Emotional Regulation and Attention in Four Year Old Children

by

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Abstract

Understanding behaviour as the intersection of social and biological factors is reflected in the work of Posner and Rothbart (2000), who focus on the relationship between self-regulation, temperament, and attention. This project examined these ideas by investigating the relationship between Posner and Petersen's (1990) proposed attention networks [orienting, vigilance, executive attention] and emotional regulation in 4 year old children. The hypotheses were that emotional regulation would be related to executive attention, but not to orienting and vigilance. Forty five children were tested on measures of orienting, vigilance, and executive attention. Emotional regulation was assessed via parental report and children's performance on a competitive game where 'disruptive behaviour' was coded. Emotional regulation did not relate to orienting and vigilance. Children who engaged in more cheating, appeals, and insults obtained lower accuracy scores on aspects of executive attention measures. Implications are discussed.

Examiners:

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The frontal cortex is often conceptualized as the seat of higher order functioning (Fuster, 1999). The role attributed to the frontal cortex is reflective of the role it plays in functions such as judgment, planning, decision making, and self-perception, which have been termed 'executive functions' (Tranel, Anderson, & Benton 1994).

The frontal cortex undergoes extensive development throughout childhood (Thatcher, 1997), and parallels the development of executive functions (Diamond, 2002). Advances in executive functioning are observed in the preschool period (Diamond, 2002; Jacques & Zelazo, 2001; Welsh & Pennington, 1988), which is also a time when advances in social and emotional domains occur (Fox, 1994). The simultaneity of social and biological advances highlights the notion that development can be approached through multilevel analysis (Caldwell, 1994) that considers social and biological forces. This approach can be found in the work of Bandura, Piaget, and Vygotsky (Tudge & Winterhoff, 1993), and is the focus of social neuroscience, a discipline concerned with the interaction of the brain and the social world (Cacioppo & Bernston, 2002).

The orientation of understanding human behaviour as the intersection of social and biological factors is reflected in the work of Posner and Rothbart (1991, 1994, 1998, 2000), who focus on the relationship between self-regulation, temperament, and the organization of attentional systems in the brain.

The focus of the project described in this paper is the relationship between attentional systems and self-regulation in 4 year old children. The two primary areas of relevance in this paper are regulation and attention, and this paper is organized around these topics. A definition of self-regulation and its importance to theory and practice is

presented first, followed by discussion of the characteristics of the vigilance, orienting, and executive attention systems. The next section is devoted to a discussion of why a relationship between executive attention and self-regulation is expected, followed by a review of studies conducted on this topic. Objectives of the current study are then presented, followed by methodological concerns associated with the study of emotional regulation, and how these pertain to the study described herein. Next, unexplored questions in the literature and hypotheses of the current study are discussed. Next, methodology employed in the study (participants, measures, and procedures) is presented, followed by the results of statistical analyses. Finally, limitations, implications, and future areas of research are discussed.

Self-Regulation

Kopp (1982, as cited by Ruff & Rothbart, 1996) has provided a definition of self-regulation. According to this definition, self-regulation includes the ability to: a) comply with a request, b) initiate and cease activities according to situational demands, c) modulate the intensity, frequency, and duration of verbal and motor acts in social and educational settings, d) postpone acting upon a desired object or goal, and e) generate socially approved behaviour in the absence of external monitors. The commonality among these functions is an awareness of socially approved behaviours (Kopp, 1982).

Self-regulation is an important construct in both developmental psychology and models of executive functions. Regulation becomes especially important in the preschool years, as the standards of conduct demanded at school entry require children to inhibit disruptive behaviour and cooperate with others (Gilliom, Shaw, Beck, Schonberg, & Lukon, 2002). Throughout childhood and adulthood, regulation is demanded in diverse

contexts, from close relationships to behaviour in public settings (Gilliom et al.).

Dysregulation of self-control capacities is manifest in many childhood disorders (Fox, 1994), which has led some to identify the study of regulation as the most important means of advancing the field of developmental psychopathology (Posner & Rothbart, 2000). The study of regulation is also important in theoretical terms. Specifically, it has been suggested that the study of self-regulation has the potential to integrate understanding of typical and atypical development (Cole, Martin, & Dennis, 2004), and elucidate the relationship between cognition, motivation, and action (Kopp, 1989).

Self-regulation of affect/motivation/arousal is one of the main components of Barkley's (1997) framework of executive functions. Barkley views self-regulation of affect/motivation/arousal as the ability to emote or motivate oneself, which allows one to engage and persist in behaviour across time toward a future outcome. In addition, Barkley conceptualizes self-control as the outcome of executive functioning.

Hayes, Gifford, and Ruckstuhl (1996) suggests that executive function tasks are those in which habitual sources of behavioural regulation are ineffectual, thus prompting use of alternative resources in order to control behaviour. Similarly, Graham and Harris (1996) conceptualize executive function as flexible use of strategies and self-control processes (goal-setting, planning, monitoring, and interference control). The perspective put forth by Hayes et al. and Graham and Harris has led Eslinger (1996) to identify behavioural self-regulation as an important theme in executive function theory.

Although the construct of executive functions has been criticized as being conceptually vague and poorly defined (Tranel et al., 1994), the notion that the development of these capacities allows one increasing independence from the

environment appears across models of executive functions (Barkley, 1997; Eslinger, 1996; Welsh & Pennington, 1988). As regulatory capacities are purported to allow increasing independence from external influences, a theme in the concept of self-regulation is internal control of behaviour (Ruff & Rothbart, 1996), which is very similar to conceptualizations of executive functions.

The connectedness of executive functions and self-regulation is one way of conceptualizing the relationship between higher order cognitive functioning and self-regulation. This relationship can also be viewed through the connection between executive attention and self-regulation (Posner & Rothbart, 2000).

The Cognitive Neuroscience of Attention

Posner and Petersen (1990) have devised a theoretical framework encompassing three attentional networks (vigilance, orienting, and executive attention networks). In addition, Ruff and Rothbart (1996) have constructed a framework for understanding the development of the orienting and executive attention networks in early childhood. Both these frameworks are utilized in the following sections to describe the development, neuroanatomical constituents, and tools used to measure the attentional networks.

The vigilance network.

The primary function of the vigilance network is the maintenance of an alert state. Vigilance allows one to be alert while exploring the environment, and is thus considered a basic form of attention, which supports other cognitive and perceptual functions (Parasuraman, Warm, & See, 1998). The vigilance network involves the right parietal lobe, right frontal cortex, as well as the locus coeruleus (Posner & Petersen, 1990).

Posner (1978) has used warned reaction time tasks to study vigilance. These reaction time paradigms generally involve serial presentation of a warning and a reaction signal to which the participant is required to respond to as quickly as possible (Murphy-Berman & Wright, 1987).

In the framework put forth by Ruff and Rothbart (1996), vigilance does not occupy a prominent role. This may be due to the fact that the authors credit the vigilance network as supportive of the functioning of the orienting and executive attention networks. Based on a decrease in errors of omission and response time on a reaction time task over 3.5 to 4.5 years of age, as well as decreases in instances of looking away during tasks demanding different degrees of attention (Ruff, Weisbsberg, Lawson, & Cappozzoli, 1995, as cited by Ruff & Rothbart), Ruff and Rothbart postulate that it is at this time that the vigilance network advances (Akshoomoff, 2002) or comes under the child's internal verbal control. Morrison (1982) found that 8 year olds and adults alerted more quickly and sustained alertness better than 5 year olds, suggesting that vigilance develops relatively early and is at an adult level at some time between age 5 and 8.

The orienting network.

The orienting system has been contrasted with the executive attention system, the former being conceptualized as the lower order of the two (Ruff & Rothbart, 1996). The processes characteristic of this network include engaging, disengaging, and shifting attention (Posner & Petersen, 1990). The brain areas involved in this network include the posterior parietal lobes, the pulvinar nucleus of the thalamus, and the superior colliculus (Posner & Petersen).

The attentional direction in this network is bottom-up, indicating that it is an exogenous, stimulus-driven type of control. The orienting network encompasses two other networks, specifically one that orients to locations (the 'where' system) and one that is involved in object recognition (the 'what' system; Ungerledier & Mishkin, 1982).

This network is tested through use of a spatial orienting paradigm designed by Posner and Cohen (1984). In this task, a location cue is presented (on one of two sides of the screen), followed by a target. If the cue is 'valid' this means that it appeared in the same location as the target. The cue is 'invalid' if it appears in the opposite location of the target. Response times are faster for validly cued trials than invalidly cued trials.

The heavy involvement of subcortical structures in this system has led researchers to postulate that this attention system emerges and develops early in life (Posner, Rothbart, Thomas-Thrapp, & Gerardi, 1998). As a consequence, much research has been conducted on the development of the orienting system in infancy, allowing Ruff and Rothbart (1996) to summarize that attraction to "biological importance, operant contingency, signal value, novelty, intensity, and unpredictability" (Waters & Wright, 1979 p. 111) dominates in the first year of life (Ruff & Rothbart, 1996).

Preference for this type of stimuli can be seen in a newborn, whose attention is gained by patterns and objects with large features and high contrast. The tendency for attention to be directed is so powerful that infants have trouble disengaging their look once a salient stimulus has been presented (Stechler & Latz, 1966). This develops further at 2 to 3 months, when an infant begins to have more specific preferences (such as faces or bulls eyes; Ruff & Turkewitz, 1975, 1979), and are better able to disengage attention

(Johnson, Posner, & Rothbart, 1991). The refinement of this system continues, as the 'what' and 'where' systems develop and exploratory activity predominates (Gibson, 1988).

The period of 9 to18 months represents a transition period, during which attention becomes increasingly controlled by the executive attention system as opposed to the orienting system. Ruff and Rothbart (1996) postulate that behaviour then becomes controlled by internally generated plans rather than attributes of the environment, thus making attention more endogenous (goal-directed) than exogenous (stimulus directed).

The executive attention network.

The most sophisticated attentional network is the executive attention system. Posner and Petersen (1990) describe this system as involving the midline frontal areas (the anterior cingulate, the supplementary motor area, and portions of the basal ganglia).

Operations associated with this network include: target and error detection, conflict resolution, inhibition, and goal-directed behavior (Bush, Luu, & Posner, 2000). In 1978, Posner appears to have conceptualized this network as 'conscious attention', and attributed to it functions of inhibition (higher level systems inhibiting lower systems from acting,), translation (coordination of activities of sub-systems by a central system), and generalization (flexible application of patterns of behaviour).

As is perhaps evident from the heterogeneity of these functions, the term 'executive attention' can be used in many ways. In recognition of this difficulty, Posner and DiGirolamo (1998) utilized the rubric of Norman and Shallice's (1986) model of attention, which although criticized as postulating a homonculus (Zelazo & Mueller, 2002), provides a framework to organize the functions of the executive attention network. The Norman-Shallice model consists of subsystems controlled by either contention

scheduling, or the supervisory attentional system.

Contention scheduling uses condition ('if') to action ('then') statements to coordinate behaviours and thoughts that are well-learned (Posner & DiGirolamo, 1998). However, if a situation is encountered in which automatic processing is insufficient, the supervisory attentional system operates. The specific situations in which executive control (via supervisory attentional system) is required are identified by Norman and Shallice (1980, 1986 as cited by Posner & DiGirolamo) as: planning/decision-making, error correction, novel or not well-learned responses, conditions deemed difficult or dangerous, and overcoming habitual responses.

The supervisory attentional system becomes critical under these conditions, as it has access to both representations of the environment and the internally generated goals of the individual. Thus, this system operates when routine processing is inadequate, or when environmental representations or goals change (Posner & DiGirolamo, 1998).

Although not specifically identified by Posner and DiGirolamo (1998) as part of the executive attention network, it can be argued that working memory is subsumed within the executive attention network. Working memory can be defined as the ability to maintain and transform temporary information during mental operations (Hitch & Towse, 1995), which resembles Posner's (1978) 'translation' function (the coordination of the activities of specific systems by a central system). Baddeley and Logie (1999) view working memory as instrumental in enabling humans to comprehend and represent their environments, acquire new knowledge, and formulate goals. These types of skills are like those functions assigned to the executive attention system, leading some researchers to describe working memory as primarily attention (Engle, 2002). Working memory's

prominence in multiple executive function models [Barkley (1997); Denckla (1996); Roberts & Pennington (1996)], also speaks to it's supervisory function and fit with the Norman- Shallice model of supervisory attention. In addition, it has been suggested that inhibition and working memory operate interactively (Roberts & Pennington, 1996), and are thus difficult to separate completely. In previous research it has been shown that there is often overlap in task demands of these abilities. For example, in conflict tasks children are required to suppress an inappropriate response (inhibition), but also activate and maintain the 'appropriate' response (working memory; Carlson, Moses, & Breton, 2002; Roberts & Pennington, 1996). For these reasons, working memory as well as inhibition tasks will both be termed 'executive attention' in this thesis.

In their review of the functions performed by the anterior cingulate, Posner and DiGirolamo (1998) posited a prominent role for the anterior cingulate in the supervisory attentional system described by Norman and Shallice (1986). The reasons for this are its involvement in planning/decision-making (Colebatch, Cunningham, Deiber, Frackowiak & Passingham, 1991 as cited by Posner & DiGirolamo), error correction (Dehaene, Posner, & Tucker, 1994), novel or not well-learned responses, and in situations that involve overcoming habitual responses (Pardo, Pardo, Janer, & Raichle, 1990).

The development of the anterior cingulate, like many frontal regions, is protracted (Conel, 1939-1967, as cited by Bush et al., 2000). The executive attention network is the last of the attentional networks to develop, emerging near the first year of life and evidencing important transitions at 18 months and 4 years (Ruff & Rothbart, 1996). Ruff and Rothbart view focused attention as reflective of the development of the executive attention network, and suggest that it is the child's goal-directed behaviour that

propels his/her ability to focus attention. Given the supervisory nature of executive attention, however, it is also probable that development of the executive attention network is reflected in advances in executive functioning, which reportedly undergo advances at 18 months (Welsh & Pennington, 1988) and 4 years (Diamond, 2002).

The high order nature of the executive attention has led some to suggest that it also plays a role in higher order behavioural functions, including self-regulation (Posner & Rothbart, 2000). The rationale for suspecting a relationship between self-regulation and executive attention can be found in the work of Luria, Posner, Ruff and Rothbart, and from research conducted on anterior cingulate structure and function.

Luria and Posner's Conceptualizations of the Attentional Systems

Luria's (1973) distinction between an involuntary attentional system and a voluntary, socially based attention system stimulated the thinking of Posner and colleagues (Rothbart, Posner, & Boylan, 1990). Ruff and Rothbart (1996) also utilize Luria's theory in support of their framework.

Luria's involuntary attention system, which corresponds to Posner and Petersen's (1990) orienting network, is characterized by attention that predominates during the first few months of life, and is attracted by biologically salient stimuli (Luria, 1973). In contrast, the second attention system (first identified by Vygotsky) is higher order and voluntary, and undergoes a lengthy formation, stabilizing during the preschool period (Luria, 1973). The ideas proposed by Luria, in combination with the contemporary study of attention, prompted Posner and colleagues to view the development of self-regulation as the result of the interaction of biological and social forces.

One of the points of divergence between Luria and Posner's perspectives on the attention systems is that Luria conceptualized the involuntary system as devoid of social roots. Posner and colleagues, however, view the orienting system as linked with social forces. For instance, Posner and Rothbart (1994) suggest that up until children are 3 months old, caregivers attempt to mitigate distress by merely holding and rocking infants. However, at 3 months of age, when the orienting system is developing, caregivers begin to soothe infants by drawing their attention to other stimuli (distraction).

Harman and Rothbart (1992, as cited by Posner and Rothbart, 1994) conducted a study of the relationship between distress and attention in infants 3 to 4 months of age. Initially, infants in their study were overstimulated by lights and sounds, which reportedly induced distress. Infants were then presented with interesting auditory and visual events. They strongly oriented to these stimuli, and facial and vocal signs of distress disappeared. When the interesting event was removed, signs of distress reappeared. Posner and Rothbart (1994) interpreted this as suggesting that there exists an internal system that "hold[s] the initial level of distress and it returns if the infant's orientation to the novel event is lost" (Posner & Rothbart, 1994, p.48), a system also termed the 'distress keeper' by Harman, Rothbart, & Posner (1995, as cited by Harman & Fox, 1997). The interaction between orienting and distress also provides evidence that distress and orienting utilize the same cognitive resource. Thus, as the orienting network is utilized, distress is diminished, and regulation of emotion is the observed result.

As the infant grows into a child, the link between self-regulation and the orienting network may subsequently be paralleled by the relationship between self-regulation and the executive attention network. The influence of the development of executive attention

can be thought of in terms of Denckla's (1996) assertion that "a great deal of the difference between child and adult resides in the unfolding of executive functions" (p. 264). That is, as the child becomes older, the development of functions characteristic of the executive attention network (conflict resolution, error and target detection, inhibition, and goal-directed behaviour), combined with social forces acting as the bridge "between the elementary forms of involuntary activity and the higher forms of voluntary attention" (Luria, 1973, p. 262-263), allow self-regulation to become the domain of the executive attention network rather than the orienting network (Harman & Fox, 1997).

Themes Gleaned From Ruff & Rothbart

Luria and Posner's ideas concerning the complex interactions among environmental influences and attention development are echoed in the theory put forth by Ruff & Rothbart (1996). In this theory, the development of the attention networks is related to multiple other factors, including brain development, social influences, and changes in physical and cognitive capacities of the child. This notion can be illustrated by considering processes that occur in a 9 month old child (Ruff & Rothbart).

In terms of brain development, 3 to 9 months of age is a time when the visual system and anatomical constituents of the orienting system are rapidly developing (Aslin, 1987). This development supports disengaging, shifting, and orienting to novel events.

In terms of social influences, it is at 9 months that an infant begins to engage in social referencing and shared attention. Not only do these enable the infant to interact more competently with caregivers, but this development is also reflective of the infant's ability to exert control of attentional capacities.

Physical changes also occur at this time, allowing the infant to crawl and manipulate and visually explore objects, allowing the infant to gain new perspectives on the environment (Bertenthal & Campos, 1990, as cited by Ruff & Rothbart, 1996).

At approximately 9 months of age, developments in the cognitive system also occur, such as improvements in memory (Bell & Fox, 1992; Fox, Kagan, & Weiskopf, 1979) and problem solving (Willats & Rosie, 1989, as cited by Ruff & Rothbart, 1996).

Anterior Cingulate Structure and Function

A third reason to expect a relationship between attentional control and regulation can be derived from research into the anterior cingulate, a region conceptualized as the locus of control in the executive attention network. In their review of anterior cingulate function and structure, Bush et al. (2000) ascertained that the anterior cingulate is involved in the regulation of cognitive and emotional processing. Bush et al. describe the anterior cingulate as comprised of two subdivisions. The first subdivision is termed dorsal cognitive (ACcd), and the second is termed rostral-ventral affective (ACad).

The cognitive division (ACcd) is involved in influencing sensory or response selection, monitoring competition, error detection, complex motor control, working memory, and anticipation in cognitively demanding tasks. This division is activated by tasks that involve stimulus-response selection with competing information, such as Stroop tasks, divided attention tasks, and working memory tasks.

The affective division (ACad), in contrast, is involved in assessing emotional and motivational information and regulating emotional responses. This division is activated in studies of emotional processing, symptom provocation in psychiatric disorders (such as anxiety, phobia), as well as induced sadness in normal participants.

Brief Review of Studies Directly Relevant to the Topic of Interest

There have been few published studies investigating the hypothesized relationship between executive attention and self-regulation (Berger, Jones, Rothbart, & Posner, 2000; Gerardi-Caulton, 2000; Davis, Bruce, & Gunnar, 2002; Wolfe & Bell, 2003).

Gerardi-Caulton (2000) designed a task intended to tap into executive attention capacities of children age 24, 30 and 36 months of age. This task was designed to be a variant of the Stroop task (Simon task; Lu & Proctor, 1995), identified by Posner and Rothbart (2000) as the most frequently used task that activates the frontal midline. Rather than the verbally demanding Stroop task used with adults, this task presented a conflict between location and identity and was thus labeled the Spatial Conflict task.

Two response buttons were located in front of the child. Picture A was depicted on the left button, and Picture B was depicted on the right button. Compatible trials were those in which Picture A was flashed on the left side of the computer screen (or Picture B on the right side of the computer screen). Incompatible trials were those in which Picture A was flashed on the right side of the computer screen (or Picture B on the left side of the computer screen). The incompatible trials thus posed a conflict between location (left or right side) and identity (Picture A or Picture B). The child was required to press the button that corresponded to the picture on the screen. Success on the incompatible trials required pressing the button that matched the picture presented on the screen, thus inhibiting the prepotent response of responding based on location (i.e. right or left side presentation) in favour of responding based on identity (Picture A or Picture B).

This measure of conflict resolution was compared to performance on various measures of inhibition as adapted from Kocahanska, Murray, Jacques, Koenig, and

Vandegeest (1996, as cited by Gerardi-Caulton, 2000). These tasks included paradigms called "Snack Delay", "Whisper", and "Tower". "Snack Delay", a measure of delay of gratification, consisted of the placement of a treat under a clear cup. The child was required to wait for the bell to ring before lifting the glass and eating the snack. A failure of inhibition in this task consisted of prematurely lifting the cup. "Whisper" involved the presentation of cards of cartoon characters, of which the child was instructed to 'whisper' the identities. A failure of inhibition in this task involved saying the names of the characters in a voice louder than a whisper. The final task used to assess inhibition was "Tower", which consisted of taking turns while building a tower out of wooden blocks. A failure of inhibition on this task was manifest as failing to take turns.

Performance on the measures of inhibitory control ("Tower", "Whisper", "Snack Delay") and executive attention (Spatial Conflict task) were compared with parental reports of effortful control [assessed by the Child Behaviour Questionnaire (CBQ)]. Congruent with the hypothesized relation between self-regulation and attentional control, significant associations between performance on inhibitory tasks, parental reports of effortful control, and elements of the executive attention measure were found.

A second study examining the relationship between self-regulation and executive attention was conducted by Davis et al. (2002). The aim of this study was to extend the findings of Gerardi-Caulton (2000) to include tasks that have been demonstrated via imaging studies to involve the executive attention system. Tasks used to assess executive attention included "Go/NoGo" and "Attentional Control" tasks. The "Go/NoGo" task required the child to respond to every letter presented on the computer screen except the letter X. In this way, this task measures the ability to inhibit a prepotent motor response

by attending and responding selectively to target stimuli (all letters besides X) while inhibiting responses to non target stimuli (Xs). The "Attentional Control" task involved the presentation of three stimuli on a computer screen. The stimuli varied either in shape (circles or squares) or in color (black or white). The child was required to determine which of the three stimuli was different from the other two, but was not told in advance what feature (color or shape) would be discriminatory. This task required the child to process many attributes, and inhibit attention to features that were not relevant.

In their study, Davis et al. (2002) also assessed the ability to delay gratification. The measures used were adapted from Kochanska, Murray, and Coy (1997). The first was "Dinky Toys", which required the child to choose a prize from a box. However, the child was required to do so while keeping his/her hands on his/her lap, and was not permitted to touch or point. A failure to delay gratification was manifest as pointing, touching, or grabbing the prize. The second delay of gratification task employed in this study was the "Gift Task". The child was told that (s)he would receive a prize, but the researcher would have to wrap it first, and the child was not allowed to peek. The child sat facing away from the researcher, who noisily wrapped a gift and then left the room to 'get a ribbon'. A failure to delay gratification was manifest as peeking at the gift.

These investigators hypothesized that three scales of the CBQ, Inhibitory Control (ability to plan and suppress inappropriate responses under novel or uncertain conditions), Attention Focusing (ability to maintain attentional focus on tasks), and Impulsivity (speed of response initiation), would be related to performance on executive attention ("Go/NoGo", "Attentional Control") and delay of gratification tasks ("Dinky Toys", "Gift"). The investigators found that parental ratings of Inhibitory Control and

Impulsivity were related to accuracy on the executive attention tasks. The authors failed to find a relationship between delay of gratification measures and the executive attention tasks, which they speculated may be due to the instability of the delay of gratification tasks, which require multiple measures to achieve stability.

The third study of relevance is that conducted by Berger et al. (2000). Though intended primarily as an investigation of adult attention tasks adapted for children, the authors were able to examine the relationship between a child version of the Stroop and the CBQ. In this Stroop variant, conflict was created by presenting two animals (e.g. cat and dog) while simultaneously presenting the sound made by one of the animals (e.g. a bark). In the incompatible condition, the child's task was to touch the animal that did not match the sound (while viewing a cat and a dog and hearing a bark, the child was to touch the cat). The authors found that the compatibility effect (i.e. difference between reaction times on compatible and incompatible trials) was inversely related to the Effortful Control factor on the CBQ, indicating that children less slowed by conflict were also more efficient at controlling their behaviour (according to parental report).

A fourth study of relevance was conducted by Wolfe and Bell (2003), who investigated inhibition (Stroop, "yes-no"), delay of gratification (labeled as laboratory temperament measures; "Tongue", "Dinky Toys", "Wrapped Gifts", "Bow" tasks), physiological functioning (EEG, heart rate), temperament (CBQ), and language (Peabody Picture Vocabulary Test-Revised) in children 4 years of age. The authors were interested in investigating how physiology, temperament and language contribute to inhibition.

The inhibition tasks used included the day-night Stroop task and the "yes-no" task. In the day-night Stroop, the child is instructed to say "day" when presented with a

card with a picture of a yellow moon, and to say "night" when shown a card with a picture of a yellow sun. In the "yes-no" task, the child is instructed to say "no" when the experimenter nods yes, and say "yes" when the experimenter nods "no". The "Dinky Toys" and "Wrapped Gift" tasks were as described previously. In the "Tongue" task, the child was challenged to hold a treat on his/her tongue without chewing, for increasing intervals of time. The latency to swallow or chew the candy was recorded, with shorter latencies indicative of failure to delay gratification. The "Bow" task was a variation of the "Wrapped Gift" task, whereby after the experimenter wrapped the gift s/he put the gift on the table in front of the child and left the room to "get a bow", instructing the child not to touch the gift until s/he returned. Touching, lifting, or opening the gift were manifest as failures to delay gratification. Each scale from the CBQ was administered, with hypothesized relations between performance on the inhibition and delay of gratification tasks and the Effortful Control factor and Anger/Frustration scale.

The authors found relationships between the inhibition tasks and the Attentional Focusing, Inhibitory Control, and Anger/Frustration scales of the CBQ. They found a relationship between the "Wrapped Gift" task and performance on the inhibition tasks, and correlations between scales of the CBQ and the "Tongue" and "Wrapped Gift" task.

Questions Unexplored in Previous Studies and Purpose of Current Study

Although the studies conducted by Gerardi-Caulton (2000), Davis et al. (2002), Berger et al. (2000), and Wolfe and Bell (2003) yielded valuable information, there remain multiple questions regarding the relationship between attentional control and self-regulation. The aforementioned studies limited direct observation of self-regulation to delay of gratification tasks. It is important to examine the ability to control emotion in

social and highly affective contexts. Despite the emphasis placed by Posner and Rothbart on the bidirectional relationship of attentional control and social behaviour, few studies have yet tested this idea through direct observation in controlled conditions, which invoke the need for emotional regulation in a social context.

The primary measure used in the aforementioned studies to assess self-regulation was the Effortful Control dimension of the CBQ, a factor that includes the scales of Inhibitory Control, Attention Focusing, Perceptual Sensitivity, and Low Intensity Pleasure (Ahadi, Rothbart, & Ye, 1993; Rothbart, Ahadi, Hershy, & Fisher, 2001). Descriptions and sample items from these scales are provided in Appendix C. While it is logical to view Effortful Control as an integral component of self-regulation, it is also conceivable that compromised self-regulation (as defined by Kopp, 1982) would be manifest as disruptive behaviour, anger, or frustration, indicating difficulties with emotional regulation.

The relationship between attentional control and emotional regulation has been posited in the literature. For example, Derryberry and Rothbart (1988) propose a link between attentional control and self-regulation of emotion. Posner and Rothbart (2000) suggest that attentional capacities assist in the regulation of negative affect, and across development emotional and attentional processes are expected to function in synchrony. Studies of the CBQ revealed that while Effortful Control was negatively related to a Negative Affectivity factor (which included dimensions of Discomfort, Sadness, Fear, Anger/Frustration, and Soothability) they were separable factors (Rothbart et al., 2001).

Previous research has also provided rationale for expecting a relationship between emotional regulation and executive attention. In the aforementioned study conducted by

Davis et al. (2002), performance on executive attention tasks was negatively related to parental reports of externalizing behaviour problems, Effortful Control, and performance on the delay of gratification measures. This suggests that children who were disruptive also tended to be less able to control their behaviour and less able to delay gratification.

In the previously discussed study conducted by Gerardi-Caulton (2000), children age 30 months who were rated higher on Anger Frustration (defined by Rothbart et al., 2001 as negative affectivity related to interruption of ongoing tasks or goal blocking) also performed more poorly on delay of gratification tasks. Children aged 36 months who were rated higher on Anger Frustration were also found to exhibit a greater tendency to perseverate. Based on the relation between Anger/Frustration and inhibition found in the study conducted by Gerardi-Caulton (2000), Wolfe and Bell (2003) also hypothesized that Anger/Frustration would be related to inhibition, a contention that was supported for some of the inhibition measures implemented in their study.

Additionally, use of tests designed to measure orienting, vigilance, and executive attention in young children is important in elucidating the developmental trajectories of these networks. Although it has been stated by Ruff and Rothbart (1996) that the orienting and vigilance networks are "fully functional" (p. 41) by infancy, the data gathered by Berger et al. (2000) suggests that even at age 5 years, children do not exhibit performance at adult levels on the orienting and vigilance tasks. This provides support for the need to investigate the functioning of each of the attentional networks in children.

This study attempted to extend the literature by investigating the relationship between self-regulation and the attentional networks, as well as attentional networks and a direct observation of social behaviour in a sample of children 4 years of age. In the

study presented here, it was hypothesized that executive attention would be positively related to regulation. No relationship was expected between orienting and vigilance and emotional regulation, due to the lower-order nature of these attention networks. These hypotheses were investigated by assessing the relationship between performance on attentional networks and emotional regulation measures in children 4 years of age.

Operationalization of Emotional Regulation and Attention

Orienting and alerting attention was assessed through child friendly versions of the spatial orienting and warned reaction time paradigms, respectively. Executive attention in this study was assessed through both working memory and inhibition measures. Working memory measures used in this study included both the Self-Ordered Pointing Task (SOPT) and Delayed-Alternation/Non-Alternation (DANA) tasks, which both required the child to maintain and transform temporary information during mental operations. Inhibitory measures used in this study included the Motor Conflict and Go/No Go tasks. These tasks required the child to inhibit a prepotent response in favour of a less dominant response. The Motor Conflict task was chosen due to its similarity to the Spatial Conflict task used by Gerardi-Caulton (2000) . These tasks will be described in greater detail in the 'Methods' section of this paper.

In order to understand how emotional regulation will be measured in this study, it is useful to present a brief overview of important considerations in the measurement of emotional regulation. Emotional regulation has historically been poorly defined and studied in a methodologically compromised manner (Cole, Martin, & Dennis, 2004). In light of these shortcomings, Cole et al. (2004) reviewed the literature on studies of emotional regulation in early childhood, with the intent of delineating problems and

providing suggestions in order to steer the study of emotional regulation toward greater scientific rigor.

Cole et al. (2004) suggest that it is important to obtain converging measures of emotional regulation. Pursuant to this, the study reported here involved multiple measures of regulation, including experimenter observation ('Snap' game) and parental report (Children's Behaviour Questionnaire; CBQ).

One of the measures of emotional regulation used in this study was the CBQ, which was introduced previously in this paper (Appendix C). The authors of the CBQ (Rothbart et al., 2001) generated items based on theoretically derived temperament dimensions, including emotional reactivity, arousability, and self-regulation. Internal consistency was established (mean estimate of .77; Ahadi et al., 1993). Temporal stability was also investigated by comparing ratings of children at 5 and 7 years of age. Maternal ratings averaged a stability estimate of .65 across scales, and paternal ratings averaged a stability estimate of .63 across scales (Rothbart et al., 2001). In addition, similar factor structure of the CBQ was found in samples of North American, Chinese (Ahadi et al., 1993), and Japanese (Kusanagi, 1993, as cited by Rothbart et al., 2001) children, which speaks to the cross-cultural validity of this instrument.

A second measure of emotional regulation used in this project was a dyadic and highly competitive game labeled 'Snap' (Hughes et al., 2002). 'Snap' involves the potential threat of losing a game to a peer, and thus is likely more emotionally salient than delay of gratification measures. Cole et al. (2004) put forth a suggestion that emotions and emotional regulation should be independently assessed. The measures obtained from 'Snap' are the presence of disruptive acts and behaviours. However, a lack

of disruptive behaviour may be reflective of a failure to activate an emotion or of a failure of the child's ability to regulate that emotion. It is possible to assess emotional activation in a post-procedure interview consisting of two simple questions. These questions include: "When I was losing at the game, I felt..." and "when I was winning at the game, I felt...". It should also be noted that the conditions put forth in the 'Snap' paradigm (i.e. disappointment) are such that it is likely that all children would feel angry/frustrated, during the losing streak, but not all children would manifest this emotion in disruptive acts.

A third point made by Cole et al. (2004) is the value of laboratory measures of emotional regulation. Because the 'Snap' game is laboratory based, conditions are controlled and the probability that emotions and regulatory capacities will be activated is heightened.

In this study, measurement of orienting and alerting were child-friendly variants of tasks used in previous studies to assess these abilities. Executive attention was measured through both working memory (DANA, SOPT) and inhibition (Motor Conflict, Go/No Go) tasks. Emotional regulation was measured via parental report (CBQ) and an experimenter observation of disruptive behaviours ('Snap').

Specific Hypotheses of the Current Study

Primary hypotheses of the current study were two fold. First, it was hypothesized that better performance on the executive attention tasks would be related to fewer disruptive acts during the competitive game, and higher parental ratings of regulatory abilities. No relationship was expected between performance on the orienting and vigilance tasks and measures of emotional regulation.

Power Analysis

Results from studies assessing the relationship between self-regulation and executive attention were used to provide effect sizes for power analyses. Gerardi-Caulton (2000) obtained a correlation between a measure of delay of gratification and accuracy on an executive attention task of .47. Wolfe and Bell (2003) obtained a correlation between a delay of gratification task and an aggregate measure of executive attention tasks of .38. According to Cohen's (1992) conventions, these are medium to large effect sizes. The program GPOWER (Erdfelder, Faul, & Buchner, 1996) was used to perform an a priori power analysis assuming an effect size of .47, with power set at .8, which yielded a sample size of 30 children. GPOWER was also used to perform an a priori power analysis assuming an effect size of .38 (with power set at .8), which yielded a sample size of 49 children. These analyses suggested that a sample size necessary to achieve sufficient power ranged from 30 to 49 children.

Method

Participants

Forty five children participated in this study (M =4.53 years, SD = .35 years; range= 3.97 – 5.33 years, 29 girls, 16 boys). Participants comprising the sample in this study were recruited through daycares and preschools in communities in Victoria and surrounding area. A letter was sent to parents providing information describing objectives and methods of the study.

Children were excluded from final analysis only if: they had been diagnosed with a psychiatric or psychological disorder or they exhibited hearing or sensory impairments. These exclusion criteria were employed because it was the intent of the study to draw a

sample from the population of typically developing 4 year old children, and given the verbal nature of the tasks implemented here, it was crucial that the children were able to comprehend the instructions. In order to preserve power, five children who had very recently turned 5 years old were included in the sample (ages 5.04, 5.07, 5.09, 5.19, 5.33). Following the exclusion criteria, no children were excluded from the sample.

Written consent was obtained from the parents of the participants, and (given the young age of the children involved) verbal consent was obtained from the children who participated in the study. Information provided in the consent form included purpose of study, the benefits of study, the procedures to be undertaken, and notification of the participants right to withdraw at any time during the course of the study. Every effort was made to communicate this information to the child in a comprehensible manner.

Measures

The constructs of interest in this study and the measures employed included: vigilance (Help the Farmer game), orienting (Feed the Fish game), executive attention as assessed through both inhibition (Go-No/Go and Motor Conflict), and working memory tasks (Delayed Alternation/Non-Alternation and Self-Ordered Pointing tasks), and emotional regulation (subscales of the CBQ and 'Snap'). In order to obtain descriptive information pertaining to the participants involved in the proposed study, information on developmental history was collected. The tasks and questionnaires used are discussed in the following sections.

Child History Questionnaire – measure of developmental history.

The child history questionnaire is a medical/developmental history questionnaire in which parents are asked to provide information pertaining to prenatal, birth and postnatal complications, medical and educational history (please refer to Appendix B).

Alerting - measure of vigilance network.

In this task, animals appeared on a computer screen one at a time, and the child was to touch the animal when it appeared. The task was framed for the child as "help the farmer catch the animals that want to run away". The child touching the animal represents the creatures going "back to the farm".

The targets were farm animals of 6 degrees by 6 degrees. They were presented one at a time at the corner of a touchscreen. The warning signal (tone) was presented randomly in half of the trials before the target's appearance. The interval between presentation of the tone and appearance of the target was one of the following duration: 200, 500, 1,000, or 2,500 msec. This task consisted of 4 practice trials, followed by 32 trials (4 of each combination of tone/no tone and interval). After the game, a picture of the farm with the animals the child helped to catch was presented on the screen.

Orienting task - measure of orienting network.

In this task, the child was presented with two glass tanks on the touch computer screen, placed 10 degrees to the left and right of a central fixation point. Trials consisted of a fixation stimulus, followed by a cue (a change in the colour of one of the tanks), and a target (a fish inside one of the tanks). The task was framed for the child as a "feed the fish" game, in which each time a fish appeared, the child was to feed the fish by touching it with a finger as quickly as possible.

Variables obtained from this task included: validity (cue and the target both occurring in the same side tank) and stimulus onset asynchrony (SOA; 100 or 1,000 msec), which was the interval between the beginning of the cue and the beginning of the target. This task was comprised of 32 trials (4 trials for each combination of left/right cue placement, left/right target placement, and 100/1,000 SOA).

Go/No Go – measure of executive attention (inhibition).

The Go/No Go task employed here was a child friendly version of the traditional Go/No Go task, adapted from LaPierre, Braun, and Hodgins (1995). This task consisted of two blocks. In the first block, 60 dogs appeared on the screen (one per second) and the child was to press the spacebar whenever s/he saw a dog. This block was designed to develop a prepotent response (response habit) to dogs, and as such was not scored.

The second block consisted of 150 trials, divided into three sections consisting of 50 trials per section. In the first section, both dogs and bears appeared and the child was required to respond only to the bears, and not to the dogs (requiring the child to withhold his/her prepotent response to the dogs). In the second section, both dogs and bears appeared but the child was now required to respond to the dogs, and not to the bears (requiring the child to withhold his/her prepotent response to the bears). In the final section, both dogs and bears appeared but the child was required to respond to the bears, and not the dogs (requiring the child to withhold his/her prepotent response to the dogs).

The measures obtained from this task were the number of commission errors (incorrectly responding to a 'no go' stimuli), omission errors (incorrectly not responding to a 'go' stimuli), hits (correctly responding to a 'go' stimuli) and correct responses (correctly responding to a 'go' stimuli or not responding to a 'no go' stimuli).

Motor Conflict task – measure of executive attention (inhibition).

The Motor Conflict task is a modified version of a task presented by Nassauer and Halperin (2003), and was chosen due to its similarity to the Spatial Conflict task used by Gerardi-Caulton (2000). In this task, the child was required to respond with a button bar, which had a blue button on the child's left side and a green button on the child's right side. Green and blue squares flashed on either the right side or left side of the computer screen. This task consisted of four conditions.

In the first condition, the child was instructed to respond with the button that was on the same side as the square that appeared on the screen. For example, if a square appeared on the left side of the screen, the child was instructed to respond by pressing the left button, and vice versa for a square appearing on the right side of the screen. In the second condition, a conflict element was introduced. The child was instructed to press the button that was opposite the side the square appeared. For example, if the square appeared on the right side of the screen, the child was required to press the left button, and vice versa for a square appearing on the left side of the screen.

The third condition required the child to press the button that was the same colour as the square that appeared on the screen. For example, if a blue square appeared on the screen the child was to press the blue button, and vice versa for the presentation of a green square. In the final condition, a conflict element was introduced by requiring the child to respond to the opposite color that appeared. For example, if a blue square appeared, the child was required to respond by pressing the green button, and vice versa for the appearance of a green square.

This task consisted of 160 trials (40 trials per condition). The measures derived from this task included the number correct and reaction time measures for the conditions.

Delayed Alternation/Non-Alternation (DANA) - measure of executive attention (working memory).

This task was a modified version of the DANA introduced by Patriot et al.(1996), and adapted from Archibald and Kerns (1999). In this task, two basketball hoops appeared at the top right and left sides of the touch computer screen and a basketball appeared at the bottom center of the screen. In each trial, the sound of a whistle cued the child to "shoot" the basketball into one of the hoops (right or left) by touching the hoop of their choice. If the response was correct, both baskets disappeared and the word "SCORE!" appeared and positive sounds of cheering were heard. If the response was incorrect, both baskets disappeared and no feedback was provided. After the child responded, there was a 15 second interval before the next trial.

This task was comprised of two blocks, delayed Alternation and delayed Non-Alternation. In the Alternation condition, the correct response strategy was one in which children had to alternate their responses ('win shift' strategy; Archibald & Kerns, 1999) and choose alternating hoops. In the second block (Non-Alternation), the correct response strategy was one in which children were to *not* alternate their responses, but instead shoot at the same basket ('win stay' strategy; Archibald & Kerns, 1999). The Non-Alternation condition followed the Alternation condition without warning.

Each condition of the DANA had a criterion of 5 consecutive correct trials and a failure criterion of 15 trials. Therefore, each condition consisted of a minimum of 5 trials

(indicating the child responded immediately with the correct strategy) and a maximum of 15 trials (indicating the child did not learn the correct strategy).

The measures of interest obtained from this task were the number of: hits in the Alternation condition (number of responses to the correct basket), errors in the Alternation condition (number of times the incorrect basket was chosen before reaching criterion), and trials required to reach criterion (sum of the hits and errors). Corresponding measures were obtained from the Non-Alternation condition.

Self-Ordered Pointing Task (SOPT) – measure of executive attention (working memory).

This task was a modified version of the SOPT, a task based on Petrides and Milner's 'Representational Drawings' (1982) and adapted from Archibald and Kerns (1999). This task was presented via touchscreen and consisted of five sections, each consisting of a different number of stimuli (4, 6, 8, 10, 12). In the first section, an array of four pictures was presented four separate times to the participants. The same pictures were presented each time, but with a different spatial array on each presentation. The participant was instructed to point to a different picture each time a new array appeared, and thus the participant was to have pointed to all the pictures by the end of the presentation, without having repeated a choice. After completion of this trial, another two trials with the same four stimuli was presented. Sections two through five were identical to the first section, except that they consisted of 6, 8, 10, and 12 pictures.

The measures of interest obtained from this task were the number of errors from each block (defined as the number of pictures in each of the three sections that were pointed to more than one time).

The Child Behavior Questionnaire (CBQ; select scales) – parental report of self-regulation.

The CBQ was designed to be an assessment of temperament in early childhood. . This instrument is comprised of 195 statements rated by parents on a scale ranging from one to seven ('extremely untrue' to 'extremely true' of his/her child). The CBQ yields 15 scales (as described in Appendix C), which reduce into three factors (Negative Affectivity, Surgency Extraversion, and Effortful Control).

The scales of Anger/Frustration, Sadness, and Falling Reactivity/Soothability most clearly exemplify the construct of emotional regulation, and thus items from these scales were administered in the current study (please refer to Appendix D).

'Snap' - direct observation of self-regulation.

'Snap' is a rigged competitive game that has been used as a means of directly observing disruptive behaviour (Hughes et al., 2002). In this game, the researcher sits in front of two children. The researcher simultaneously deals both children a pair of cards (specific instructions, as taken from Hughes et al., 2002 are presented in Appendix E). If the child receives a matching pair, the child is allowed to move a magnetic counter one place along a playing board. The children are both told that the first to the end of the board wins the game. The cards are rigged so that each child received a winning streak (10 deals) and a losing streak (10 deals), so the two children playing are neck in neck during the game. The game ends in a tie, and each child is given a prize. The 'Snap' game has been coded in a number of ways (as presented in Appendix A). One of these is the Global Scale and Event Frequency approach. In this approach, The Global Scale is an index of minor and major disruptive acts occurring during the duration of the game,

while the Event Frequency Scale is an index of the frequency of rule violations. Hughes et al (2002) report that inter-rater reliability values all exceeded .83, indicating a high degree of inter-rater agreement.

Another means of coding the 'Snap' game is the Eight Target Approach (Hughes, Cutting, & Dunn, 2001). In this approach, eight target events are identified as present or absent on each deal (Appendix A). Hughes et al. (2001) report inter-rater agreement of .70 to .92 for these target events.

The Event Frequency and Global Event Frequency approach appear to be a grosser categorization of disruptive behaviour during the 'Snap' game, while the Eight Target Event method seems more of a detailed and descriptive measure of disruptive behaviour. The study described here incorporated elements of both methods.

The Eight Target method was altered from the Hughes et al. (2001) scale to include only six targets, including: positive comments about the self (e.g. gloating, such as 'ha, ha, I'm going to be the winner!'), negative comments about the friend (e.g. insults, such as 'you're not very good at this, are you?'), complaints (e.g. 'it's not fair!'), whining/sad appeals (e.g. 'can you make me win now?'), cheating (child says 'Snap' when their cards don't match, and attempts to move piece), and controlling behaviour (e.g. 'give me a 'Snap' now!' and physical aggression).

Minor acts of disruption were not well accounted for in the Target Event approach. Therefore, they were added in the current study as a seventh target event of minor disruptive acts, which according to Hughes et al. (2002) includes such acts as singing while the researcher explains the instructions, or interrupting the researcher.

Thus, disruptive behaviour during the 'Snap' game was coded as seven different events (Appendix A), which were mutually exclusive of each other (e.g. purposefully moving the counters to the wrong place during the instructions would be counted only as a 'cheating' event, not as a 'cheating' event and a 'minor disruption' event). Due to practical considerations, it was not possible to pair children in a controlled manner (such as based on age or gender). Pairing was based on the presence of children at the daycare/preschools whose parents had completed and returned consent forms.

Materials

In order to administer the computer tasks described above, a computer and touch monitor (specifically a laptop and an EloTouch Entuitive 15" monitor) was used. In order to administer the 'Snap' game, a video camera (to code for target events), 'Snap' cards, two counters (to move along the board), and a board with a picture of two caterpillars (with ten places per caterpillar) was used.

Procedure

This project was conducted in daycares and preschools in the communities in and surrounding Victoria. Children were required to complete the orienting, alerting, and executive attention measures, as well as the 'Snap' game. These tasks were administered in two sessions. One session consisted of the orienting, vigilance, and motor conflict tasks, and the 'Snap' game. The second session consisted of the DANA, SOPT, and Go/No Go measures. Sessions were counterbalanced.

Each testing session was approximately 30 minutes in duration. Following completion of the tasks, the child was allowed to choose a prize from a bag of toys. The

parents completed the CBQ and Developmental History Questionnaire, which were sent home with the child. The parents were provided with a thank you note and a monetary stipend of $5.00 in acknowledgment of their time in completing the questionnaires.

Results

Results from the measures implemented here will be discussed in the following manner. First, results from the alerting and orienting tasks will be presented, included descriptive statistics and the manner in which summary measures were derived. Following this, results from performance on the executive attention measures will be discussed. Particularly, performance on measures of inhibition (Go/No Go and Motor Conflict tasks) will be discussed, followed by presentation of results from performance on working memory measures (DANA and the SOPT). Next, patterns of interrelations among performance on all attention measures will be discussed. Results from the CBQ and 'Snap' will be addressed, individually as well as their relationship with one another. Finally, major hypotheses as presented earlier in this paper will be discussed.

Help the Farmer - Measure of Alerting Network

The primary use of this task was to obtain an overall index of alerting function. In order to achieve this, a score was computed from the reaction times in this task. Specifically, the summary score was defined as the average reaction time for correct trials on the alerting task. The reaction time was summed across the 32 trials. The number of trials in which the child timed out (did not respond in the allotted time) was recorded, and the reaction time from these 'timed out' trials was subtracted from the sum of the reaction time across the 32 trials. This score was then divided by the number of trials 'correctly'

responded to (e.g. excluding the timed out trials) to provide an average reaction time measure of 977.68 ms (*SD* = 134.39 ms), with a range of 751.47 ms to 1313.00 ms.

Feed the Fish - Measure of Orienting Network

As described in the 'Methods' section of this paper, this task involved both validly cued (compatible) and invalidly cued (incompatible) trials. There was a trend toward longer reaction times in the incompatible trials [t (1, 44) = -1.85, p = .09]. The primary use of this task was to obtain an overall index of orienting function. In order to achieve this, a score was computed from the reaction times in this task. Specifically, the summary score was defined as the average reaction time for correct trials on the task. The reaction time was summed across the 32 trials. The number of trials in which the child 'timed out' (did not respond in the allotted time) or touched outside the required area of the target was recorded. The reaction time from these 'timed out' or incorrect trials was then subtracted from the sum of the reaction time across the 32 trials. This score was then divided by the number of trials 'correctly' responded to (e.g. excluding timed out trials and those in which the child touched outside of the target area) to provide an average reaction time measure. The mean for the orienting task was 1374.60 ms (*SD* = 289.57 ms), with a range of 859.52 ms to 2107.29 ms.

Go/No Go - Measure of Executive Attention (Inhibition)

The primary measure of interest from the Go/No Go task was number of errors (*M* = 44.22, *SD* = 21.75). The number of omission errors from the three sections of the Go/No Go task were significantly correlated (first omissions with second omissions r =

.65, p <.001; first omissions with third omissions r = .39, p =.01; second omissions with third omissions r = .68, p < .01) and a summary measure was created.

Commission errors from the three sections were related (first commissions with second commissions r = .87, p <.001; first commissions with third commissions r = .73, p <.001; second commissions with third commissions r = .74, p < .001) and a summary measure was created. Due to these significant correlations, summary measures for errors will be used in analyses.

Motor Conflict Task - Measure of Executive Attention (Inhibition)

Measures of interest on the Motor Conflict task included the number correct on the conflict (M = 30.67, SD = 7.35; M = 32.07, SD = 5.86, blocks two and four, respectively) and non-conflict conditions (M = 34.78, SD = 6.15; M = 35.58, SD = 5.22, blocks one and three, respectively). Also of interest were the reaction time measures for correct responses in the conflict (M = 1310.49, SD = 381.02; M = 1500.03, SD = 422.97, blocks two and four, respectively) and non-conflict conditions (M = 945.83, SD = 258.04; M = 1154.39, SD = 299.89, blocks one and three, respectively).

One would expect that accuracy in conflict conditions (correct in blocks two and four) would be significantly lower than accuracy in non-conflict conditions (correct in blocks one and three). This was found to be true [t (44) = 8.24, p < .01], indicating that children obtained fewer correct responses on the conflict conditions of this task. Similarly, the summary measure of conflict reaction time (reaction time for blocks two and four) was significantly higher than the summary measure of non-conflict reaction time [reaction time in blocks one and three; t (44) = -7.82, p < .01], indicating that children took more time to respond in conflict conditions than non- conflict conditions.

Delayed Alternation Non-Alternation (DANA) - Measure of Executive Attention (Working Memory)

The descriptive statistics for the measures obtained from the DANA are listed in Table 2. Seventy three percent of the sample reached criterion for the Alternation condition, while 58 % reached criterion for the Non-Alternation condition. A within-subjects ANOVA revealed this difference was not significant [F (1, 44) = 2.19, p =.15].

A within-subjects ANOVA revealed the difference between hits in the Alternation and Non-Alternation conditions to be not significant [F (1, 44) = 2.86, p =.10]. However, the difference between errors in the Alternation and Non-Alternation conditions was found to be significant [F (1, 44) = 7.86, p=.01], as was the difference in the number of trials required to reach criterion in the Alternation and Non-Alternation conditions [F (1, 44) = 8.59, p =.01]. These were in the expected direction, with more errors made in the Non-Alternation condition than in the Alternation condition, and more trials required to reach criterion in the Non-Alternation condition than the Alternation condition.

Table 1

Mean Hits, Errors, and Number of Trials for the Alternation and Non - Alternation Conditions of the DANA

Condition	*M*	*SD*
Alternation		
Hits	6.89	1.97
Errors	2.84	3.03
Trials	9.73	3.97
Non-Alternation		
Hits	7.42	1.80
Errors	4.73	2.90
Trials	12.04	3.57

Self Ordered Pointing Task (SOPT) - Measure of Executive Attention (Working Memory)

The measures of interest obtained from this task were the number of errors from each section (defined as the number of pictures in each of the sections that were pointed to more than one time). Significantly more errors were made at each successive level of the SOPT (all *t*s (44) > 8.14, all *p*s <.01). The descriptive statistics for the SOPT are listed in Table 2.

Table 2

Mean Errors in Each Section of the SOPT

Section	*M*	*SD*
4 item	2.02	1.22
6 item	3.87	1.55
8 item	6.51	1.97
10 item	8.16	2.46
12 item	10.67	3.13

Help the Farmer, Feed the Fish, Go/No Go, Motor Conflict, SOPT, and DANA - Relationships Among Attention Measures

Because working memory measures and inhibition were conceptualized as executive attention, and orienting and alerting were viewed as lower-order attention, it was of interest to examine interrcorrelations among the attention measures (Table 3), with age partialed out of this relationship. In order to facilitate discussion of these results, relationships among inhibition measures, working memory measures and then correlations among these will be addressed.

Table 3

Partial Correlations Among Orienting, Alerting, and Executive Attention Tasks

	Alert	Orient	Error GNG	MC Cor	MC rt	Err Alt	Err NAlt	SOPT Errors
Alert	-	.52**	-.05	.04	-.02	-.05	-.02	-.11
Orient		-	-.10	-.06	.19	.14	.08	.11
Error GNG			-	-.46**	.04	.30*	-.07	.46**
MC Cor				-	.40**	-.29	.02	-.34*
MC rt					-	.21	-.13	.07
Err Alt						-	-.12	.17
Err NAlt							-	.08
SOPT								-

Note. *Alert = average reaction time alerting task, Orient = average reaction time orienting task, Error GNG = total errors in Go/No Go task, MC Cor = total correct in conflict conditions of Motor Conflict task, MC rt = reaction time in correct trials of conflict condition in Motor Conflict task, Err Alt = errors in Alternation condition of DANA, Err Nalt = errors in Non-Alternation condition of DANA, SOPT = total errors in SOPT.* $p < .05$, ** $p < .01$*

Go/No Go and Motor Conflict tasks - relationships among the inhibition measures.

As the Go/No Go and Motor Conflict tasks are both measures of the executive attention network, one would expect performance on these tasks to be related. Correlational analyses revealed that total errors made on Go/No Go was negatively correlated with total correct in conflict conditions of the Motor Conflict task ($r = -.54$, $p < .01$).

SOPT and DANA - relationships among working memory measures.

As the SOPT and DANA are both conceptualized as measures of working memory, one would expect these to be correlated. However, the sum of errors on the SOPT was not significantly related to the number of errors in either condition of the DANA ($r = .17, p = .28$; $r = .08, p = .59$, number of errors in Alternation and Non-Alternation conditions, respectively).

SOPT, DANA and Go/No Go, Motor Conflict - relationships among the executive attention measures.

As can be seen in Table 3, a number of significant correlations were observed between working memory and inhibition measures. To further assess the structure of these tasks, a factor analysis was performed with varimax rotation. Entered into this analysis were orienting and alerting average reaction time, total error on Go/No Go, total correct on conflict conditions of the Motor Conflict task, reaction time on conflict conditions of the Motor Conflict task, errors in the Alternation and Non-Alternation conditions of the DANA, and sum of errors on the SOPT. An 'eigenvalue greater than one' rule was used to extract three factors. These factors accounted for 63.95% of the variance.

The first factor had loadings primarily of total errors on Go/No Go (.80), errors in the Alternation condition of the DANA (.51), sum of errors on SOPT (.74), and number correct in conflict conditions of the Motor Conflict task (-.83). The second factor had loadings of errors in the Non-Alternation condition of the DANA (-.56) and reaction time in conflict conditions of the Motor Conflict task (.86). The third factor had loadings of

orienting (.82) and alerting (.83) reaction time measures. The first factor was labeled 'Executive Attention' while the third factor was labeled 'Lower Order Attention'.

Children's Behavior Questionnaire (CBQ) – Measure of Emotional Regulation

The measures of interest obtained from this instrument included parental ratings of behaviour for the Anger/Frustation ($M = 4.39$, $SD = .62$), Sadness ($M = 4.00$, $SD = .66$), and Falling Reactivity/Soothability ($M = 4.91$, $SD = .55$) scales. As discussed in the 'Methods' section of this paper, the response choices on this instrument ranged from 1 to 7 The descriptive statistics for this instrument indicate that the responses provided were within a restricted range, primarily concentrated around response option 4 which reflected a neutral option of 'neither true nor false'.

Internal consistency reliability was examined for items comprising each scale of the CBQ. Inter-item correlational analysis revealed low correlations among items comprising the Anger/Frustration scale (Cronbach's $\alpha = .53$), the Soothability scale (Cronbach's $\alpha = .42$), and the Sadness scale (Cronbach's $\alpha = .42$). In addition to the inter-item analysis, a factor analysis was conducted. One would expect that three factors would be extracted from the CBQ data, given that the items are expected to reflect three dimensions. However, the factor analysis performed yielded 13 factors.

One would expect the relationship among the three scales to parallel that as found in Rothbart et al.'s (2001) work, with correlations between Anger/Frustration, Soothability, and Sadness. However, no significant relationship was found between Anger/Frustration and Sadness ($r = .13$, $p = .39$), or between Soothability and Sadness ($r < .001$, $p = .99$). A trend was found in the direction of a significant negative relationship between Soothability and Anger/Frustration ($r = -.28$, $p = .07$).

Due to the low reliability of the CBQ, correlations obtained may be an 'underestimate' of the true correlation between these scales, and between the scales and various other measures. As such, correction for attenuation calculations were performed on the obtained correlations between the CBQ and measures employed in this study, according to the procedure outlined by Cohen and Cohen (1983). When correcting for attentuation, the correlation between Anger/Frustration and Sadness increased (r = .28) as did the correlation between Anger/Frustration and Soothability (r = -.59). Consistent with Cohen and Cohen (1983), because the correction for attenuation is used to derive a hypothetical value (true score) significance tests cannot be computed. The correction for all correlations performed with the CBQ are reported in Table 8.

'Snap' – Measure of Emotional Regulation

The primary measures of interest from this task were the target events of: gloating/positive comments about self, negative comments about friend, complaints, whining/sad appeals, cheating, controlling behaviour, and minor disruptive acts. In order to establish interrater reliability, the performance of a third of the children in the sample who played 'Snap' was coded by the primary researcher as well as a research assistant. The results of the interrater reliability analysis revealed good to excellent agreement, with intraclass correlation coefficients (absolute agreement; McGraw & Wong, 1996) ranging from .73 to 1.00 for the target events (please refer to Table 4).

Table 4

Absolute Agreement (ρ_I) of Disruptive Behaviours Coded in 'Snap'

Behaviour	ρ_I
Gloating	.94
Insults	.73
Complaints	.88
Appeals	1.00
Cheating	.77
Controlling	.93
Minor disruptive acts	.83

Consistent with the guidelines put forth by Cole, Martin, and Dennis (2004), emotional activation was assessed by asking children how they felt when they were losing the game, and how they felt when they were winning the game. The majority (64.4%) of children evidenced a change in feeling from losing to winning conditions, in the direction of being happier when they were winning. In contrast, 33.3% of children reported no change in the losing and winning conditions. A small group of children (2.2%) provided responses suggesting that they did not understand the question (for example, describing how the game was played).

The descriptive statistics for the events coded during the SNAP game are as listed in Table 5. A factor analysis was performed on the target events to investigate common variance. Three factors accounted for 67.97 % of the variance. The first factor had loading primarily of positive comments about self (.73), complaints (.86), controlling behaviour (.68), and minor disruptive acts (.55). Based on the heavy verbal expressive aspect of this factor, it was labeled 'Talk'. The second factor had loading primarily of negative comments about other (.60) and cheating behaviours (.77). Based on the

antisocial nature of this factor, it was labeled 'Negative Behaviour'. The third factor was primarily appeals (.88), and was labeled 'Appeal'.

Table 5

Descriptive Statistics for Behaviours Coded in 'Snap'

Behaviour	*M*	*SD*
Gloating	6.49	5.43
Insults	.76	1.23
Complaints	3.31	3.23
Appeals	.29	.66
Cheating	.40	.78
Controlling	1.24	2.16
Minor disruptive acts	1.93	2.28

CBQ and 'Snap' – Relationships Between Measures of Emotional Regulation

No significant relationships were found between parental report of emotional regulation (CBQ) and direct observation of disruptive behaviour ('Snap') as presented in Table 6. There was, however, a trend for the factor score comprising cheating and negative comments about others ('Negative Behaviour') to be related to soothability (r = -.28, p = .07), indicating children who were faster in recovering from arousing events engaged in more cheating behaviours and negative comments.

Table 6

Correlations Between Factor Scores for Disruptive Behaviours Coded in 'Snap' and Scales of the CBQ

CBQ Scale	'Snap' Talk	'Snap' Negative Behaviour	'Snap' Appeal
Anger/Frustration	-.10	-.04	-.04
Soothability/ Falling Reactivity	.22	-.28	.03
Sadness	.00	.20	.08

Major Hypothesis – Relationship Between Executive Attention, Orienting, Vigilance and Emotional Regulation Measures (CBQ and 'Snap')

As stated at the outset, it was expected that better performance on the executive attention tasks would be related to fewer disruptive acts during the competitive game, and higher parental ratings of regulatory abilities. No relationship was expected between performance on the orienting and vigilance tasks and measures of emotional regulation.

Orienting and alerting network in relation to CBQ and 'Snap'.

As predicted, no significant relationships were found between the 'Lower Order' attention factor score and the CBQ on any of the scales (Anger/Frustration $r = -.02$, $p = .91$; Soothability/Falling Reactivity $r = -.14$, $p = .37$; Sadness $r = -.06$, $p = .71$). No relationship was found between the 'Lower Order' attention factor and 'Snap' (Talk factor $r = -.28$, $p = .07$; Negative Behaviour factor $r = .08$, $p = .59$; Appeal factor $r = -.01$, $p = .93$). Though these relationships were not significant, it should be noted that there was a trend for 'Talk' to be related negatively to the 'Lower Order' attention score, indicating those more verbally expressive also had faster reaction times on orienting and alerting tasks.

Executive attention and working memory measures in relation to CBQ.

A significant relationship was found between the 'Executive Attention' factor and the Anger/Frustration scale of the CBQ ($r = -.31$, $p = .04$). A trend was found for a relationship between this factor and the Sadness scale of the CBQ ($r = -.25$, $p = .10$), and it is interesting to note that the number of errors made on the SOPT was significantly negatively related to Sadness scale of the CBQ ($r = -.36$, $p = .02$). No significant

correlation was found between the 'Executive Attention' factor and Soothability/ Falling Reactivity scale of the CBQ ($r = -.12, p = .45$).

Executive attention measures in relation to 'Snap'.

As stated previously in this paper, three factors were extracted from 'Snap'. The first factor was comprised of positive comments about self, controlling behaviour, complaints, and minor disruptive acts. The second factor was comprised of cheating and negative comments, while the third factor was appeals. In light of this pattern of loadings, the behaviours comprising the factors were looked at more closely in relation to executive attention.

First, the distribution of the behaviours comprising the 'Talk' factor (positive comments, complaints, controlling, and minor disruptive acts) was examined. Children were placed into two groups: those who were elevated on at least one of these behaviours (defined as greater or equal to 1 standard deviation above the mean) and those who were not elevated. This resulted in 24 children classified as not elevated, and 21 children classified as elevated.

To then examine the relationship between the 'Executive Attention' factor and the 'Snap' behaviours loading on the 'Talk' factor, a one-way ANOVA was performed. No significant differences were observed between the groups ($F = .01, p = .98$). To further analyze the relationship between executive attention and behaviour on the 'Talk' factor of the 'Snap' game, an ANOVA was performed to investigate group differences in specific measures of inhibition and working memory, controlling for performance on alerting and orienting tasks. These analyses revealed that children elevated on 'Talk' behaviours obtained significantly fewer errors on the Alternation condition of the DANA [$F(1, 43) =$

3.36, p =.04]. A trend was also found for children elevated on 'Talk' behaviours to obtain faster response times on the Motor Conflict task [F (1, 43) = 2.97, p =.09]. No other significant group differences were found for Go No Go errors, errors in the Motor Conflict task, errors in the Non-Alternation condition, or SOPT errors [F (1, 43) = .00, p = .96; F (1, 43) = .65, p = .42; F (1,43) = .12, p = .73; F (1,43) = .22, p = .64].

Next, the distribution of behaviours comprising the second and third factors (negative comments, appeals, and cheating) was examined. These behaviours were all found to have low frequencies (80% of children exhibited one or no negative comment, 75.6% of children exhibited no cheating behaviours, and 80% of children exhibited no appeals). Children were then placed into two groups: those who were elevated on at least one of these behaviours (defined as greater or equal to 1 standard deviation above the mean), and those who were not elevated. This division resulted in 22 children being classified as elevated, or 'disruptive' and 23 as non-elevated, or 'non-disruptive'.

To then examine the relationship between the 'Executive Attention' factor and the 'Snap' behaviours, a one-way ANOVA was performed with the grouping variable as 'disruptive' or 'non-disruptive', revealing no significant differences between the groups (F = 2.44, p =.13). To further analyze the relationship between executive attention and behaviour on the 'Snap' game, an ANOVA was performed to investigate group differences in specific measures of inhibition and working memory, controlling for performance on alerting and orienting tasks. These analyses revealed that children classified as disruptive had significantly more errors on the Go/No Go task [F (1, 43) = 6.72, p = .01], and exhibited a trend toward fewer correct responses on the Motor Conflict task [second block, F (1, 43) = 3.05, p = .09]. No other significant group

differences were found for Alternation errors, Non-Alternation errors, or SOPT errors were found [F (1, 43) = 2.56, p = .12; F (1, 43) = .90, p = .35; F (1,43) = .00, p = .95]. Mean scores for each of these groups are presented in Table 7.

Table 7

Means for Go/No Go Errors, Motor Conflict Block 2 Correct Responses, Alternation and Non-Alternation (DANA) and SOPT Errors by Group (Non-Disruptive vs. Disruptive)

Measure	Non-Disruptive	Disruptive
Go/No Go Errors**	37.13	51.6
Motor Conflict Block 2*	32.61	28.64
DANA Alternation Errors	2.04	3.68
DANA Non-Alternation Errors	5.04	4.41
SOPT Errors	31.30	31.09

** = $p<.10$, ** = $p<.05$*

Because important transitions in executive functions have been found to occur across the fourth year of life (Jacques & Zelazo, 2001), it was of interest to examine if age was confounding the relationship between disruptive behaviours and executive attention measures. A one-way ANOVA revealed a trend toward an age difference between 'non-disruptive' and 'disruptive' children [F (1, 44) = 3.89, p = .06], with 'non-disruptive' children slighter older than 'disruptive' children (M = 4.63 years, SD = .37 vs. M = 4.43 years, SD = .30). To further examine this, it was of interest to investigate relative contributions of age and group membership ('disruptive' vs. 'non-disruptive') to performance on Go/No Go. A hierarchical regression was performed, with age entered first, and the 'disruptive'/'non-disruptive' variable entered second. This analysis revealed that group membership accounted for a significant portion of variance over and

above age [$R^2 = .21, F(1, 44) = 5.50, p = .01$]. This was also true for correct responses on the second block of the Motor Conflict task [$R^2 = .25, F(1, 44) = 6.85, p < .01$].

Table 8

Correction for Attenuation for Scales of the CBQ, Snap Factor Scores, and Attention Factor Scores

Factor Scores	Anger/Frustration	Soothability/ Falling Reactivity	Sadness
'Snap Talk'	-.14	.34	.00
'Snap Negative'	-.06	-.32	.31
'Snap Appeal'	-.06	.05	.12
'Lower Order Attention'	-.03	.22	-.09
'Executive Attention'	-.43	-.19	-.39

Discussion

Summary of Objectives and Results

In sum, this project attempted to investigate the relationships among emotional regulation, orienting, alerting, and executive attention in four year old children. The primary hypothesis of this study, namely that executive attention would be related to emotional regulation while orienting and alerting would not, was partially supported.

Congruent with hypotheses, no relations were found between performance on the alert and orient tasks and either measure of emotional regulation. Significant relations were found between children who were elevated in their levels of appeals, insults, and

cheating behaviours and total errors on Go/No Go task, and a trend in this direction was found for the conflict condition of the motor conflict task.

Parental report of emotional regulation revealed anomalous correlations with the executive attention measures. Specifically, a significant negative relationship was found between executive attention measures and the Anger/Frustration scale of the CBQ, suggesting that reacting with anger or frustration when goals were blocked was related to better performance on executive attention measures. The number of errors on the SOPT was related to the Sadness scale of the CBQ, indicating that better performance on this task was related to increased tendency to become sad following a distressing event.

Theoretical Significance and Relationship With Previous Research

The results of this study were similar to the results of previous studies in this area (Berger, Jones, Rothbart, & Posner, 2000; Gerardi-Caulton, 2000; Poggi Davis, Bruce, & Gunnar, 2002; Wolfe & Bell, 2003), specifically in finding an association between measures of self regulation and executive attention. This study differed from previous findings in the failure to find an expected relationship between parental reports of regulation and executive attention. This may be due to deficiencies in the validity and precision of the questionnaire, as evidenced by the results of the factor analysis and reliability analysis reported earlier.

In addition to augmenting previous research, there are many theoretical implications of this study. First, the failure to find a relationship with orienting and alerting networks and emotional regulation provides support for Posner and Rothbart's theory (1991, 1994, 1998, 2000). This finding is consistent with Ruff and Rothbart's (1996) notion that the lower order attention networks provide either a supportive (as

alerting network) or redundant (orienting network) function with age in the context of self-regulation. As discussed previously, this study also provides support for the existence of a relationship between executive attention and dimensions of self-regulation.

Second, the significant findings between negative behaviours and elements of the executive attention tasks are very interesting and compelling for theory and research in this area. Although many behaviours were coded during the 'Snap' game, the compilation of behaviours relating to executive attention were negative behaviours, that were either explicitly prohibited by the experimenter (cheating), or are likely prohibited in the child's socialization experiences (insults and whining are likely discouraged by caregivers). The relation between executive attention measures and cheating is especially interesting, in that cheating was the only behaviour coded during 'Snap' that, if the cheater was successful, could help s/he win the game and obtain the prize. Cheating also involves a lack of insight that the probability of getting caught is quite high (the experimenter was directly in front of the dyad and the dyad had been warned at the start of the game about cheating).

The fact that a rule was introduced that prohibited cheating, and cheating reflected risky behaviour, may explain why this behaviour was related to executive attention. That is, rule breaking and risk taking are signs of diminished executive functioning, and a lack of inhibition. The fact that some children performed this behaviour in a setting where this act was specifically prohibited and risky lends credence to the relationship between inhibitory cognitive function and behaviour in 4 year olds in an ecologically valid setting.

The relatedness of negative behaviours and executive attention found in this study also provides some support for aspects of emotional regulation as reflecting 'hot'

executive functioning, which refers to affective aspects of executive function (Metcalfe & Mischel, 1999; Zelazo & Muller, 2002). The relatively strong link between negative behaviours (cheating, insults, appeals) and inhibition, as opposed to general executive attention, may suggest that inhibition serves as the common link between 'hot' and 'cool' executive function. Relatedly, this finding suggests that the key link between inhibition and emotional regulation is directly executive, and emotional regulation is not related to other functions with less of an inhibitory based component.

This project, when reviewed in conjunction with previous research, provides insight into both traditional and non-traditional tests of executive functions in 4 year old children. For example, Archibald and Kerns (1999) report ceiling effects in their sample of children age 7 to 12 years on the Alternation component of the DANA. In this study, however, the Alternation condition of the DANA appeared to be the most useful measure from the DANA. Although task parameters differed between the DANA used here and the DANA used by Archibald and Kerns (1999), this nonetheless provides some insight into the development of executive capacities across childhood.

An interesting finding in this study is of the positive relation between proneness to sadness (CBQ) and working memory. Working memory functions to replay immediate past experience (Baddeley & Logie, 1999) and hold this information 'on-line'. Speculation for this relation may then be that good working memory enables a child to ruminate on immediate (distressing) experience and intensify the sadness of an experience. This is congruent with the finding in adult literature that depressed individuals may have difficulty overcoming automatic responses involved in the perseveration of negative affect, making recovery following a distressing event especially

challenging (Davidson Pizzagalli, Nitschke, & Putnam, 2002). Although compelling and consistent with other literature, the shortcomings of the questionnaire suggests that interpretation should be made with caution.

Practical Significance

Underwood (1997) has identified questions pertaining to emotional regulation that merit further investigation. One of these questions was: how much does emotion regulation vary across situations/contexts? Although the integrity of the questionnaire used here is questionable, the answer suggested by differential results obtained from the questionnaire and 'Snap' suggests that emotional regulation may vary a great deal across contexts. Parents may see their child most often in contexts that do not involve peers or a relatively unfamiliar adult. This may speak to the influence of the environment on a child's emotional behaviour, and suggests that clinicians and other professionals and parents should be aware of this when evaluating behaviour.

A related question posed by Underwood was: what types of information can and cannot be gleaned about a child's capacity for emotion regulation from questionnaires completed by parents and teachers? Although the CBQ should be interpreted with caution in this study, results from the relationship between this questionnaire and 'Snap' suggest that parents may be able to report behaviours that they see in the home or with specific individuals (such as siblings), but these ratings do not relate to the child's emotional regulation capacities in a novel, dyadic, and highly affective setting.

Another practical contribution of this study is that it provides insight into what executive measures can be used successfully with preschoolers. For example, this research suggests that the switch to a new problem-solving approach in the DANA may

be too challenging for most 4 year olds. In contrast, the utility of the Go/No Go task in this study suggests that this measures is a plausible means of obtaining insight into the executive attention abilities of preschool children.

Future Directions

The working memory tasks could be modified in future research to provide more meaningful measures of executive functioning in this age group. The fact that many of the children were not able to switch their response pattern in the DANA suggests that, congruent with other literature (Jacques & Zelazo, 2001) children at this age may evidence difficulties in flexibly altering patterns of behaviour. It would be interesting to investigate if children are able to switch their behaviour if explicitly informed that the pattern enabling them to win was changed.

As discussed previously in this paper, Cole, Martin, and Dennis (2004) report that emotional regulation has been poorly defined in previous research and studied in a methodologically compromised manner. Given this concern, it may be important for future research that implements these measures to introduce modifications to result in more controlled measures of regulation. For example, it would be advisable for future research to strictly control the composition of the dyad participating in 'Snap' thereby ensuring standardization across participants. It would be most desirable for a child confederate, with a pre-specified and consistent script, to play 'Snap' with a participant naive to the status of the confederate. In this way, all participants would be subject to the same degree of 'provocation' and the task would be more standardized and thus a more meaningful measure of regulation across participants.

Similarly, the performance of the CBQ in this study suggests that it would be

valuable to incorporate more objective ratings of behaviour in parental questionnaires (for example, rather than an item being phrased as: "Gets angry when told s/he has to go to bed" and response options ranging from 'extremely untrue' to 'extremely true', an item may be phrased as: "Gets angry when told s/he has to go to bed", with response choices consisting of: 'one time per week' to 'seven times per week').

A valuable direction for future research will be to explore how executive attention relates to disruptive behaviours coded in the 'Snap' game throughout development. For example, cheating behaviours during 'Snap' can be viewed as breach of a rule that was explicitly stated by the examiner and understood by 4 year old children. However, behaviours such as gloating and minor disruptive acts are likely to be less understood as socially prohibited acts in 4 year olds. It is likely that as children age and gain new understanding of their social world and the rules governing it, the relation between executive attention and disruptive behaviours may change with age.

The tasks used to measure executive attention in this study were most consistent with the 'cool' type of executive function, which refers to cognitive aspects of executive function (Zelazo & Muller, 2002). It would be interesting to expand this investigation to consider the relationship between emotional regulation and 'hot' aspects of executive function, which refers to affective aspects of executive function (Zelazo & Muller).

An additional avenue for future research would be to investigate how different executive functions relate to emotional regulation, and how these change across development. For example, given the relation found between inhibitory function and aspects of emotional regulation, it would be interesting to investigate if other types of inhibition (eg. Nigg, 2000) are related to aspects of emotional regulation. Similarly, as

some researchers view theory of mind abilities as types of (or intimately related to) executive functions (Carlson, Moses, & Breton, 2002), the relationship between types of theory of mind and aspects of self-regulation may be worthy of exploration.

In a related point, the fact that working memory was not found to be consistently related to emotional regulation in this study does not necessarily suggest that working memory is unimportant in the development of self-regulation. Given its role in allowing for retention of immediate past experience and supporting the acquisition of new knowledge (Baddeley & Logie, 1999), it may be that working memory participates in the development of regulatory abilities. That is, although the status of the working memory system may not relate to the emotional regulation at age 4, it may be that differences in working memory at an earlier age precede differences in emotional regulation at age 4.

Additionally, finding a relationship between regulation and executive attention is only the beginning in understanding this connection. A subsequent and critical step is to investigate the processes themselves that may underlie this relationship. For example, the preschool years are a time in which children become more self-aware, and are able to exercise more sophisticated regulatory capacities to comply with social standards, decrease their own levels of distress, or achieve their goals (Gilliom et al., 2002). Given this, an important avenue for future research is to investigate what strategies are effective in reducing distress, complying with social standards, and achieving goals (Jones, Rothbart, & Posner, 2003). These strategies may vary with age or temperamental disposition, and may vary under conditions that require different motivational demands, for example, when a reward is at stake as compared to when there is no reward available.

A particularly favourable candidate mechanism that may regulate processes in

both behavioural and cognitive inhibitory tasks is language, particularly speech for self or private speech. Due to language's ability to allow for communication, reflection, and guidance of one's behaviour, it is reasonable to expect that it may be the common link between behavioural and cognitive inhibition, allowing for regulation in both these domains. Investigation of language in relation to self-regulation and executive attention would thus be a valuable area of future research.

Finally, an important area for future research is to investigate the relationship between executive attention and measures of emotional regulation in clinical populations, where deficits in regulation are hypothesized to be present (Posner & Rothbart, 2000).

Limitations

This study augmented theory and knowledge in the area of regulation and executive function and provided ideas for potential avenues of future research. However, this study also had several limitations, which should be addressed.

First, recruitment in this study was necessarily selective. The first level of selection was that participants were recruited through daycares and preschools, as opposed to more general community recruitment. The second level of selection was that some daycares agreed to participate, while others did not. A third level of selection was that some families chose to participate, while other families chose not to participate. Thus, a sampling bias was introduced in this study, which may have had the effect of limiting generalizability of the results to the general population of 4 year olds.

Second, testing was conducted in daycares. Although every effort was made to ensure that environmental confounds (such as noise) were kept to a minimum, it is possible that some level of distraction was still present. Relatedly, there existed a number

of factors that may have impacted performance or limited generalizability that were not controlled for in this study. This included such things as: time of day, amount of rest, ethnicity, and socioeconomic status.

Another limitation is that the composition of the child dyad in the 'Snap' game was not controlled, and consequently children of varying age, sex, cognitive ability, and familiarity with one another participated together in the 'Snap' game.

A fourth limitation is that the integrity of the questionnaire used in this study is questionable, as evidenced by the results of the factor analysis and inter-item reliability analysis discussed in the results section of this paper. This suggests that interpretation of the questionnaire should be done with caution.

A fifth limitation is that the questionnaire used in this study and some of the attention measures had a restricted range in the values obtained, which limited the variability of the measure and likely attenuated the size of the relationships reported.

Another limitation in this study is that the measurements of emotional regulation and executive attention were likely along different levels of analysis. As addressed briefly in the introduction section of this paper, research on the cognitive neuroscience of attention has a lengthy history of being relatively clearly defined, and tasks used to assess these abilities are correspondingly relatively well-researched and specific. As also addressed in this paper, the construct of emotional regulation has historically been poorly defined, which renders measures of emotional regulation correspondingly more general and lacking in clarity.

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Appendix A: Coding for the 'Snap' Game

Global Scale and Event Frequency Approach (Hughes et al., 2002)

Minor acts of disruption include behaviours such as moving the counters to the wrong place, interrupting the researcher, and singing during explanation of the game. Major acts of disruption include behaviours such as grabbing the board, knocking the board over, throwing counters, grabbing the researcher's cards, refusing to return the cards, verbal or physical aggression, and storming out of the room. The coding for the Global Scale is as follows:

1=child cooperative throughout the game

2=child not fully cooperative (i.e. obeys sluggishly)

3=child failed to cooperate more than once, or has one minor disruption.

4=child shows one major disruptive act, or several minor disruptive acts.

5=child's disruptive behaviour results in premature game termination.

Examples of rule violations include calling 'Snap' without having a matching pair of cards, or trying to move the counter more than one square along. Coding for the Event Frequency Scale is as follows:

1 = not present

3 = occurred once or twice

5 = occurred more than twice.

Eight Target Event Approach (Hughes, Cutting, & Dunn, 2001)

In this approach, eight target events are identified as present or absent on each deal. These include:

1. Positive comments about the self.
2. Positive comments about the friend.
3. Negative comments about the self.
4. Negative comments about the friend.
5. Accusations or angry complaints.
6. Whining/sad appeals.
7. Cheating.
8. Controlling behaviour.

Appendix B: Child History Questionnaire

This questionnaire is designed as a measure to obtain basic information about your child. Whatever information you may be able to offer will be invaluable in helping us to determine which applicants are most suitable for this phase of the study. We appreciate your participation in what we feel is an exciting and important study.

ID #: _____

Gender: ☐ M ☐ F **D.O.B.:** _____ **Age:** _____

DEVELOPMENTAL / MEDICAL HISTORY

Pregnancy with this child:

Were there any complications with your pregnancy with your child (e.g. anemia, high blood pressure, toxemia, diabetes, infections, hospitalizations, etc.)?

_____

_____

Were any medications/drugs used during the pregnancy (if yes, please explain)?

_____

_____

Complications during birth:

Induced: _____

C-section: _____

Forceps: _____

Fetal Distress: _____

Breech (feet first): _____

Twins: _____

Other (e.g. breathing problems, cord around neck):

_____

Newborn:

Following delivery, was the baby:

- blue at birth: _____
- requiring oxygen: _____
- having jaundice: _____
- requiring phototherapy: _____
- having seizures: _____
- Other: _____

Was medication used? ☐ yes, reason: _____
☐ no

Childhood: (see interview form)
Are there any medical problems currently affecting your child. If yes, please explain.

_____
_____

Appendix C: Dimensions of Child Behavior Questionnaire Original Form

The Children's Behavior Questionnaire

The Children's Behavior Questionnaire is administered to parents of children ages 3 to 8. Parents are asked to rate their child on each of the 195 items, using a 7-point scale ranging from 'extremely untrue of your child' to 'extremely true of your child'.

Responses yield information along 15 scales. These scales, and sample items from them, include:
Activity Level - rate and extent of motor activity.
Example: 'seems always in a big hurry to get from one place to another'

Anger/Frustration - negative affectivity related to interruption of ongoing tasks or goal blocking.
Example: 'has temper tantrums when s(he) doesn't get what s(he) wants'

Attentional Focusing - capacity to maintain attentional focus on task-related channels.
Example: 'when picking up toys or other jobs, usually keeps at the task until it's done'

Discomfort - negative affectivity related to intensity or rate of sensory stimulation.
Example: 'is not very bothered by pain'

Fear - negative affectivity, including unease, worry, or nervousness relate to anticipated pain or distress.
Example: 'is not afraid of dogs and/or other animals'

High Intensity Pleasure - enjoyment related to situations involving high intensity or rate of stimulation
Example: 'likes going down high slides or other adventurous activities'

Impulsivity - speed of response.
Example: 'usually rushes into an activity without thinking about it'

Inhibitory Control - ability to plan and suppress inappropriate approach responses.
Example: 'can lower his/her voice when asked to do so.'

Low Intensity Pleasure - enjoyment related to situations involving low stimulus intensity or rate.
Example: 'rarely enjoys just being talked to'

Perceptual Sensitivity - Detection of slight, low-intensity stimuli from the external environment
Example: 'notices the smoothness or roughness of objects s(he) touches'

Positive Anticipation - amount of excitement and anticipation for expected pleasurable activities.
Example: 'gets so worked up before an exciting event that s(he) has trouble sitting still'

Sadness - negative affectivity related to exposure to suffering or disappointment.
Example: 'cries sadly when a favorite toy gets lost or broken'

Shyness (versus Social Approach) - slow (versus rapid) speed of approach and discomfort (vs. comfort) in social situations.
Example: 'often prefers to watch rather than join other children playing'

Smiling/Laughter - positive affect in response to changes in rate or intensity of stimuli.
Example: 'laughs a lot at jokes and silly happenings'

Soothability (and Falling Reactivity) - rate of recovery from peak distress, excitement, or general arousal.
Example: 'has a hard time settling down for a nap'

Appendix D: Scales and Items of CBQ Used to Assess Emotional Regulation

ANGER/FRUSTRATION (AN), N = 13, Alpha = .76

My child:

2. Gets angry when told s/he has to go to bed.
19R. Rarely gets irritated when s/he makes a mistake.
34. Has temper tantrums when s/he doesn't get what s/he wants.
62. Gets quite frustrated when prevented from doing something s/he wants to do.
73. Gets mad when even mildly criticized.
78. Gets angry when s/he can't find something s/he wants to play with.
120R. Rarely gets upset when told s/he has to go to bed.
128. Becomes easily frustrated when tired.
140. Gets irritable about having to eat food s/he doesn't like.
156R. Rarely protests when another child takes his/her toy away.
173. Easily gets irritated when s/he has trouble with some task (e.g., building, drawing, dressing).
181. Gets angry when called in from play before s/he is ready to quit.
193. Gets mad when provoked by other children.

FALLING REACTIVITY & SOOTHABILITY (SO), N = 13, Alpha = .80

My child:

14R. Has a hard time settling down for a nap.
27. Calms down quickly following an exciting event.
42. Can be "cheered up" by talking about something s/he is interested in.
53R. Has a hard time settling down after an exciting activity.
68R. When angry about something, s/he tends to stay upset for ten minutes or longer.
85. Seems to forget a bump or scrape after a couple of minutes.
92. Changes from being upset to feeling much better within a few minutes.
103. Falls asleep within ten minutes of going to bed at night.
118. If upset, cheers up quickly when s/he thinks about something else.
134. Is easy to soothe when s/he is upset.
150R. Is very difficult to soothe when s/he has become upset.
167R. Has a hard time going back to sleep after waking in the night.
177. Rarely cries for more than a couple of minutes at a time.

SADNESS (SD), N = 12, Alpha = .67

My child:

18.	Cries sadly when a favorite toy gets lost or broken.
39.	Tends to feel "down" at the end of an exciting day.
44.	Tends to become sad if the family's plans don't work out.
55.	Seems to feel depressed when unable to accomplish some task.
64.	Becomes upset when loved relatives or friends are getting ready to leave following a visit.
72R.	Does not usually become tearful when tired.
81.	Her/his feelings are easily hurt by what parents say.
94.	Becomes sad when told to do something s/he does not want to do.
109R.	Rarely cries when s/he hears a sad story.
112R.	Rarely becomes upset when watching a sad event in a TV show.
127.	Sometimes appears downcast for no reason.
149R.	Rarely becomes discouraged when s/he has trouble making something work.

Appendix E: Instructions for 'Snap' game

"Have you ever played a game called 'Snap' before? Well, we're going to play a game a bit like 'Snap', using these special snakes. This one is for you [to Child A] and this one is for you [to Child B]. I'm going to give you each 2 cards with pictures of farm animals. [To A:] If your cards have the same animal on them, I want you to say 'Snap'. [To B:] And if your cards are the same, you can say Snap too! [To both:] When you get a 'Snap', you can move your magnet ONE place along the snake. [Give magnets to children.] No Cheating! Move your magnet one place along each time you get a 'Snap'. The winner is the first to get to Number 10, and will get a special prize. OK, do you understand what to do? Let's have a practice first without the magnets. First, I'll give 2 to (B). That's right, they're a 'Snap'. Now, in the proper game, you'd move your magnet one place, wouldn't you? Now it's (A)'s turn. Oh, so they are not the same. So you wouldn't say 'Snap', would you?"