). For T-scores, a sample mean of 50 and SD of 10 is expected. One sample t-tests revealed significantly lower scores on several scales of the BRIEF-P as compared to the normative population, meaning this sample has *higher* EF.

No BRIEF-P scales correlated with age or EF as measured by Day-Night (all ps $>$ .05). However, children with higher Flanker Task accuracy (in the TV-off block) were rated better on Working Memory, $r(73) = -.25$, $p = .03$, and Flexibility, $r(73) = -.25$, $p = .04$, scales. Flanker Task accuracy and GEC correlated marginally, $r(73) = -.23$, $p = .06$.

Table 7

Mean (SD) Scores on BRIEF-P

EF Scale/Index	Mean (SD)
Inhibit (I)	48.35 (7.99)
Shift (S)	46.88 (8.30)**
Emotional Control (EC)	49.35 (10.51)
Working Memory (WM)	46.12 (6.45)**
Plan/Organize (P/O)	45.09 (7.63)**
Inhibitory Self Control Index (I+EC)	48.41 (8.59)
Flexibility Index (S+EC)	47.49 (8.86)*
Emergent Metacognition Index (WM+P/O)	45.35 (6.49)**
Global Executive Composite (GEC) (I+S+EC+WM+P/O)	46.32 (7.12)**

Note. * $p < .05$; ** $p < .01$: significantly lower than normative population mean of 50.

EF (BP), BTV, looking and performance on Puzzle and Story Tasks. To investigate whether, and how, the reported BTV effects on attention and performance varied with EF as measured by the BRIEF-P (BP), regression and logistical regression analyses were performed as described above for EF (DN). If BTV effects varied with EF (BP), it would be evident as TV by EF (BP) interactions. Results showed, in this subsample of 75, that EF (BP) was not a significant predictor, nor did it interact with BTV, on any of the looking, story, or puzzle measures (all *p*s >.05).

EF (BP), BTV and Flanker Task Performance. For Flanker Task accuracy, a mixed 2 (TV conditions) x 2 (orders) ANOVA with EF (BP) as a covariate, revealed a marginal main effect of EF (BP), $F(1, 70) = 3.78$, $p = .056$, $\eta_p^2 = .05$ and no TV by EF (BP) interaction, $F(1, 70) = .06$, $p = .81$, $\eta_p^2 = .001$. Thus, children's accuracy on this behavioural measure of attention and EF, in TV-off and TV-on conditions, did not vary with parent's rating of EF. There is one exception to note. As reported earlier (RQ3), while gender was generally irrelevant, girls made fewer omissions than boys on the Flanker Task TV block when it was first, though just as many when it was second, showing greater endurance but ultimately equal EF depletion. On the BRIEF-P, girls rated less problematic than boys on the Emotional Control [46.49 (1.68) versus 52.13 (1.65); $F(1, 74) = 5.76$, $p = .02$, $\eta_p^2 = .07$] and Plan/Organize [43.27 (1.23) versus 46.87 (1.21); $F(1, 74) = 4.36$, $p = .04$, $\eta_p^2 = .04$] scales. These aspects of everyday EF, not reflected in Day-Night scores, may account for girls' greater resistance to the effect of BTV on EF. Though most BTV effects did not vary with EF (BP), the next section demonstrates that some BRIEF-P measures were associated with TV and screen media experience.

Research Question 6: Do Preschool Children's Attention, Task Performance and EF Vary with BTV Exposure at Home?

It was hypothesized that children exposed to more BTV at home may be less attentive, have lower EF and perform more poorly on tasks. Data on TV watching and BTV exposure, as well as other screen media use, was gathered for 79 children. Results showed average daily screen time (TV, DVDs, videos on other screens) ranged from 0 to 8 hours (M = 3.48, SD = 1.91) and exceeded, $t(77) = 11.46$, $p < .001$, the recommended maximum of one hour daily screen time for this age group (Canadian Paediatric Society, 2017). Every child had used a TV and only two parents reported their child watched no daily TV. With video gaming added, total daily screen time rose to 4.25 (SD = 2.27) hours. Parents reported that children had used, on average, 2.76 (SD = 1.73) different devices, other than TV; most popular were tablets (used by 59.49% of children) and smart phones (58.23%), followed by Wii gaming system (40.51%), computers (39.24%), Nintendo DS (25.32%), PlayStation (12.66%), LeapPad (15.19%) and XBOX (8.86%). In this sample, 13.9% of children had a TV in their bedroom.

Correlational analyses showed neither hours of TV watching (including all video platforms), nor total screen time (including video gaming), was associated with Looking, Day-Night, Flanker, Story, or Puzzle Task performances (all ps > .05). However, while TV watching and screen time were not associated with performance on these tasks, the parental practice of BTV did correlate with attention and EF measures. As an indicator of potential BTV exposure, and of parental attitudes and practices concerning children's access and exposure to TV, parents were asked: *"In your home, how often is the TV on,* *even if no one is actually watching?"* Parents responded on a five-point scale: 1. never (18.2 % of respondents), 2. rarely (19.5%), 3. sometimes (28.6%), 4. often (27.3%) or 5. most of the time (6.5%). Thus, higher scores indicated a more frequent practice of having BTV on in the home and greater opportunity for exposure. For more than 60% of families, BTV was on at least sometimes and for over 30% it was a frequent practice. Also, this practice correlated with time spent watching TV, $r(78) = .56$, $p < .001$, total screen time (TV and computer), $r(79) = .54$, $p < .001$, number of devices used, $r(79) = .28$, $p = .01$, and bedroom TV, $r(79) = .27$, $p = .02$. Thus, it appears that a BTV routine may reflect a parental attitude and practice that correlates with less parental control of, and thus greater child access and exposure to, TV and other screen media. Parental rules and routines in general, and specifically concerning TV use, are the kind of structure, or "other" regulation, that children need in the home to support their developing EF and self-regulation.

Further correlation analyses examined whether the practice of having TV on in the background (BTVp) was associated with children's attention to, and performance on, the assigned tasks, or with the behavioural (Flanker Task, Day-Night) and parental (BRIEF-P) measures of EF. Results are shown in Table 8.

Table 8

Correlations among attention, performance, EF measures, and BTV practice

	BTVp	Age	GEC§	EMI §	WM §	P/O	DN	Looks	Puzzle	Learn	Test	Oscar	TV off
Age	-.11	-											
GEC	.24*	-.12	-										
EMI	.30**	-.09	.76**	-									
WM	.24*	-.11	.68**	.92**	-								
P/O	.31**	-.05	.66**	.85**	.57**	-							
DN	-.32**	.33**	-.14	-.11	-.09	-.13	-						
Looks	-.20	-.10	-.04	-.02	-.03	.02	-.08	-					
Puzzl	-.04	.42**	-.02	.02	-.04	.09	.29**	.03	-				
Learn	-.21	.51**	-.13	-.12	-.16	-.05	.29**	-.18	.22*	-			
Test	-.12	.56**	-.08	-.06	-.08	-.03	.34**	-.30**	.27**	.64**	-		
Oscar	.06	.45**	-.05	-.04	-.02	-.06	.15	-.30**	.25**	.32**	.48**	-	
TV off	-.27*	.67**	-.23	-.18	-.25*	-.07	.43**	-.05	.49**	.45**	.46**	.47**	-
TV on	-.26*	.64**	-.21	-.12	-.17	-.05	.43**	-.11	.37**	.41**	.43**	.33**	.82**

BTVp – Background TV practice; Age – age in months; GEC – Global Executive Composite; EMI – Emergent Metacognition Index; WM – Working Memory; P/O – Plan/Organize; DN – Day-Night; Looks – Proportion of looking off-task during story reading; Puzzle – Puzzle Task score; Learn – Immediate Verbal Story Recall; Test – Delayed Verbal Story Recall; Oscar – delayed verbal recall; TV off – Flanker Task Accuracy, TV off; TV on, Flanker Task Accuracy, TV on.
§ Higher scores indicate lower functioning; * $p < .05$; ** $p < .01$

These results show that BTV was associated with children's EF, and this was true even though the amount of foreground TV watching and screen time use were not associated. Children in homes where BTV was more routine had lower Day-Night scores, lower Flanker Task accuracy in TV-off and TV-on conditions, and lower scores on selected parent reported (BRIEF-P) measures of EF. Specifically, scores on working memory (WM) and plan/organize (P/O) scales, the emergent metacognition index (EMI), and the global executive composite (GEC), indicated these aspects of EF were more problematic in children from homes with higher BTV. Insofar as greater opportunity means greater BTV exposure, these results indicate that BTV exposure is associated with lower EF by behavioural and parent reported measures. To illustrate the relationship between BTVp and EF, as measured by Day-Night, mean scores were graphed for children in each BTVp category. Figure 17 shows the significant linear decrease in EF with increases in BTV.

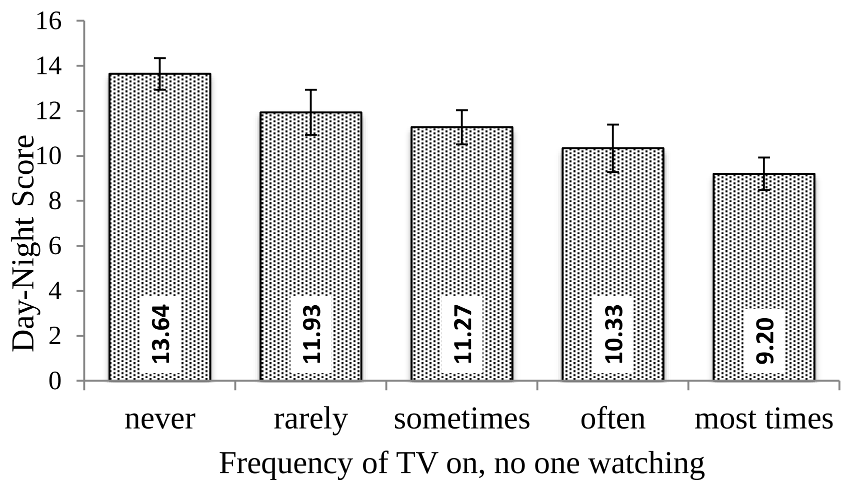

Figure 17. Mean (SE) Day-Night score by exposure to background TV in the home.

Final questions to parents aimed to understand how their perceptions of potential effects of TV on children's attention might relate to their TV practices. Parents rated how often (never to most of the time) their child is distracted from play when the TV is on, and, on a scale of 1 to 5 (not very to very), how focused their child is on TV when watching, or on the activity, when playing. Some responses were associated with the practice of having BTV on. Correlation analyses showed no association between BTV practice and parent's assessment of focus on play when playing, $r(79) = -.08$, $p = .49$. However, focus on TV when watching correlated negatively with BTV practice, $r(79) = -.25$, $p = .03$, as did TV distracting from play, $r(79) = -.26$, $p = .02$. In other words, parents who reported more frequent BTV, also reported their children as less focused on TV when watching it (i.e., easy to get his/her attention), and less distracted by TV during play. Parents who allowed less BTV reported their children as more focused on TV (i.e., difficult to get attention when watching) and more distracted by TV when playing. However, the data (Table 8) from Flanker and Day-Night Tasks, and parents' reports, indicate that children in homes with more BTV, in fact, displayed lower EF. These findings suggest that parent's responses may reflect their attitudes to TV exposure and their level of concern about their child's attention, and thus their likelihood to limit BTV, rather than an objective evaluation of their child's ability to attend to, or be distracted by, the TV. That is, it may be that parents who feel TV can be detrimental are those who limit it and who have, by the Day-Night and Flanker measures and their own BRIEF-P assessments, children with higher EF, yet they feel, and thus report, that their children are more distracted by the TV when playing. Conversely then, parents who feel TV is not potentially harmful are less likely to limit it and feel, and therefore report, that their children are not distracted by the TV during play, though the objective measures show otherwise.

Chapter 6: Discussion

Given that young children are developing and learning against the backdrop of TV, it is imperative to understand how BTV exposure affects attention, performance, learning and EF in preschoolers who are undergoing significant attentional control and EF development. Research to date has shown that effects are not straightforward but vary with content, context and child characteristics. This study focused on child-directed content, in the important learning context of adult-child interaction and play activities, and the role of children's EF maturity and BTV experience at home. An overview of the main findings will first be presented, followed by a more detailed discussion, generally organized around the research questions outlined in Chapter 3.

Summary of Main Findings

Overall, results showed that BTV reduced children's attention to tasks. While this distraction did not differ across ages and did not affect their ability to learn and perform a puzzle-matching task or to answer story content questions asked while reading, it did reduce recall to questions asked after the story. Even when questions were repeats, BTV reduced delayed recall. BTV also diminished joint attention with the adult reader, an effect previously shown for parent-child interaction with younger children. In addition, 4-year-olds exposed to BTV while learning were less able to reproduce the ordered-actions sequence depicted in the story (i.e. put Oscar back together), though 5-year-olds fared better. These BTV effects on task performance were found not only for the children who were continuously exposed to BTV as they were tested, as demonstrated in one other study (Kannass et al., 2010), but also for those who were given the opportunity to recall without BTV (i.e., TV-on/off group). Thus, this study contributes to the very limited experimental literature showing BTV effects on attention, shared attention, and measured task performance in preschoolers, and adds the unique finding that BTV has a detrimental effect on retention of acquired information, which resulted from distraction during learning and not simply from continued distraction through testing. This suggests that BTV interfered with encoding processes and not retrieval. Results also showed that only scores on delayed recall measures of the Story Task, those affected by BTV, were correlated with looking, indicating focused attention was more important to these measures than to immediate story recall or Puzzle Task performance. This finding suggests BTV may have increased cognitive load and attentional demands beyond resource limits during the more demanding Story Task (Armstrong & Greenberg, 1990; Courage et al., 2015; Kahneman, 1973; Rothbart & Posner, 2009).

Contributing to the limited experimental literature on BTV effects on attention and on EF, this study found that BTV reduced sustained selective attention, response inhibition, speed and accuracy, and error detection, as measured by the Flanker Task, though conflict resolution was unaffected among 5-year-olds, the only age group assessed on that skill. An order effect suggested that BTV depleted EF over the course of the Flanker Task, and that girls showed more resistance. Perhaps this gender difference was because of their better "ability to manage current and future-oriented task demands within the situational context" as reflected in their higher parent-rated planning and emotional control skills (Isquith, Gioia, & PAR Staff, 2008, p. 9). The effect of BTV on concurrently measured EF extends the findings of others (Li et al., 2018; Lillard et al.

2011; Lillard, Drell et al., 2015; Lillard, Li et al., 2015) who previously demonstrated an effect of TV watching (i.e., foreground TV) on *subsequently* measured EF. Though children in the present study looked at the TV enough that Flanker Task performance suffered, most recalled nothing of the Arthur program content and those who did, did so at the cost of performance, an expected finding, yet one that contradicts the proposal that children "devise a strategy that allows them to effectively divide attention between TV and toy play" (Lorch et al., 1979, p. 726). Individual EF, as measured by the Day-Night Task, modified the effect of BTV on delayed verbal recall. Specifically, children with higher EF, though not lower, did, in fact, retain story details for delayed recall. More mature EF helped children to maintain attention and performance on challenging tasks and in distracting conditions. None of these results varied with parent-reported EF, though ratings on some BRIEF-P scales correlated with Flanker accuracy, and all three EF measures (BRIEF-P, Day-Night and Flanker) varied with the practice of BTV at home. As parents reported, the more frequently BTV was on, the greater was children's screen time, variety of devices used, and likelihood of having a bedroom TV, and the lower was EF as rated by parents and measured by Day-Night and Flanker Tasks. Thus, as expected, children exposed to more BTV at home, therefore more "practiced" with it, did not show greater ability to manage distraction or to multitask, on the contrary, they had lower EF. Interestingly, parents who were less likely to limit TV exposure felt TV did not distract their children from play, yet their children were, in fact, those who exhibited lower attention and EF. Conversely, parents who rarely allowed BTV felt TV did distract their children from play yet their children had higher EF.

The results of this study align with and provide additional support to several possible mechanisms by which BTV may have detrimental effects, specifically: 1. competition for attentional resources reduces attention to tasks; 2 interference with adult-child interaction diminishes shared attention; 3. attending to more challenging tasks and more than one task at a time depletes EF; 4. these effects on task-directed and social partner attention, and on EF, in turn reduce learning and performance on challenging tasks, and 5. a lack of parental limitation on TV exposure may indicate a lack of the kind of home structure needed to support a developmental trajectory to optimal attention and EF.

Finally, the results of this study reinforce current concerns about children's development as they are exposed to several hours of TV daily. The media-saturated culture and popular belief in and value given to multitasking (Courage, 2015) seems to foster parents' belief in the benefit, or at least harmlessness, of having the TV on, even when no one is watching. Many parents in this sample were no different as screen times exceeded CPS recommended maximums and BTV was a common practice. Though parents may expose their children to TV believing it a source of enrichment (Nathanson, 2015; Vaala, 2014; Zimmerman et al., 2007), this study provided no support for that belief and instead supports proposals to limit BTV. The discussion will now turn to a more detailed account of the main findings of the study, how they fit with the current literature, and what they add.

BTV Reduces Preschool Children's Attention to Tasks and Social Partner During Play-based Activities

As expected, BTV attracted children's attention and reduced on-task looking during Puzzle and Story Tasks. This finding extends those of others who reported lower attention to toys in infants and toddlers in the presence of BTV (Courage et al., 2010; Schmidt et al., 2008; Setliff & Courage, 2011) and corroborates the one other experiment measuring attention to play-based tasks in preschoolers in the presence of comprehensible, child-directed BTV programming (Kannass et al., 2010).

Attention during tasks. In the Story Task, "on-task" included looking to the experimenter who was reading the story, asking questions, and responding to children's questions and comments; thus it was an indicator of the joint attention integral to shared reading. Children in the BTV groups looked less to the experimenter, which disrupted the quality and continuity of the adult-child reading interaction. This effect aligns with others who reported that BTV reduced parent-child interaction in free play with infants, toddlers and young (36 months) preschoolers (Courage et al., 2010; Kirkorian et al., 2009; Lavigne et al., 2015; Pempek et al., 2011, 2014; Tanimura et al., 2007) and extends the finding to older preschoolers in the context of an adult-child interaction in an educational setting. Nathanson and Rasmussen (2011) observed richer parent-child interactions during shared reading versus TV co-viewing, which highlights how BTV effects on children's attention to shared reading, or TV displacement of shared reading, could reduce the language sharing and scaffolding that happens in that context and thereby diminish learning.

Age differences. Contrary to expectation, there was no developmental difference in attention to tasks or in BTV effects on looking. It was expected that with the substantial increase in attentional control and EF skill that characterizes development from ages 3 to 5 years, older children would look less to the TV. Instead, children of all ages deployed looks among targets in the same way, with or without BTV. There are several possible explanations for the absence of an age difference in attention and distractibility in Story and Puzzle Tasks. First, it may be that these tasks were sufficiently engaging to offset younger children's presumably higher distractibility. This may explain why Anderson et al. (1987) also found no difference in distractibility between 3- and 5-year-olds. In their study they used TV as the primary task in competition with a secondary audiovisual distractor, so, perhaps, TV was an engaging primary task with which the distractor could not compete at any age. Engaging tasks are less vulnerable to distraction and likewise, more salient distractors are more distracting (Dixon et al., 2012; Wyss et al., 2013). The balance between task appeal, which is affected by task difficulty, and distractor salience can differ across tasks, distractors and ages (Courage et al., 2015; Dixon et al., 2012). Different tasks and distractor characteristics may explain why Kannass et al. (2010) found an age difference in looking in their preschoolers with intermittent distractors but, like the current study, not with continuous, and why Wyss et al. (2013) found age differences in attention to some tasks but not others. Secondly, therefore, it is also possible that the BTV program used during Story and Puzzle Tasks was more interesting or comprehensible to older children, offsetting their typically greater ability to resist distraction (Courage & Setliff, 2011; Kannass et al., 2010). It has been reported that attention to TV increases with age and comprehensibility (Anderson & Pempek, 2005). Thus, just as distractibility decreases with age, the attractiveness of TV goes up. Considered in terms of Rothbart and Posner's (2007) attention networks model, children's performance on any given task depends on the relative contributions of the alerting, orienting and executive networks. So an appealing task (or distractor) can activate the alerting network, boosting arousal, and the orienting network, sharpening focus on the task-relevant (or distractor-related irrelevant) information, thus boosting (or reducing) performance (Ruff & Capozzoli, 2003). On less appealing tasks, or with salient distractors, performance depends more on effort and the executive network, giving more mature children an advantage. Third, it may simply be that the children in this age range were equally distracted by BTV. This was not expected, but maybe it should not be surprising. Perhaps it illustrates how uniquely powerful a distractor BTV is, particularly when it is broadcasting engaging, child-directed programming in competition with tasks that vary in their appeal and difficulty, to a group of children who all have immature EF (Kannass & Colombo, 2007; Kannass et al., 2010; Wyss et al., 2013). Finally, it may be that with comprehensible TV programming, looking is not an accurate measure of attention or distractibility because children can monitor the narrative carried in the program soundtrack and look only to confirm comprehension, when engaged in another task – a rather strategic, and nonobvious, deployment of attention (Hawkins et al., 1997, 2005; Lorch et al., 1979). Looking can serve only as a measure of the *direction* of *visual* attention and not of the *efficiency* or *depth* of attention, and it cannot measure *aural* attention. Maybe younger children were more distracted than their visual attention suggested, perhaps listening more than older children. It is also possible that younger children exerted greater cognitive effort to ignore distractors and maintain visual attention equal to the older children, leaving fewer resources for the task at hand. Neither aural monitoring nor cognitive effort could be measured, but the cost of directing limited resources to these processes, rather than to tasks, could be poorer task performance. The discussion will now turn to the effects of BTV on performance and learning.

The Impact of BTV on Learning During Activities Varies with the Task

Story Task. For the Story Task, learning of details was tested by verbal recall immediately as read and again after the story ended, as well as by non-verbal recall, also after a short delay. BTV had no effect on short-term recall, probably because questions came before the memory trace could fade, but it significantly interfered with delayed verbal recall, likely because it reduced the quantity and/or quality of *encoding* of story information and thus its availability for recall (Bauer et al., 1999; 2012). BTV diverted attentional and processing resources, as evident in decreased on-task looking, that were needed to adequately encode story information. It was hypothesized that children distracted by BTV would miss information and thus not acquire as much as those not distracted. However it appears that they do initially acquire information, but they do not retain it. The fact that children did not retain story details that were not only read to them but to which they had had their attention drawn through questioning, also suggests that BTV interfered with encoding, and not that it simply caused children to miss information. That is, the effect of BTV on learning was not simply that it elicited orienting responses (Armstrong & Greenberg, 1990; Armstrong & Chung, 2000). It appears that children exposed to BTV acquired information and held it in working memory long enough to answer a question immediately but then failed to transfer it, or transferred poorer quality representations of it, to long term storage. Why? As Bauer et al. (1999) explain, without focused attention or active rehearsal, information quickly fades. The fact that children performed more poorly even on repeated questions also suggests some depth of processing is required for proper encoding and that BTV interferes with achieving that depth. Children not distracted by BTV maintained a train of thought, followed the story, connected events, and thus acquired details in the context of the narrative. This might be considered akin to keeping the information active, a form of rehearsal. By comparison, interruptions to focused attention on story continuity meant children exposed to BTV acquired disconnected and decontextualized story information as they looked to the TV and listened to the soundtrack. Also important is the fact that children exposed to BTV looked less to the experimenter, which may also indicate less cognitive engagement with the story. Thus, children learning in the presence of BTV acquired poorer quality knowledge that was harder to retain and/or retrieve. We are most adaptable to our environments when our knowledge is durable and flexible enough to be applied to novel situations. It appears that the knowledge acquired in the context of BTV may not be the robust kind that children can use and apply flexibly. An experiment by Foerde, Knowlton, and Poldrack (2006) suggests an interesting explanation. They had adults complete a weather prediction task, one group with, and one without, a secondary task. As with story recall in the current study, their two groups performed the weather task with equal accuracy but the dual task group later recalled less about task content than the single task group. Furthermore, MRI scans showed that learning in the two groups was mediated by different memory systems. Without distraction, the medial temporal lobe (MTL) mediated the task. The MTL supports declarative knowledge that requires conscious attention for learning and can be consciously recalled. By contrast, with distraction, the striatum becomes active. The striatum supports procedural learning that does not require conscious attention and creates knowledge that is not available for application to new situations

(Courage et al., 2015). Thus, it may be possible that children chronically exposed to BTV may be training brain areas that support inflexible procedural knowledge rather than declarative knowledge that can be recalled and applied flexibly to new situations. Given that mental flexibility is a core component of EF, this may also be a mechanism by which BTV can interfere with EF development.

Children did learn some story detail despite BTV, and though the TV-off group learned more than either BTV group, the fact that TV-on and TV-on/off groups performed equally on delayed verbal recall suggests there was no BTV effect on *retrieval* of learned material. That is, story information that children did manage to encode, despite distraction, was retrieved, with or without BTV. This aligns with findings from earlier divided attention experiments (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996). When participants experienced divided attention (e.g., performing a secondary task while hearing word lists) during encoding they recalled fewer words, but divided attention during retrieval had either a lesser effect on recall, or none at all. The explanation given, from that study and others, was that encoding processes, more than retrieval processes, rely heavily on strategic control of attentional resources (Craik et al., 1996; Craik, Naveh-Benjamin, Ishaik, & Anderson, 2000). Presumably then, children in the current study were able to summon sufficient attentional control for effective retrieval of learned information but not for efficient encoding. The fact that children answered immediate questions and retrieved learned information in the presence of BTV, and that individuals can perform well on tasks despite distraction, and that decrements are evident in later but not immediate recall, may explain why many parents do not recognize detrimental effects of BTV on their children's attention and learning and why so many of us think we can effectively multitask (Courage et al., 2015).

On delayed non-verbal recall in the Story Task, only 4-year-olds were negatively affected by BTV. For them, BTV distraction meant the details of how Oscar was put back together were not retained from the story, likely again because of poor *encoding* (Bauer et al., 1999) and maybe because the striatum mediated the learning of procedural knowledge (Foerde et al., 2006) that did not transfer well to performing this declarative memory task (Bauer et al., 1999; 2000). The fact that TV-on and TV-on/off groups performed equally shows that BTV had no effect on *retrieving* the steps to putting Oscar back together. Three-year-olds did not perform well on this measure with or without distraction, it was simply not a good test for them, perhaps because they were not able to transfer the story and picture information to action as well as the older children. Others have shown developmental improvement from 18 to 24 to 30 months of age on children's imitation of an ordered-actions sequence depicted and described in a story (Simcock & Deloache, 2006; Simcock & Dooley, 2007). On the Oscar Task, as compared to 3- and 4-year-olds, 5-year-olds performed better and showed no detrimental effect of BTV. They were able to reproduce the sequence they had learned. Why did they differ from the 4-year-olds on this task? It may be, as was expected, that they were not as distracted, or were less affected by distraction, even though looking revealed no age group difference. It may also be that the task was easier for older children, due to better representation, verbal, and memory skills and more experience with narratives (Simcock & Dooley, 2007). Another explanation may be that, because children were presented with the Oscar toy to reassemble, it acted as a prompt to memory rendering the task more akin to cued-recall than free-recall, an aid that helped 5- but not 4-year olds (Bauer et al., 2012; Courage et al., 2015; Craik et al., 1996; Simcock & Dooley, 2007). The Oscar toy acting as a cue to recall may also explain why 5-year-olds showed lowered delayed verbal, but not non-verbal, recall of information learned in the presence of BTV. The demands of the Oscar Task combined with BTV distraction did not tax the cognitive resources of the 5-year-olds, where it did overtax 4-year-olds. The task alone overloaded 3-year-olds.

These findings align with the only other study that measured preschoolers' problem solving performance in the presence of comprehensible BTV. Kannass, Colombo, & Wyss (2010) found that BTV reduced performance on timed problem solving tasks in 3- and 4-year-olds. Figuring out a challenging problem, like making a Lego© house match a model, required more attention than was allocated in the presence of BTV. Just as BTV reduced story recall by interfering with encoding in the current study, so it likely disrupted children's ability to effectively hold and manipulate information in working memory and thus their ability to solve the problems in the Kannass et al. study, particularly when given a limited time in which to do so. It may also be that the poorer task performance in that study reflects mediation by striatum rather than MTL. A negative effect on learning and performance on challenging tasks in the presence of BTV in preschoolers was not unexpected based on the bulk of classical divided attention and dual task studies using various distractors (Armstrong & Greenberg, 1990; Courage et al., 2015; Kannass & Colombo, 2007), but this finding does contribute some further clarity to an inconsistent literature where TV effects vary with task, distractor, content, context, and child characteristics. How these factors balance against cognitive capacity determines the effect of the BTV and whether or not other areas of the brain must be recruited to handle the overflow, for better or worse.

Puzzle Task. BTV had no effect on Puzzle Task accuracy, strategy use, or placement of distractor pieces. As stated, performance decrements become evident when demands of the task and distractor combined exceed cognitive resources, which vary individually and developmentally. Thus, presumably, delayed Story Task recall was more demanding than the puzzle, a suggestion supported by higher Puzzle (75%) than Story (67%) Task scores. This may mean that the puzzle was a cognitively simpler task, but the Puzzle Task was also more engaging, as evident in the lower proportion of off-task looking during puzzle (6%) than story (15%). Children were less distractible during the Puzzle Task. They required fewer resources to resist looking to BTV and were not hindered by the same BTV content that interfered with delayed story recall. More complex and effortful tasks require executive attention (Rothbart & Poser, 2015) and attention and performance are more highly correlated when there is more competition for attentional focus (Dixon & Salley, 2006; Kannass & Colombo, 2007). Indeed off-task looking and performance were not correlated for the Puzzle Task, nor for immediate story recall, but they were correlated for delayed verbal and non-verbal recall, where effects of BTV were evident. Another consideration is the fact that children learned the Puzzle Task through hands-on demonstration as well as verbal instruction which means it was less dependent on verbal processing and, therefore, likely created less of what Kahneman called "structural interference" with the BTV soundtrack, as would be the case with the Story Task (Armstrong & Greenberg, 1990). It may also be important that, in contrast to the Story Task where the experimenter had more control over the pace, children directed the Puzzle Task and had unlimited time to learn the matching strategy and complete the test. It has been shown that multitasking can be more efficient in self-paced versus timed tasks (Courage et al., 2015). Kannass et al. (2007; 2010) used timed tasks and they observed a detrimental BTV effect on their conceptually similar puzzle-matching task, where none was observed in the current study. It may be that the pressure of timed tasks increases cognitive load to the point that the addition of BTV is detrimental to performance, whereas a non-timed task does not add that burden. It must be noted that if self-pacing alleviated BTV effects in the present study, it would have been through an effect on *how* children used their time, or the time pressure they felt, because they didn't take any more time to complete tasks when BTV was present. As noted earlier, there was no difference in task durations across TV conditions in Story or Puzzle Tasks, though there was a difference in how attention was allocated within task time. Others have also shown that external constraints (e.g., time limits; instructions to pay attention) affect the way children distribute their attention (Kannass et al., 2013). Finally, the physically interactive nature of the Puzzle versus Story Task may also have made it more resistant to distraction. Huber et al. (2018) suggested interaction was likely the explanation for why their 2- and 3-year-olds improved subsequent EF task performance after playing an interactive game, but not after watching TV. Similarly, Li et al. (2018) found decreased EF in their 4-6 year-olds who watched a video of a game but not after they played the game. Perhaps interaction makes tasks more tangible, less abstract, and therefore less demanding on mental representation. It may also be that interaction is simply more engaging. Anecdotally, several children in the current study were very excited by the puzzles and declared, "I love puzzles!" According to Rothbart and Posner's (2007) attention networks model, the appeal of the puzzle may have increased arousal via the alerting network, in turn focusing the orienting network on the task. Again, the current results add to the growing understanding that the effect of BTV on attention and performance depends on the net demand on resources resulting from the trade-offs between task, distractor, and child characteristics.

BTV Reduces Preschool Children's Executive Function Performance

The literature review completed for this study uncovered no other experiments that aimed to directly measure preschool children's EF performance in the concurrent presence of comprehensible child-directed BTV, corroborating the statement of Nathanson et al., (2014, p. 1502) that, in the study of TV effects, the construct of EF "has largely been ignored." Rather, the few recent experiments investigated short term effects of TV and found poorer EF performance, on various tasks, immediately *after* children viewed fantastical programs (i.e., foreground TV) but not after realistic shows or drawing (Lillard et al., 2011), toy play or reading (Lillard, Drell, et al., 2015), or playing an interactive game on an iPad (Huber et al., 2018; Li et al., 2018). Thus, the current study contributes to and extends these findings by showing that children exposed to BTV *during* a block of the Flanker Task, mimicking the common situation where children play while TV is on in the room, performed more poorly than on the TV-free trial block, an effect evident on every basic measure the task yields. That is, children were slower, less accurate, made more errors, and showed much greater variability in response timing. Given that fast, accurate, and consistent performance on the Flanker Task requires sustained selective attention and the abilities to resist distraction, inhibit dominant responses, detect errors, and resolve conflict, this result shows that BTV had a powerfully negative effect on at least some, if not all, of these EF processes. Since executive attentional control is central to all EF processes it is likely, as Lillard, Li, et al. (2015) suggest, that EF depletion results from an overtaxing of attentional networks. They also proposed that dynamic and novel content (e.g., children flying in space) repeatedly elicits orienting responses, thus top-down reorienting efforts, and, because children have no schema for such events, it exhausts the same information processing resources needed to perform subsequent EF tasks. Processing TV content and EF tasks *simultaneously*, as in the present study, and as children do when the TV is always on, could only amplify these effects.

The detrimental effect of BTV on Flanker Task attention and performance aligns with that found for Looking and Story Task learning. By directing cognitive resources away from tasks, BTV caused a breakdown in the efficiency of attention networks and executive functioning (Fan et al., 2002) making it very difficult for children to sustain a steady rhythm of selective attention and stable performance. As Mezzacappa (2004, p. 1374) predicted in an analysis of the associations between SES and EF, such a breakdown in attention and EF would have "negative repercussions" for learning. Indeed, the detrimental BTV effects on looking and story learning in the current study provide convincing support for this prediction.

On the Flanker Task measure of attention and EF, BTV increased Reaction Time variability (RTSD) and the omissions (long RTs) that generated that variability, and these increases were even greater when TV was on in the second trial block. This provides further evidence for EF depletion, as Lillard and colleagues (2011; 2015) found. Also, this order effect on RTSD (and omissions) was not evident on accuracy or mean RTs, which is particularly interesting given that, as an indictor of *inconsistency* in attentional control, response variability is a hallmark of ADHD (Tamm et al., 2012) that reliably differentiates children with ADHD from those without, even when accuracy, mean RTs, and conflict scores may not (Adólfsdóttir et al., 2008; Epstein et al., 2011; Gómez-Guerrero et al., 2011; Plessen et al., 2014). Thus, as an independent indicator of overall attentional control, RT variability has garnered great interest (Epstein et al., 2011). Recently, RT variability was shown, in typically developing preschoolers, to correlate with accuracy measured on the same continuous performance task, and with scores on EF (DCCS task) and cognitive (math and reading) tasks (Isbell et al., 2018). The current study corroborates and extends this finding. RT variability on the Flanker Task correlated with accuracy on that task, and with Day-Night, Story and Puzzle Task scores. Plus, the current study showed experimentally that BTV induced greater inconsistency in attentional control, as is characteristic of ADHD, in the same children who also showed poorer learning with BTV. Tamm et al. (2012) state that, in ADHD, RT variability likely reflects lapses in attention that result from inefficient top-down executive control due to frontal lobe dysfunction, which, in turn, results in impaired information processing. The current results suggest that BTV can induce a similar effect. In the presence of BTV, executive control of attention switches from stable, on-task and goal-oriented to erratic, off-task, and "out of the zone" (Isbell et al., 2018, p. 390). Whereas ADHD medications and attentional training can normalize RT variability (Tamm et al., 2012), BTV destabilizes it. By this mechanism, BTV could, with chronic exposure, impair attention, EF, cognitive development and learning over the long-term.

Error detection. Detecting and correcting errors is a self-regulatory strategy that depends on attention and EF and is fundamental to achieving goals (McDermott et al., 2007). On the Flanker Task, children slowed down after making errors when there was no BTV, but not when the TV was on, providing further evidence for BTV interference with EF. While younger children were slower, there was no age difference in responses to errors or in the effect BTV had on error monitoring. McDermott at al. (2007) also reported no differences in post-error slowing across a 4- to 6 year-old age range, on three versions of a Flanker Task, and concluded that such self-regulatory behaviours are more influenced by factors such as inhibitory control maturity than by age per se. This result shows that, like lower RT variability, error monitoring reflects a consistent and controlled performance strategy, and BTV disrupts that.

Conflict resolution. The Flanker Task requires the resolution of conflict for successful completion, thus the slower and less accurate performance in the presence of BTV may have resulted from interference with this EF process. Unfortunately, the effect of BTV on conflict resolution could not be directly tested in the 3- and 4-year-olds because accuracy dropped below chance on trials with incongruency and/or BTV. Given that 4-year-olds were accurate at above-chance levels on incongruent trials without BTV but not with it, does suggest an interference with the EF ability to resolve conflict, but, as stated, the direct comparison could not be made. Five-year-olds, on the other hand, resolved conflict with and without BTV. McDermott et al. (2007) found no conflict effects among their 6-year-olds and suggested they may have employed a strategy, based on knowledge, such as left and right, that the younger children did not yet have. For the 5-year-olds in the current study, BTV was harder to manage than conflict.

For young children, the Flanker Task can be difficult, as evident here. Modifications can simplify it, like giving more response time or spacing between fish to reduce conflict (McDermott et al., 2007). Though such modifications were made, the task still proved challenging, and with BTV added, performance dropped to chance for many. While this result is informative by showing that children could not maintain performance in the presence of BTV, floor effects precluded a direct analysis of the effect of BTV on conflict resolution. Future studies would use a more simplified form, such as the NIH Toolbox version, a product of a project funded specifically to develop measures that 3-year-olds can succeed on (Zelazo et al., 2013).

In sum, BTV interfered with every measure of Flanker Task performance. As discussed next, this was true whether children learned anything from the show or not.

Children Do Not Learn BTV Content as they Engage in a Play-based Activity

In the early days, TV research was often geared to how children attend to and learn from it. Comprehensibility and age-appropriateness of content were found to matter for engagement and learning, and, once they passed the age of the video deficit, children could learn facts, vocabulary, prosocial behaviours, and, unfortunately, aggression. It was also observed that children carried on with their toy play while TV was on, and that, with or without toys, they learned the same amount of TV content (Lorch et al., 1979; Sanchez et al., 1999). This feat was credited to a strategic use of attention. What was *not* measured was whether that learning came at any cost to the quality of the concurrent toy play. It has been learned since, and the current study extends those findings, that TV interferes with attention to play and social interactions and with the quality of the learning that takes place in those contexts. Contributing further to this literature, by measuring the cost, the current study also found that all but a half dozen children learned nothing from the Arthur program while concurrently playing the fish game (i.e., Flanker Task) and, whether or not they learned anything, their task performance suffered. Children in this study looked at the TV, and listened, as the high rates of missed trials and slowed responses indicated, but clearly, any information gathered was not richly encoded in this context of divided attention (Bauer et al., 1999; 2012). Thus, again, this calls into question the conclusion that children effectively divide attention between TV and toy play (Lorch et al., 1979; Sanchez et al., 1999). The current data clearly show children could not effectively ignore the TV, nor could they multitask. These data also dispute the notion that BTV can enrich ongoing learning during play. There is no benefit, only cost, to having TV on in the background. It would have been an interesting addition to the current study to test how much would be learned from the TV program by a group of children who were not simultaneously performing the Flanker Task. This would have provided a measure of potential learning and thus an indictor of how much can be lost to BTV.

BTV Effects on Attention and Task Performance Vary with Children's EF

Having higher EF should make it easier to manage difficult tasks and distractions. That is what this study found. On the more difficult delayed Story Task verbal recall and Flanker Task, children of all ages were adversely affected by BTV. Such was not the case on the Puzzle Task or on Story Task immediate verbal or delayed non-verbal recall. On these, children, overall, performed equally well with or without BTV. A comparison based on EF maturity, indexed by Day-Night Task scores, revealed what age group comparisons did not – that children with higher EF who were exposed to BTV while hearing the story, did, in fact, retain more of what they learned. While not a significant effect, it appeared (visual inspection of Figure 16) that children with the highest EF were approaching equal accuracy on TV-on and TV-off blocks of the Flanker Task, but only when the TV block came first. Perhaps an older group of children with more mature EF would have been able to maintain performance in the presence of BTV. Having higher EF helped children to manage BTV well enough to listen and learn from a story and to better maintain attention and performance on the Flanker Task, something children with lower EF could not do. However, attesting to the depleting effect of this effort, even the children with the highest EF, including some girls with higher parent-rated EF than the boys, showed no evidence of maintaining performance through a second round of the Flanker. Children with higher EF could hold out longer, but even their relatively higher resources became depleted as the task and BTV distraction continued.

The fact that BTV effects varied with EF but not among age groups highlights the great individual variation in the developmental trajectories of attention and EF processes. Older does not necessarily mean more mature when it comes to individual EF within the rapid development that characterizes the preschool years. In fact, 25% of the children with EF greater than the Day-Night median were 3-year-olds while 20% of those lower than the median was 5-year-olds. As discussed in the introduction, genes, and experiences such as exposure to BTV, shape EF development. Individual experiences matter as much as age.

Having higher EF did not make any difference to the detrimental effect of BTV on on-task looking during Story and Puzzle Tasks. Why not? As suggested in the earlier discussion on age differences, the effect of BTV depends on the balance of task, distractor, and child characteristics. It may be that even the higher EF children did not have sufficient attentional control to resist looking to TV, though they were better able to manage the distraction and maintain learning and performance. BTV is hard to resist and may be a "special sort of distractor with special consequences for cognitive performance" (Armstrong & Greenberg, 1990, p. 378). Also, it may be, as mentioned, that looking, or visual attention, is not an adequate indicator of how resources are being allocated when TV, which can be strategically monitored aurally, is on in the background (Hawkins at al., 1997, 2005).

The subsample of children (n=75) in this study assessed with the BRIEF-P had significantly higher EF than that of the BRIEF-P normative population. This is not surprising given the high level of education of the parents. The children in this study had identical Day-Night scores to those reported by others with highly educated parent participants (Barr et al., 2010). Maternal education, and SES, are known predictors of EF (Bernier et al., 2010; Mezzacappa, 2004; Raver, Blair, & Willoughby, 2013) and EF is highly heritable (Friedman & Mityake, 2017). Children of parents with higher EF are not only expected to inherit higher EF, but are also more likely to benefit from parents who are, as a result of their own EF, better equipped to provide the structured caregiving environment and responsive parenting that, independent of SES, further support EF development (Bernier et al, 2010). While this may be a limitation for the generalizability of the present results to children of other socioeconomic strata, it also serves to highlight the concern that if these relatively high EF children were distracted, engaged in less shared attention, learned less from stories and exhibited lower EF on tasks with BTV present, the effects would likely only be worse for those in the population with lower EF. In fact, it has been shown that EF heritability is lower and more open to environmental influence in those of lower SES (Friedman & Miyake, 2017) which suggests that children of lower SES may be more vulnerable to BTV and also more likely to benefit by limiting BTV exposure.

Preschool Children's Attention, Task Performance and EF Vary with BTV Exposure at Home

The ability to manage environmental distractors improves with experience, which suggests that children with greater BTV exposure might outperform those with less, but this study found the opposite (Armstrong & Greenberg, 1990; Courage & Howe, 2010). Children in homes with more BTV also watched more TV, used more games and devices, more often had a bedroom TV, had lower EF as measured by Flanker and Day-Night Task performance and parent-rated BRIEF-P, and children with lower EF were shown to be more negatively affected by BTV on challenging tasks. These findings align with many reports of negative associations between TV and attentional control (Kostryka-Allchorne et al., 2017).

These results support the proposal that BTV exposure has direct and indirect, and acute and chronic, effects on the development of attention and EF networks by continuously eliciting orienting responses and aural monitoring that interrupt and deplete executive attention and by recruiting alternate brain areas, like the striatum, to process information in superficial ways that leads to knowledge that is less flexible and durable than when attention is not divided. Without the powerful draw and cognitive challenge of engaging and fantastical programming, executive attention is permitted the resources and control to create stable and sustained focus on the task at hand, and shared attention with social partners who may scaffold the task, leading to uninterrupted and richer information processing mediated by preferred neural systems such as the medial temporal lobe that create robust declarative knowledge that can be flexibly applied to novel situations. The pathways that get the most practice become the strongest. By interrupting and displacing these processes, and the play and learning activities that engage them, BTV can impede optimal development, a problem that is only compounded with further BTV exposure.

The current results also support the idea that the practice of BTV may be a marker of parenting styles and household environments that are less optimal for supporting attention and EF development. Vaala (2014) reported that parent's practices regarding TV viewing were best predicted by whether they believed TV to be generally beneficial or harmful (see also Lauricella, Wartella, & Rideout, 2015). The present study extends these findings to parent practices regarding BTV by showing that those who believed it did not interfere with attention and play permitted more BTV, while parents who believed otherwise, limited BTV exposure. The present study also found that while parent BTV practices aligned with their beliefs they diverged from their child's reality. Parents who limited BTV had children with higher EF while the parents of those with lower EF, who were most vulnerable to BTV distraction, permitted more.

Parents who diverge on the practice of BTV may approach parenting differently. In this study, higher exposure to BTV was associated with more screen time and access to TV and devices. In other studies, these factors were also associated with BTV during bedtime and family meals, and BTV also indicated greater household chaos (Rideout, 2013; Vernon-Feagans et al., 2016; Martin et al., 2012). Parents in these homes may provide less structure, in the form of rules and limits, and possibly less responsive involvement, given that children spend more time with media and also had TV access in their own bedrooms. Conversely, parents who restricted BTV, also limited screen time, devices, and unsupervised access, as would be more likely with a bedroom TV, and they expressed more concern about the effects of BTV on their children's attention and play. This pattern suggests that these parents who limit BTV may also provide more of the structure and involvement that govern the everyday activities that teach children to manage their own behaviour and which support the development and practice of EF skills (Carlson, 2009; Grolnick, 2009). Parents vary by the degree of structure and involvement they provide their children and whether they do this while also supporting their child's autonomy, versus in a controlling manner, defines parenting styles that are reliably associated with child outcomes (Grolnick, 2009). Authoritative parents provide warm involvement and autonomy-respecting structure in the forms of scaffolding, rules, expectations, and predictable routines that are explained and discussed. Structure helps children develop from parent- or other-regulated to self-regulated (Bernier et al., 2010; Cuevas et al., 2014, Hughes & Devine, 2017). Children raised by authoritative parents have the best developmental outcomes, including higher EF (Grolnick, 2009). By contrast, Authoritarian parents are too controlling which impedes children's independence and opportunities to practice self-control, while Permissive and Uninvolved parents provide too little structure to optimally support EF development. Chronic BTV exposure may be an indicator of caregiving environments that tend to hinder more than help (Hughes & Ensor, 2009) and that may be more chaotic than predictable (Vernon-Feagans, et al., 2016). Parents create the media environment their children are exposed to and their parenting practices can mediate and moderate its effects on children's development (Gentile, Reimer, Nathanson, Walsh, & Eisenmann, 2014; Nathanson, 2015).

Given the importance of the caregiving environment and the influence of parent's beliefs on how they structure that environment, the fact that most parents view TV as more beneficial than harmful calls for greater education (Vaala, 2014). Research to date, including the current study, shows that the benefits of TV and video programming are constrained by content, context and the child's characteristics (Kostryka-Allchorne et al., 2017; Courage et al., 2015). Recommendations telling parents to simply limit TV may not be as effective (Evans, Jordan & Horner, 2011) as those that incorporate this evidence into more nuanced messages (Canadian Paediatric Society, 2017). Parents need to know that outside of the context of parent co-viewing and scaffolding and without well-developed educational content, BTV can be harmful, particularly for children with immature attentional control and EF skills.

Conclusion

This study adds to the accumulating evidence showing that for preschoolers, who are undergoing significant development of their attentional control and EF processes, child-directed programming, by its visually, auditorily, and, often, narratively rich nature, may be a uniquely engaging and powerful distractor (Armstrong & Greenberg, 1990;

Lillard, Li, et al., 2015). The consequence of exposure to this distractor is decreased attention to shared tasks and poorer processing, encoding and memory of information presented during those tasks. Chronic exposure, as may happen when the TV is always on, can only compound these negative effects. Well-practiced or easier tasks that require fewer resources are less affected by BTV. However, the kinds of cognitively challenging play and social activities that children learn the most from, that, according to theorists like Vygotsky (Bodrova et al., 2011), push their development forward, are those that require the greatest attention, deepest thinking and most resources, and thus are the most vulnerable to distraction. Its ability to engage also makes children's programming a potentially powerful teaching tool, a capacity that can be maximized when content is slow-paced, realistic and educational and when children co-view with someone who helps them to process the content. Simultaneous presentation of TV programming with play or challenging tasks creates attentional competition that can overwhelm children's resources preventing them from reaping the potential benefits of either activity. Basic attentional and EF processes subserve higher cognitive, social, emotional and behavioural control processes that are critical for adaptive functioning, thus it is imperative that children experience environments that optimize development. An optimal environment can include co-viewing of well-designed educational programming, but it does not include BTV.

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Appendix A
TV Conditions and Order of Tasks

	TV-off	**TV-on**	**TV-on/off**
Story Task			
1. Read the story, ask 5 *immediate verbal recall* questions during story	TV off	TV on	TV on
2. After story ends, ask 8 *delayed verbal recall* questions	TV off	TV on	TV off
3. Present Oscar Toy, ask to put together like in the story - *delayed non-verbal recall*	TV off	TV on	TV off
Puzzle Task			
1. Learn to match puzzles	TV off	TV on	TV on
2. Test of puzzle matching	TV off	TV on	TV off

The order of Story and Puzzle tasks was counterbalanced for half of the 36 children in each condition

Appendix B
The Story Text and Questions

Story Text and Immediate Verbal Recall Questions*	**Page**
Oscar Learns to Share	Cover
Hello there! Welcome to Sesame Street! Do you know these guys? Can you tell me their names?	1
Meet Oscar the Grouch. Oscar lives in a trash can on Sesame Street with his friend Slimey Worm. *(What is the name of Oscar's worm friend?)**	2
Meet Cookie Monster. Cookie monster loves cookies! His favourite kind of cookie is chocolate chip He is eating his last one now and wishes he had some more. He's hungry! *(What is cookie monster's favourite type of cookie?)**	3
Guess what??? Oscar finds cookies down in the bottom of his trash can. Cookie monster wants them!!! *(What did Oscar find in his trash can?)**	4
But Oscar says NO!!! He is a grouch and he does not want to share with Cookie Monster. So he starts to run away, but trips and falls down a flight of stairs! Bump, bump, bump! Ouch!	5
Now Oscar is broken into little pieces. The cookies spill out on to the ground! Poor Oscar! What is he going to do now?	6
Slimey Worm got a scare and has wiggled away. He is hiding under the trash can lid. (*Can you see where Slimey Worm is hiding)?**	7
Look! Here comes a little boy, maybe he can help. His name is Daniel, he is 5 years old. He is wearing a red shirt. *(How old is Daniel?)**	8
Daniel will try to put Oscar back together. Then Oscar can find Slimey Worm. He thinks maybe he should share his cookies with Cookie Monster. Watch very, very carefully to see how Daniel fixes Oscar.	9
First Daniel must find Oscar's legs so he can stand up. Do you see Oscar's legs? Daniel attaches them to Oscar's body and now he can stand up. Thanks Daniel!	10
Next, he must find Oscar's head. Do you see Oscar's head?	11
He must put Oscar's head back on so he can see where Slimey Worm is hiding.	12
Next he must find Oscar's arms. Do you see Oscar's arms?	13
Daniel puts Oscar's arms on so she can lift the trash can lid and find Slimey Worm.	14
Now he must find Slimey Worm. Do you see Slimey Worm?	15
Finally, with Daniel's help, Oscar can pick up Slimey worm.	16
Daniel helps Oscar and Slimey Worm get back in the trash can.	17
Remember, he first attached his legs to his body so he could stand up. Then he added his head so he could see. Then he added his arms so he could pick up Slimey. Finally he picked up Slimey and put him back in the can! Legs, Body, Head, Arms, Slimey, Can! All done! Great work Daniel!	18
Now Oscar is not feeling so grouchy. He is feeling thankful for having such great friends to help him. He decides to share his cookies with Cookie Monster! Good bye!! And Thanks for all your help!!	19

Delayed Verbal Recall Questions:

1	Oscar has a worm friend, what is his name?
2	What did Oscar find at the bottom of his trash can?
3	Where did Slimey worm hide when he got scared?
4	What happened to Oscar – why did he fall apart?
5	What was the little boy's/girl's name?
6	What is Cookie Monster's favourite cookie?
7	What did Oscar learn to do?
8	What other toy did we see the little girl/boy playing with?

Appendix C
The BRIEF-P

BRIEF-P

Behavior Rating Inventory of Executive Function-Preschool Version

RATING FORM

Gerard A. Gioia, PhD, Kimberly Andrews Espy, PhD, and Peter K. Isquith, PhD

Instructions to Parents and Teachers

On the following pages is a list of statements that describe young children. We would like to know if the child has had *problems* with these behaviors *during the past 6 months*. Please answer *all the items* the best that you can. Please do not skip any items. Think about the child as you read these statements and circle:

N	if the behavior is	**Never** a problem
S	if the behavior is	**Sometimes** a problem
O	if the behavior is	**Often** a problem

For example, if having tantrums when told "No" is **never** a problem, you would circle **N** for this item:

Has tantrums when told "No" (N) S O

If you make a mistake or want to change your answer, ***DO NOT ERASE***. Instead draw an **X** through the answer you want to change and then circle the correct answer:

Has tantrums when told "No" ~~N~~ (S) O

Before you begin answering the items, please fill in the child's name, gender, age, and birth date, as well as your name, relationship to the child, and today's date in the spaces provided at the top of the next page. <u>If you are the child's teacher or child care provider, please check the box next to the response that best describes how well you know the child and indicate how long you have known the child in the space provided</u>.

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Child's Name ______________ Gender ________ Age ________ Birth Date ___/___/___

Your Name ______________ Today's Date ___/___/___

Relationship to Child: ☐ Mother ☐ Father ☐ Teacher* ☐ Other* ______________

How well do you know the child? ☐ Not Well ☐ Moderately Well ☐ Very Well *Have known the child for_____ ☐ months ☐ years.

During the past 6 months, how often has each of the following behaviors been a *problem*?	Never	Sometimes	Often
1. Overreacts to small problems	N	S	O
2. When given two things to do, remembers only the first or last	N	S	O
3. Is unaware of how his/her behavior affects or bothers others	N	S	O
4. When instructed to clean up, puts things away in a disorganized, random way	N	S	O
5. Becomes upset with new situations	N	S	O
6. Has explosive, angry outbursts	N	S	O
7. Has trouble carrying out the actions needed to complete tasks (such as trying one puzzle piece at a time, cleaning up to earn a reward)	N	S	O
8. Does not stop laughing at funny things or events when others stop	N	S	O
9. Needs to be told to begin a task even when willing to do it	N	S	O
10. Has trouble adjusting to new people (such as babysitter, teacher, friend, or day care worker)	N	S	O

11. Becomes upset too easily	N	S	O
12. Has trouble concentrating on games, puzzles, or play activities	N	S	O
13. Has to be more closely supervised than similar playmates	N	S	O
14. When sent to get something, forgets what he/she is supposed to get	N	S	O
15. Is upset by a change in plans or routine (for example, order of daily activities, adding last minute errands to schedule, change in driving route to store)	N	S	O
16. Has outbursts for little reason	N	S	O
17. Repeats the same mistakes over and over even after help is given	N	S	O
18. Acts wilder or sillier than others in groups (such as birthday parties, play group)	N	S	O
19. Cannot find clothes, shoes, toys, or books even when he/she has been given specific instructions	N	S	O
20. Takes a long time to feel comfortable in new places or situations (such as visiting distant relatives or new friends)	N	S	O

21. Mood changes frequently	N	S	O
22. Makes silly mistakes on things he/she can do	N	S	O
23. Is fidgety, restless, or squirmy	N	S	O
24. Has trouble following established routines for sleeping, eating, or play activities	N	S	O
25. Is bothered by loud noises, bright lights, or certain smells	N	S	O
26. Small events trigger big reactions	N	S	O
27. Has trouble with activities or tasks that have more than one step	N	S	O
28. Is impulsive	N	S	O
29. Has trouble thinking of a different way to solve a problem or complete an activity when stuck	N	S	O
30. Is disturbed by changes in the environment (such as new furniture, things in room moved around, or new clothes)	N	S	O

During the past 6 months, how often has each of the following behaviors been a *problem*?

		Never	Sometimes	Often
31.	Angry or tearful outbursts are intense but end suddenly	N	S	O
32.	Needs help from adult to stay on task	N	S	O
33.	Does not notice when his/her behavior causes negative reactions	N	S	O
34.	Leaves messes that others have to clean up even after instruction	N	S	O
35.	Has trouble changing activities	N	S	O
36.	Reacts more strongly to situations than other children	N	S	O
37.	Forgets what he/she is doing in the middle of an activity	N	S	O
38.	Does not realize that certain actions bother others	N	S	O
39.	Gets caught up in the small details of a task or situation and misses the main idea	N	S	O
40.	Has trouble "joining in" at unfamiliar social events (such as birthday parties, picnics, holiday gatherings)	N	S	O
41.	Is easily overwhelmed or overstimulated by typical daily activities	N	S	O

42.	Has trouble finishing tasks (such as games, puzzles, pretend play activities)	N	S	O
43.	Gets out of control more than playmates	N	S	O
44.	Cannot find things in room or play area even when given specific instructions	N	S	O
45.	Resists change of routine, foods, places, etc.	N	S	O
46.	After having a problem, will stay disappointed for a long time	N	S	O
47.	Cannot stay on the same topic when talking	N	S	O
48.	Talks or plays too loudly	N	S	O
49.	Does not complete tasks even after given directions	N	S	O
50.	Acts overwhelmed or overstimulated in crowded, busy situations (such as lots of noise, activity, or people)	N	S	O
51.	Has trouble getting started on activities or tasks even after instructed	N	S	O
52.	Acts too wild or out of control	N	S	O

53.	Does not try as hard as his/her ability on activities	N	S	O
54.	Has trouble putting the brakes on his/her actions even after being asked	N	S	O
55.	Unable to finish describing an event, person, or story	N	S	O
56.	Completes tasks or activities too quickly	N	S	O
57.	Is unaware when he/she does well and not well	N	S	O
58.	Gets easily sidetracked during activities	N	S	O
59.	Has trouble remembering something, even after a brief period of time	N	S	O
60.	Becomes too silly	N	S	O
61.	Has a short attention span	N	S	O
62.	Plays carelessly or recklessly in situations where he/she could be hurt (such as playground, swimming pool)	N	S	O
63.	Is unaware when he/she performs a task right or wrong	N	S	O

Appendix D

Parent Media and Demographics Questionnaire

Your child's name: ______________________________________

Child's gender: Female □ Male □

Child's date of birth: ______/_______/_________

day / month / year

YOUR CHILD'S EXPERIENCE WITH TELEVISION AND MEDIA

1. How much time does your child spend watching TV (or other screen media, including videos and DVDs) on an average day?

Weekdays__________ Weekends__________

2. How much time does your child spend playing video games on a gaming system (e.g., Wii; Nintendo DS, PlayStation etc.) or computer, tablet or smart phone on an average day?

Weekdays__________ Weekends____________

3. In your home, how often is a TV on, even if no one is actually watching it?

Never	Rarely	Sometimes	Often	Most of the Time

4. When your child is playing and a TV is on in the background, how frequently does it distract his/her attention from the activity?

Never	Rarely	Sometimes	Often	Most of the Time

5. Please rate on the scale below: When watching TV, how focused does your child become on the TV?

Not very, it is easy to get his/her attention	1	2	3	4	5	Very focused, difficult to get his/her attention

6. Please rate on the scale below: When playing, how focused does your child become on the activity?

Not very, it is easy to get his/her attention	1	2	3	4	5	Very focused, difficult to get his/her attention

7. Does your child have a TV in his or her bedroom? YES NO

---

8. Please indicate all the gaming systems/devices your child has played with:

Nintendo DS	PlayStation	XBOX	Wii	PSP	PC	Tablet	Smart Phone	Other please name

9. How many brothers/sisters does your child have in the home and what are their ages?

___________ Ages: ____

10. Please indicate your highest level of education completed:

- ☐ Less than high school
- ☐ Graduated high school
- ☐ Some technical or trade college or university
- ☐ Completed a technical or trade college diploma program
- ☐ Completed a university degree program

Thank You