

NEW MEASURES FOR HOT EXECUTIVE FUNCTION

BY

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## **Abstract**

The purpose of the current study was to examine whether two new preschool-friendly versions of Delayed Match to Sample (DMS) and Delayed Non-Match to Sample (DNMS) could be used as measures for hot executive function. Ninety-four children completed three tasks: match to sample tasks (DMS and DNMS), Preschool Gambling Task (PGT), and an empathy task. The findings of the study indicated that there was a significant age difference in the performance of children in both DMS and DNMS tasks where four-year-old children overall performed better on both the tasks. It was also found that children overall performed better on DMS when compared to DNMS, which suggested that children were good at learning the matching rule. The findings also indicated that both DMS and DNMS were associated with PGT. More specifically, DNMS was related to the learning phase (first 30 cards) of PGT, while the DMS was related to the awareness phase (last block) of PGT. These results indicated that ‘conceptual’ scores on DMS were predictive of PGT awareness scores and the ‘learning’ scores on DNMS were predictive of PGT learning of index. Therefore, it was concluded that the results were indicative of having two distinct processes of decision making. Finally, it was also found that DNMS and DMS were positively associated with the empathy task.

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## **New Measures for Hot Executive Function**

A child's preschool years are critically important in terms of significant cognitive development, one of the most prominent being the development of executive function (EF). Kerr and Zelazo (2004) found that executive function and the abilities associated with the prefrontal cortex undergo rapid development between the ages of three and four. Executive function can be defined as a set of neurocognitive skills that are required for controlling attention and other processes to solve goal-directed problems (Semenov & Zelazo, 2018). Executive function is divided into two constructs: hot executive function and cool executive function. Cool EF is used to solve abstract problems, whereas hot EF is used to solve problems that are related to motivation (Garon, 2016). Cool EF is also found to be predictive of academic achievements, whereas hot EF predicts behaviours linked to temperament and self-regulation (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009). Moreover, performance in hot EF is more strongly associated with measures of social functioning such as prosocial behaviour and empathy (Eisenberg, Spinard, & Smith., 2004).

There is a large body of work exploring the development of cool EF and the measures used to identify cool EF (Boudreau, Dempsey, Smith & Garon, 2017; Kerr & Zelazo, 2004; Miyake & Friedman, 2013); however, there is a lack of research concentrating on hot EF and hot EF measures. There are many robust measures used to study cool EF, such as the Self-ordering Pointing task, the Wisconsin Card Sorting Test (WCST) and the Dimensional Card Sort (DCCS) (Hongwaniskul, Happaney, Lee & Zelazo, 2005). However, when it comes to measuring hot EF, there are not as many measures, particularly for preschoolers. Some of the prominent measures used for hot EF are the Preschool Gambling Task (PGT) and Delay of Gratifications (DoG) tasks (Hongwaniskul et al., 2005). Interestingly, the PGT and DotG tasks have not been associated

with one another (Hongwanishkul et al., 2005; Poon, 2018). The goals of the present study are to explore whether the Delayed Match to Sample (DMS) and Delayed Non-Match to Sample (DNMS) tasks, two hot EF tasks, are predictive of performance on the Preschool Gambling Task, a more established measure of hot EF in preschool and whether they are associated with a measure of empathy.

### **Executive Function**

Executive function is an umbrella term that often refers to various mental processes that help us perform day to day activities like planning, focusing attention, remembering instructions, and more. Semenov and Zelazo (2018) identified three neurocognitive skills that together are at the core for executive functions. The first one was cognitive flexibility, which refers to the ability to be able to think about problems from different perspectives, such as what you believe to be true versus someone else's false belief. The second one was working memory, which refers to the skill of holding in mind and manipulating information such as solving a math problem. The third one was inhibitory control, which is deliberately controlling an automatic response, such as paying attention to what the teacher is teaching while ignoring the whispered conversations happening around you.

The prefrontal cortex, which underlies EF, is divided into three main networks: the dorsolateral prefrontal cortex (DL-PFC), medial prefrontal cortex (M-PFC) and orbitofrontal cortex (OFC). These divisions loosely parallel the division of EF into cool and hot components. Research has demonstrated that DL-PFC is more strongly associated with cool EF. The OFC, which is a part of the frontostriatal circuit and its connection to the amygdala and limbic system, is more strongly associated with the regulation of affectively motivated decisions or in other words, hot EF (Levine, 2017). Research has also shown that connections between OFC and

amygdala are required for affective decision making due to the roles these connections play in processing emotional and social stimuli (Damasio, 1994). The ventromedial prefrontal cortex (VM-PFC) is made up of medial PFC and OFC. Research on hot EF stemmed from research on adult patients with VM-PFC damage. Bechara, Damasio, Damasio and Anderson (1994) conducted a study, which found that adult patients with damage to VM-PFC displayed deficits in their executive function. Patients with damage to VM-PFC were unable to comprehend the future consequences of their actions and were guided by immediate rewards (Bechara et al., 1994). Participants with damage to OFC had impairments in their abilities to process reward-related information and especially detect changes in reinforcement contingencies that are necessary to make appropriate modifications to their behaviour (Elliot, Dolan & Frith, 2000).

There has been much literature that looks at how hot and cool EFs are similar and dissociable. Some studies have not been able to find evidence to support the difference between hot and cool EF. One such study is by Allan and Lonigan (2011), who performed a study to examine the dimensionality of executive function in preschool children. They found that in previous literature, socioemotional related outcomes were associated with hot EF, and academic-related issues were related to cool EF. Hence, they hypothesized that tasks representing cool dimensions of EF would correlate better with academic performance and tasks representing hot dimensions of EF would correlate better with socioemotional development. They had eight measures of EF: four measured the hot dimension and four-measure the cool dimension. Their results did not support the multidimensional structure of executive function, or in other words, they could not find any difference between the hot and cool executive function. This study concluded that the executive function is represented best as a unidimensional construct. However, a null result cannot be used to provide support for a theory.

Nevertheless, some studies have been able to distinguish between hot and cool EF. In a review of the literature, Garon (2016) has found a few similarities and differences between hot and cool EF. One distinction discussed in the paper is the use of top-down and bottom-up processes by hot and cool EF. Miyake and Friedman (2012) identified working memory, response inhibition, and shifting as the three core cool EF components, which primarily involve top-down regulation. Metcalfe and Mischel (1999) explained how hot EF involves bottom-up regulatory processes. Garon (2016) argued for the importance of bottom-up regulatory influence in regulating top-down EF processes. The differences in the position of the two constructs (hot and cool EF) on the EF processing hierarchy is one of the challenges that makes studying hot EF difficult. Cool EF is at a higher level than hot EF on the EF processing hierarchy. Therefore, due to this arrangement, when it comes to resolution of hot EF problems, both hot and cool EF may be involved. This involvement and interaction between the two executive functions make it very hard to dissociate between hot and cool executive function.

Moreover, it is complicated to study hot EF exclusively because of the task-impurity problem (Miyake and Friedman, 2012). As any measure of a task does not only include the target EF but also will consist of the systematic non-EF variance and measurement errors. Task-impurity is more of a problem in hot EF than cool EF as many hot EF tasks require the activation of cool EF. Researchers argue that making an advantageous choice might include the involvement of both hot and cool EF (Garon, 2016). They state that the decisions made in the task would rely on the cool EF network's ability to strengthen the functioning of the hot EF network by providing information about goals and context to update the value. The two hot EF tasks (Preschool Gambling Task and Delayed Gratification task) vary on the extent to which they activate both hot and cool EF processes. Therefore, there are many barriers when studying the

hot EF, one being the difficulty of distinguishing between what is self-regulation and what is executive function. Moreover, it is challenging to separate the hot vs. cool EF measures, which makes it very hard for research in this area to move forward.

The two main tasks used today to measure hot executive functions are the Preschool Gambling task (PGT) (Kerr & Zelazo, 2004) and Delay of Gratification tasks (DoGT) (Mischel et al. 2010). Further complicating the issue of measuring Hot EF is that these two main tasks have not been found to show an association (Hongwanishkul et al., 2005; Poon, 2018). These issues could potentially be solved by coming up with a more age-sensitive Hot EF task. Garon (2016) stated that simplifying task structure improved children's awareness and performance in the tasks.

### **Hot EF Measures in Preschoolers**

**Delay of Gratification.** This is one of the most common measures used to assess hot EF. The delay of gratification task (DoG) is used to evaluate children's self-control and their ability to think of future consequences when they are considering choices. Garon (2016) identified three variations of DoG tasks in preschoolers: 'choice DoGT,' 'wait DoGT,' and 'temptation DoGT.' The first-ever DoG task was conducted in 1962 by Mischel and Metzner, and it was the standard choice DoGT where the children had to choose between an immediate reward now and a substantial delayed reward after a specified period. Rewards were in the form of treats and small toys. Findings of age improvements have been inconsistent with choice DoG tasks.

Garon, Longard, Bryson and Moore (2012) conducted a study with 90 children from ages two to four years, where they had a choice between one sticker now or 1, 2 or 4 stickers later. They found that the youngest group (two-year-olds) and the oldest group (four-year-olds) chose to delay more as the number of stickers increased; the three-year-olds did not follow this trend.

Garon et al. (2012) explained this in terms of three-year-olds not having strong enough activation of the top-down system (associated with cool EF) to overcome the bottom-up system (associated with hot EF) which leads the child to choose in accordance to immediate desire. The two-year-old children solely focused on the quantity of the sticker and did not analyze the situation thoroughly; they just went with the higher number of stickers. The four-year-old children had a better developed top-down system to overcome the bottom-up system. Therefore, they could not only picture the more substantial reward but could also choose to wait in order to get it by suppressing their immediate desire to get it (Garon et al., 2012). Research has indicated the length of delay, the objective size of the reward, and the magnitude of delayed reward have all shown to impact choice (Garon, 2016).

The second variation of the DoG task is the ‘wait DoG task.’ This is the classic “marshmallow task,” in which the children are seated in front of two marshmallows and told that the researcher had to leave the room for a few minutes after being presented with a simple choice. They can either choose to wait until the researcher came back and get two marshmallows or ring the bell at any point and have one marshmallow. This task measures how long a child can resist settling for a small, immediately available reward. There have been age differences found between two to four years; 2-year-olds delay for a significantly shorter period than 3-year-olds (Garon, 2016). While the two versions of the DoG task seem very similar, findings indicate only a weak to moderate correlation between ‘choice DoG task’ and ‘wait DoG task’ (Garon, 2016).

Moreover, the number of seconds preschoolers waited to get the delayed treat significantly predicted higher SAT scores and better social cognitive and emotional coping in adolescence (Mischel et al., 2010). In follow up studies, it has also been found that the ability to delay immediate rewards in preschool predicted higher educational achievement, a higher sense of

self-worth, better ability to cope with stress later in adulthood. Some strategies that were suggested by Mischel et al. (2010), which helped children delay longer were self-distraction, and focusing on the non-consummatory qualities such as the shape instead of its consummatory features such as its taste and texture. This task appears to be a combination of both hot and cool EF, where there is a battle between immediate reward vs. inhibition (Mischel et al., 2010). Research with ‘wait DoG’ tasks show that mental representation that is ‘hot,’ such as focusing on the affective properties of the reward, hinders the delay because it becomes too difficult to resist the immediate availability of treat. However, representations based on ‘cool’ aspects have the opposite result.

The third variation of the DoG task is the ‘temptation DoG’ task. These tasks include two components, an attractive toy or activity and the prohibition to use the toy or engage in the activity (Garon, 2016). The difference between this variation and the ‘wait DoG’ task is the absence of large reward after the waiting. The conflict in these tasks is between immediate reward accompanied by social sanctions and delayed reward with social approval. There is a gradual increase in the ability to resist from two-years of age onwards. Furthermore, some of the strategies used to resist are distraction strategies, self-verbalization, and encouraging negative evaluations of the toy (Garon, 2016).

Therefore, research has found the involvement of both hot and cool regulatory processes in all the DoG tasks. To explain the findings in the DoG task studies, Mischel and Ayduk (2004) proposed the Cognitive Affective Processing system (CAPs). This system discussed the interaction between the emotional hot system and the cognitive, cool system. The amygdala-based emotional, hot processing system generates automatic flight or fight response, whereas the hippocampus-based cognitive cool processing system generates thoughtful reflective reactions.

Therefore, making good choices depend on suppressing the hot system and activating the cool system. As preschoolers develop hot systems before developing a cool system, they tend to make poorer choices as compared to older children (Mischel & Ayduk, 2004).

**Iowa Gambling Task.** Another widely used measure of hot EF is the Iowa Gambling Task (IGT). Bechara, Damasio, Damasio and Anderson (1994) developed a novel decision-making task to provide a more sensitive assessment for adults with damage to the ventromedial prefrontal cortex (associated with hot EF network). Bechara et al. (1994) presented VM-PFC patients and healthy control with four decks of cards that revealed a combination of gains and losses, measured in play money. Participants were given a stake of \$2000 in play money and were asked to win as much as possible by choosing cards from any of the four decks, one card per trial. They were not told how many trials there would be, but they were told that some of the decks were better than others. There were two advantageous decks (would result in a net gain) and two disadvantageous decks (would result in a net loss). There were 100 trials in the game, and after each card, they either had reward (received money) or penalty (had to give away money). Decks A and B were the bad decks with a net loss of 50% where Deck A had more frequent punishment of less magnitude, and Deck B had less frequent punishment at a higher magnitude. The good decks (Deck C and D) had an overall gain of 10%, where Deck C had more frequent rewards of less magnitude, and Deck D had less frequent rewards at a higher magnitude. Each card from the disadvantageous decks (\$100) provided a higher reward than each card from the advantageous deck (\$50).

The researchers found that both patients and controls typically preferred the disadvantageous cards at the beginning. Whereas controls were increasingly likely to select from the advantageous deck, patients were not. Bechara et al. (1994) explained these findings as a result

of patients being overly sensitive to immediate reward, insensitive to delayed punishment and finally insensitive to future consequences. Bechara, Tranel, Damasio and Damasio (1996) explored the development of conscious awareness of choice by patients with bilateral lesions to ventromedial prefrontal (VM-PFC) region as a follow-up study to Bechara et al. (1994). Skin conductance response was measured as they played the Iowa Gambling Task. It was found that autonomic response generated by controls demonstrated the nonconscious signalling, which the researchers hypothesized made them stay away from disadvantageous decks. In contrast, the VM-PFC patients did not have any such nonconscious warning.

This nonconscious signalling “feeling”, or “hunch” is explained by the Somatic Marker Hypothesis. Damasio (1994) explained why VM-PFC patients had poor judgements when making decisions. This theory proposed the VM-PFC to be a convergence zone where cognitions and emotions integrated as one. Somatic markers were described as feelings in the body that are associated with emotions such as increased heart rate (anxiety) or nausea (disgust). These somatic markers strongly influenced decision making. These somatic markers enabled quick decision making by guiding the decision-makers to concentrate on relevant salient features and ignore the rest. These reactions are based upon the individual’s previous experience with similar situations. Somatic markers increase the efficiency and accuracy of decision making. This hypothesis also emphasized the importance of bottom-up motivational processes (assessing risks and rewards) in the success of top-down regulation (making good decisions) (Garon, 2016). There has been evidence that the inability to engage in this bottom-up regulatory processes as a result of damage to limbic areas also leads to top-down processing failure. Researchers argued that cool EF processes are dependent on hot EF brain networks even though cool EF processes such as working memory are involved in decision making. There is evidence of poor

performance when one only has explicit knowledge without implicit value representations (Garon, 2016). Damage to VM-PFC impairs the somatic marker system and the processing of somatic or emotional signals; however, they do not affect other cognitive abilities. This damage leads to pathological impairment in real life and gambling tasks when it comes to decision making.

**Preschool Gambling Task.** Kerr and Zelazo (2004) developed a childhood version of the Iowa Gambling Task (IGT). They aimed to examine the development of hot EF using a task that would be sensitive to age-related changes between three and four years. They modified the IGT in several ways. First, they only had two decks of cards instead of four, and second, the number of trials was reduced from 100 to 50, and the rewards were candy instead of play money. Moreover, information about gains and losses were conveyed using happy and sad faces instead of written text. They predicted that three-year-olds would make more disadvantageous choices, whereas four-year-olds would tend to make more advantageous choices.

Kerr and Zelazo (2004) found the performance of four-year-olds improved over trials, and that they made more advantageous choices than three-year-olds during the last three blocks of trials. Therefore, results indicated that affect decision making develops rapidly during the preschool period, possibly reflecting a growth of neural system involving the orbitofrontal cortex. Other studies using child variants of IGT have supported the results found by Kerr and Zelazo (2004) in terms of age-related differences (Bunch, Andrew & Halford, 2007; Peterson & Welsh, 2013).

Further studies conducted on PGT have found that task structure has a significant influence on older preschooler's ability to choose advantageously. There are two main ways to alter the task structure: between games or between decks within a game. Task structure can vary between

games in terms of frequency of losses across trials where games differ in terms of frequency of wins and losses. Task structure can also vary between decks within a game in terms of net wins and net losses being different. Bunch, Andrew, and Halford (2007) wanted to study the effect of task complexity of CGT on performance. They created three versions of CGT: two simpler versions and one complex version. The simpler version made it easier to identify whether they were advantageous or disadvantageous, whereas it was more complicated in the third version. The results indicated that when the complexity of the task was reduced, three-year-olds were able to succeed better on the task.

Garon (2016) identified two stages in PGT. The first stage was integrating information about conflicting rewards and losses over multiple trials while the second stage was using this newly constructed value representation (somatic markers) and translating it into explicit knowledge to help make choices. Garon (2016) identified the first stage to be the most challenging stage for both preschoolers and older children. Another variable that can impact performance is awareness in decision making, where studies have shown improvement in performance after being aware of what is going on in the game. It has also been suggested that asking the children questions about the decks might help them consolidate their implicit and explicit knowledge, which can help them make better choices (Garon, 2016).

To summarise, there is an interaction of hot and cool EF networks in both IGT and DoG tasks. However, the nature of the interaction between these two processes is different. In DoG tasks, there are explicit instructions provided on the value of each choice and the delay involved; however, in IGT, this information is not provided, and the participants will have to learn it through making choices through feedback (wins and losses).

**Object Reversal Task.** Object reversal task is another promising hot EF task. The object reversal task requires the participant to learn the reinforcement value of two stimuli and then reverse the reward values. In adult monkeys, the task is dependent on the integrity of the orbitofrontal cortex. Early ablations of OFC affect monkey's performance on object reversal test from which one can conclude that object reversal task measures hot EF (Izquierdo, Suda & Murray, 2004; Rudebeck & Murray, 2008). Moreover, reversal tasks did not share large variability with measures such as A-not-B or Delayed Alternation, suggesting it was less reliant on cool EF abilities such as working memory or inhibitions (Epsy, Kaufmann, Glisky & McDiarmid, 2001).

Overman, Bachevalier, Schyhmann, and Ryan (1996) were the first ones to test object reversal in babies. They had 62 children from ages 15 months to 55 months. The task required the participants to discriminate between two stimulus objects (Problem 1) using 15 nonverbal trials per day. One of the objects always concealed food rewards (positive), and one did not (negative). The spatial location of the positive stimulus was randomly distributed across trials. After the participant learned to respond consistently to the positive stimulus (two successive 15 trial sessions with a minimum of 13 out of 15 correct), the participant learned second discrimination between two new objects (Problem 2). The day after reaching criterion on the second discrimination problem, the reward contingencies on this problem were reversed without warning, which made the previously negative object positive and vice versa. The participant was taught this reversed discrimination to criterion, after which the reward contingencies were reversed again. This pattern went on for five consecutive reversals. The participant's score for this task was the number of errors to criterion on each reversal and the total number of errors on all reversals. Overman et al. (1996) found that there was an improvement in this ability from 18

months to 36 months. Males under the age of 30 months were superior to age-matched females in object reversal, mirroring the pattern found in monkeys. This study provides evidence that OFC in humans develops earlier in males than in females. Espy et al. (2001) supported the developmental results found by Overmann et al. (1996) and found differences from 2.5 years to 5 years in a simplified version of the object reversal task.

**Delayed-Match to Sample and Delayed Non-Match to Sample.** Both these tasks have been extensively used to test learning and memory in animals. In a Delayed-Match to Sample (DMS) trial, a sample is shown to the subject, and the subject is required to take the food reward hidden under the stimulus. Following this, the stimulus is removed from view. After a delay, the sample is presented again with one or more comparison stimuli. The subject is expected to choose the original sample by retrieving the food reward under it (Overman, 1990). The Delayed non-match to sample (DNMS) task parallels the DMS procedure. However, in this case, when presented with choice after learning the initial stimulus, the subject will have to respond and choose the novel stimulus every time. Past research indicates that animals learn to match-to-non-sample tasks significantly faster than matching to sample tasks as they have a natural preference to reach for new objects (Overman, 1990).

Overman (1990) also tested 12 – to 36 – month-old children on DMS and DNMS tasks. The stimulus tray contained three food wells where a food reward (Cheerio or Froot Loop) was hidden under a sample stimulus object (small toy) placed over the center food well. The child was required to move the little toy to retrieve the food reward underneath it. The stimulus tray was pulled back, and there was a 10-second delay. The sample toy was presented again but with other comparison stimuli containing food rewards as well. In the DMS task, the original toy provided the food reward, and in DNMS, the novel stimulus contained the food reward. Every

time the child got the food reward, the experimenter used social reinforcers such as “good boy/girl” to increase motivation. The experimenters used the trial-unique method where they have over 800 different toys so that none of them would be repeated in a month. There were 15 trials each day. The results indicated that DNMS developed earlier than DMS, where early DMS was not passed until three years of age in children; however, DNMS was passed at 21 months in children. Moreover, Diamond (1990) replicated the findings using this task. Like Overman’s study, she found that children failed in DNMS until roughly 21 months of age.

One of the explanations provided by the Overman (1990) was the novelty effect. The DMS task requires the child first to associate the reward with a novel stimulus where the child gets used to identifying the novelty. However, when presented with a comparison stimulus, children had to associate the reward with familiarity (the sample object again) instead of novelty, which was tantamount to learning two rules every time. In contrast, the child only had to associate the reward with novelty in the DNMS task. Moreover, numerous studies have found that very young children have an inherent preference for novel stimuli. Therefore, DMS required more inhibition in terms of inhibiting the tendency to reach of the novel object than DNMS. Inhibition is associated with the dorsolateral prefrontal cortex, which only develops at around three years of age in children (Gerardi-Caulton, 2000), which could explain how children performed better in DNMS than in DMS.

Early research on the neuropsychology underlying these tasks indicated that these tasks tapped into the hippocampal network (Diamond, 1990) as these tasks are dependent on the explicit memory system, which is subserved by the hippocampal neural circuit. Research has shown that hippocampal damage impairs performance on the tasks (Diamond, 1990). However, more recent neuroimaging research by Elliot, Dolan and Frith (2000) with these tasks in healthy

adults with shorter delays (5s) or no delay indicates that they activate orbitofrontal networks. When neuroimaging for the matching condition was compared to the non-matching condition, a significant neural response was seen in medial caudate and ventromedial OFC. Ventromedial OFC regions are implicated in short-term memory tasks (Elliot et al., 2000). Both DMS and DNMS recruit short-term memory processes during the task, which activates the ventromedial OFC. However, a partial dissociation was noted where the DMS activated the medial orbitofrontal (OF), and the DNMS activated the lateral OFC.

There is some evidence that the medial and lateral OFC show partially dissociable functions (Elliot et al., 2000). According to Elliot et al., the evidence indicates that the medial OFC helps select and maintain stimuli based on their reward value and helps to contrast these values with possible reward values of future stimuli. The lateral OFC, on the other hand, is activated when the response to the previously associated reward has to be inhibited. Furthermore, the lateral OFC seems to have a specific role in using reward value associated with stimuli and responses to select actions. Therefore, it is involved in decision making and choosing responses, particularly in unspecified or uncertain situations (Elliot et al., 2000). These ideas were supported by Damasio (1994), who found that patients with lesions of the medial OFC manifested impairment in real-life decision making.

Furthermore, accumulating research is indicating that the two hot EF networks (lateral and medial OFC) play different roles in decision making. Medial OFC is critical for tracking the value of potential options, and lateral OFC is engaged in linking specific feedback to specific cues in a stream of information (Fellows, 2016). The lateral OFC network is implicated in processing negative feedback, dealing with uncertainty, responding quickly to changes in the environment and quickly learning when a context changes (Elliott et al., 2000). On the other

hand, the medial OFC has been implicated in using and comparing values to make the best choice, maintenance of a strategy/rule for reward, and in recalling and using emotional imagery to make a decision (Benoit, Gilbert & Burgess, 2011).

Moreover, Brand, Recknor, Grabenhorst & Bechara (2007) conducted an experiment which investigated the relationship between the performance on Iowa Gambling Task (IGT), executive function and decision making. They found that there were two mechanisms of decision making involved in IGT. The first stage involved making decisions under ambiguity, that is when the outcome of the game was unclear, and the second stage involved making decisions under risk, that is when the outcome of the game depended on known probabilities. The study suggested that the early trials of the IGT game involved making decisions under ambiguity which was when participants were learning about the choices through feedback (i.e. rewards and losses). Moreover, the study suggested that the latter trials of the IGT involved making decisions made under risk, that is once the participant had figured out the rules for gains, losses and the risks associated with it they started to switch from making decisions under ambiguity to making decisions under risk.

Additionally, Lawrence, Jollant, O'Daly, Zelaya and Philips (2009) conducted an fMRI study to explore the brain areas involved in IGT. They found that the two stages of IGT were associated with different neural networks. The first stage of IGT was associated with the lateral orbitofrontal cortex (OFC), which played a significant role during the learning phase of the task. Whereas the second stage of the IGT was associated with the medial OFC, which helped track reward values and maintained an advantageous strategy (the latter part of IGT).

## **Empathy, Prosocial Behaviour and Hot Executive Function**

Bechara et al. (1994) developed the Iowa Gambling task to assess insensitivity to future consequences and impaired decision-making in adults with lesions to VM-PFC/OFC as they were showing some poor social adjustment. Despite showing poor social adjustment, they were not impaired on traditional cool EF abilities. Schneider and Koenigs (2017) found that patients with damage to VM-PFC have severe social difficulties such as lower empathy and perspective-taking, which is the ability to infer or determine another's viewpoint. The study also suggested that medial PFC is involved in emotional response to problems, and the lack of emotional response might also lead to poor decision making. These findings indicated that the VM-PFC, which is the underlying network for hot EF, seemed to play a crucial role in adaptive behaviour.

Additionally, performance on hot EF in preschoolers has been associated with measures of social functioning, including prosocial behaviour. For example, Kim et al. (2012) studied if "hot" tasks such as delay function can predict problem behaviour reported by mothers and fathers. They found that delay function both predict reported children's problem behavior where the worse the children perform on the "hot" tasks, the more problem behaviors the parents reported. Therefore, it can be inferred that hot EF is necessary for behavioural regulation. Moreover, Hao (2017) studied how hot inhibitory control can affect prosocial behaviour. The study described hot inhibitory control as the ability to inhibit emotional or motivational tendencies. The study found that inhibitory control was positively associated with donating behaviour (prosocial behaviour), whereas hot inhibitory control notably predicted donating behaviour during the later stage of middle childhood. These results correspond to those of Di Norcia et al. (2014), who found that prosocial behaviour such as cooperation was associated with better performance of hot inhibition in children between 2- to 3-years old. Unfortunately, there are too few studies that look at hot EF and its relation to prosocial behaviour.

## **Overview of this study**

The main goal of the current research will be to explore hot EF during the preschool period using two hot EF tasks (DMS and DNMS) that have been adapted to be sensitive for older preschoolers. Previous DNMS and DMS tasks have been administered primarily to younger preschoolers and infants (Overman, 1990). The typical procedure involves real objects and rewards hidden under wells (Diamond, 1990). In the current study, the task will use pictures rather than objects, and the tasks will be administered via a flipbook. The goal of the task will be to find a gold coin and children will be given the reward (a sticker) when they lift the correct flap and find a gold coin. As the DNMS develops earlier than the DMS in young preschoolers (Overman, 1990), the first hypothesis of the study is that there will be significant differences in performance in both tasks. Furthermore, based on previous research, it was expected that children would perform better on DNMS than DMS. However, our participants are older than the children previously tested by Overman (1990). Therefore, it would be interesting to explore how different the performance of the older preschoolers will be on these tasks. For instance, adults have shown comparable performance on the two tasks (Lamar, Yousem & Resnick, 2004).

The second goal of the study was to explore the association of the DMS and DNMS with the Preschool Gambling task (PGT) (Kerr & Zelazo, 2004). As previous research suggests that both the matching task and PGT activates networks associated with hot EF, it is predicted that both tasks will be correlated with one another. Additionally, the second hypothesis of the study is that performance on the DNMS will be associated with the learning phase of the preschool gambling task (first 30 cards) while performance on the DMS will be related to performance on the last block of the preschool gambling task (Lawrence et al., 2009; Elliot et al., 2000).

Finally, the third goal is to explore the association of these DMS and DNMS tasks with an empathy induction task where a puppet loses his bottle. Schneider and Koenigs (2017) indicated

that the neural networks that underlie empathy overlap with neural networks underlying hot EF tasks. Therefore, it is expected that performance on both DNMS and DMS will be positively related to helping the puppet by handing the bottle back to the puppet when it loses it during the game (Schneider and Koenigs, 2017; Hao, 2017).

## **Method**

### **Participants**

Participants were recruited from daycares in Sackville, Moncton, and Amherst. Ninety-four children participated in the study with their parent's consent (Appendix A). There were 54 girls and 40 boys with a mean age of 49.7 months ( $SD = 7.93$ ). There were 34 three-year-old ( $M = 41.26$  months,  $SD = 3.80$ ) and 60 four-year-old children ( $M = 54.48$  months,  $SD = 5.20$ ) who participated in the study. Participation in the study was voluntary. Verbal consent was obtained from children before the administration of the games. Participants assented to their cooperation and could pick toys out of a "treasure" box after completion of each game.

### **Materials**

Parental informed consent, along with information about demographics were collected before testing each participant (see Appendix A). A box filled with small toys (Treasure box) was needed to serve as a reward for children after the completion of each task.

**Match to sample games.** This game required two flipbooks that contained pictures of two characters, "Rascally Raccoon" and "Friendly Frog." Both the flipbooks had 15 sets of images each. The first page provided a clue of what the child should look for on the next page. In the Friendly Frog flipbook, the matching sample gave the child a gold coin when they lifted the picture, whereas there would be nothing present under the flap in the non-matching sample. In

the Rascally Raccoon, the non-match sample had a gold coin underneath the flap, whereas the matched sample did not have any reward (see Appendix B – Figure 1a – 1c).

**Preschool Gambling task.** The Preschool Gambling task (PGT) was adapted from Kerr and Zelazo (2004). For this task, there were two decks of cards (Giraffe and Zebra), one advantageous and one disadvantageous. Decks contained pictures of a bunny (reward) and a monster (loss) or both depending on the deck. A board game was used to represent the rewards and losses visually. The game was set up as a board game which contained pictures of four levels in a house (basement, kitchen, living room and bedroom) and there were 40 steps in total from the bottom of the basement to the top of the bedroom. A magnetic car was used to move up and down the stairs. The advantageous deck (Zebra) had fewer losses as compared to the disadvantages deck (Giraffe) (see Appendix D).

**Empathic responding task.** *Pop the Pig* game was required for this task along with Baby Sam, who served as a puppet with a small milk bottle that functioned as his “Bubba” (see Appendix F). A video camera with a tripod was used to film the children while they played the game. Scoring sheet when coding the videos was used (See Appendix H).

## **Procedure**

The children played ten games, but only three games that are relevant to the study are explained in detail.

**Match to sample games.** The Match to Sample game (DMS) was introduced to the children as the “Friendly Frog”, and the Delayed Non-Match to Sample (DNMS) was introduced to the children as the “Rascally Raccoon” task. Both games were administered via a flipbook. The order of presentation of the games was counterbalanced; in the first order, the DMS game was

presented first, whereas, in the second order, the DNMS game was presented first. In both tasks, children were told that they would be going on a treasure hunt, and their objective was to find as many gold coins as possible. Each time they found a gold coin, they were rewarded with a sticker. They first went through a practice trial (trial round). Depending on the order, “Friendly Frog” or “Rascally Raccoon” was introduced; the frog or the raccoon held a picture that provided the clue for the children (see Appendix B). On the next page, they had two options to choose from, and if they chose the right option, there was a gold coin under the correct picture. If they picked the wrong choice, then they were shown the clue given by friendly frog/rascally raccoon again, and the experimenter said, “Ok- now look at froggy’s clue, and now look at where the gold coin was.” After further clarification, the proper trials began. There were 15 trials for each game. Children scored one point for each correct response for a total possible score of 15 on each game (see Appendix C). There were two scores that were computed for both the games. ‘The conceptual’ score which was computed by summing the total number of correct responses for the last five items on the test and could range from zero to five. ‘The learning’ score was computed by summing all the scores with a run of three or more correct responses and could range from 0 to 15.

**Preschool gambling task.** This was a board game with different levels in a house, and the house had 40 steps in total from the bottom of the basement to the top, in the bedroom. The objective of the game was to climb as high up the stairs as possible and to stay out of the scary basement. In this game, the children were introduced to two sets of cards: “Giraffe” (disadvantageous deck) and “Zebra” (advantageous deck). They were told that Giraffe and Zebra have cards that will tell them what to do in the game. The cards either had bunnies on them, which moved the car up the stairs or had monsters on them, which moved the car down the stairs.

Then they were asked, “Can you tell me what happens when you see a bunny?” and “Can you tell me what happens when you see a monster?” to make sure that the children understood the game. The magnetic car started at Step 11, which was the first step in the kitchen.

The game began when the experimenter asked the child to pick from either “Giraffe” or “Zebra.” Each card selection was recorded on a scoring sheet (Appendix E). Children received a point for each choice of the Zebra, which overall led to more bunnies than monsters over ten cards. After each card choice, the child received verbal reinforcement for gains such as “Good for you, there are X Bunnies, so you go up X steps.” When the card contained a loss, the experimenter said, “There are X bunnies, so you go up X steps, but oh no, there are X monsters, so you go down X steps. Those monsters are not very nice!”. If the child continuously chose from only one deck of cards, after ten cards, then the child was encouraged to select from the other set of cards by saying, “Why don’t we try [animal]?”

After 30 trials, the children were asked two awareness questions: “Which animal did you think was the best to pick from? Why did you think it was the best animal to pick from?” and “Which animal was the worst to pick from? Why do you think it was the worst to pick from?”. Children received one point for each correct answer for a possible total of four points. After the children answered the questions, they were asked to choose ten more times, and then they were asked the same question again. At the end of the game, the child was allowed to take one toy from the “treasure” box. Two scores were computed for analysis, the “index of learning” which was an average increase in the choice of Good cards over the first three blocks; this was computed by subtracting the scores on Block 3 from Block 1 and scores could range from -10 to 10. The PGT total “Awareness” score was computed by adding up the points that children received in their awareness questions and could range from 0 to 8.

**Empathic responding task.** The video camera was set up before the children started playing this game with the *Popping Pig* and Baby Sam. In this game, Baby Sam was introduced to the child by the experimenter. The experimenter then described the things that Baby Sam liked to do, such as “She/He likes to have her bottle and drink milk from her/his bottle. She/he cries wherever he/she loses her bubba (bottle) and is it ok if Baby Sam watches you play the Popping Pig game?” The experimenter then explained the purpose and the rules for the Popping Pig game.

The children were then asked to try to feed the Pig as many burgers as possible to make its belly pop and win a prize. After the child consented, the child started feeding the Pig some burgers while another experimenter started pressing the Pig’s head to pop its belly. When the child fed the Pig his second burger, Baby Sam dropped his bottle and started crying. The experimenter waited until the child gave the bottle back to Baby Sam; if the child did not give the bottle back within five seconds, the experimenter gave Baby Sam the bottle back. Baby Sam then again lost his bottle and started crying when the child fed the Pig his seventh burger. After the Pig’s belly was popped the first time, the child was shown a card (See Appendix F), and was asked: “How do you think Baby Sam feels when he loses his bubba?” After the child answered, they played another round of the game. The children scored one point if they looked at Sam when he dropped his bottle and 2 points if they gave him his bottle (see Appendix G). At the end of the game, the children will be presented with the treasure box again from which they could choose any toy they want to take home. Two experimenters then reviewed the footage and coded the videos and scored the children on a scoring sheet (Appendix H). The definitions of how behaviours were identified and coded are attached in Appendix I. The inter-rater reliability for the coding is provided in Table 1.

Table 1

*Inter-rater reliability for the coding of Baby Sam videos for Game 1 and Game 2 (two raters)*

Scale	Description	Reliability
Game 1		
<b>Focus</b>		
Before Loss	Scale made up of ratings:	0.658
After First Loss	Overall child focus, speed of feeding pig, and reverse coding of child looking at Sam	0.962
After Second Loss		0.925
<b>Looking &amp; Stopping</b>		
During First Loss	Scale made up of ratings: Child look duration at Sam, speed of looking at Sam, and stopping game	0.973
During Second Loss		0.984
<b>Helping Behaviour</b>		
During First Loss	No giving = 0, putting bottle next to Sam = 1, and giving bottle directly to Sam = 2	1
During Second Loss		0.916
Game 2		
<b>Focus</b>		
Before Loss	Scale made up of ratings:	0.928
After First Loss	Overall child focus, speed of feeding pig, and reverse coding of child looking at Sam	0.977
After Second Loss	Scale made up of ratings: Child look duration at Sam, speed of looking at Sam, and stopping game	0.749
<b>Looking &amp; Stopping</b>		
During First Loss		0.986
During Second Loss		0.983
<b>Helping Behaviour</b>		
During First Loss	No giving = 0, putting bottle next to Sam = 1, and giving bottle directly to Sam = 2	1
During Second Loss		0.993

*Note.* All scales range from 0 to 1 – with 0 is lowest and 1 is highest

## Results

This study examined whether the Delayed Non-Match to Sample and Delayed Match to Sample could be used to assess hot executive function in preschoolers. In order to validate the measures, they were correlated with the Preschool Gambling Task, which is an already established measure of hot executive function. In addition, in order to assess the sensitivity to age differences during the preschool period, the performance of three- and four-year-olds was compared on the two measures. Finally, the study also aimed to see if these two tasks were related to an empathy response task. Table 2 presents all the descriptive statistics and partial correlations of the main variables controlling for age in months.

Table 2

*Pearson coefficient correlation for computed scores on Matching and Non-matching game with computed scores of Preschool Gambling Task with Age in months as control*

Variable	Mean (SD)	1	2	3	4	5
1. Matching Game total learning level correct	7.72(4.06)					
2. Non-Matching game total learning level correct	4.83 (4.40)	.27**				
3. Matching game Conceptual score	3.33 (0.89)	.56**	.14			
4. Non- Matching game Conceptual score	2.81 (1.36)	.19	.63**	.05		
5. PGT index of learning	0.23 (1.18)	.117	.30**	-.04	.10	
6. PGT Total Awareness score	3.89(2.72)	-.001	.14	.25*	.04	.26*

*Note:* \* indicates  $p < .05$ , \*\* indicates  $p < .01$ . The N for all calculations including PGT (preschool gambling task) was 82. All calculations involving Matching and Non-matching game used N = 75.

### Association between Age and Matching to Sample and Non-Matching to Sample Games

A 2 (Age) X 2 (Game) repeated measures Analysis of Variance (ANOVA) was conducted to test whether there was an age difference in the performance on both Delayed Match to Sample (DMS) and Delayed Non-Match to Sample (DNMS) games. The results indicated a significant main effect of task,  $F(1,73) = 8.63, p = .004, \eta^2 = .118$ , whereby children scored higher on the Matching to Sample compared to the Non-Matching to Sample game. There was also a main effect of age,  $F(1,73) = 9.998, p = .002, \eta^2 = .137$ , whereby older children had a better performance compared to 3-year-olds. However, as it can be seen in Figure 1, there was no significant interaction between the age and the game  $F(1,73) = 0.09, p = .767, \eta^2 < .001$ .

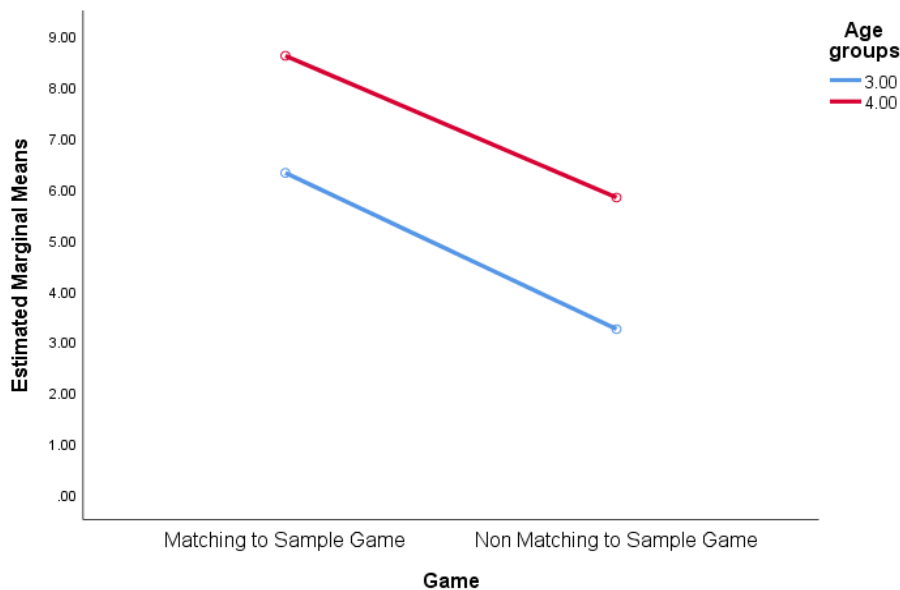


Figure 1: Age and performance effects on Matching to Sample and Non-Matching to Sample game.

### Association between Preschool Gambling Task (PGT) and DMS and DNMS

In order to explore the association between the Preschool Gambling Task (PGT) and the Delayed Match to Sample and Delayed Non-Match to Sample task, two hierarchical regressions

were run. The dependent variables were the PGT ‘awareness’ scores and the PGT ‘index of learning’ score (slope from Block 1 to Block 2 of the PGT). For each hierarchical regression, age in months was entered in Step 1. Then the Non-Matching game and Matching game ‘learning’ scores (sum of three or more consecutive correct trials) were entered and then finally the Non-Matching game and Matching game ‘conceptual’ scores (sum of the last five items on the games) were entered. The results of regression analyses are shown in Table 3.

Step 1 accounted for a significant amount of variance in awareness of the PGT,  $F(1,72) = 16.25, p < .001$ , with age accounting for 18.6% of the variability. Moreover, the overall regression for Step 2 was also significant  $F(3,72) = 5.99, p = .001$ . The predictors accounted for 20.7% of the variance in the PGT awareness scores. The partial regression coefficient was not significant for any of the ‘learning’ scores but was again only significant for age in months ( $B = 0.15, p = .001$ ). Moreover,  $F$  change was also not significant; therefore, this model was not a better predictor of PGT awareness scores compared to the first model. These results suggest that ‘learning’ scores were not good predictors of PGT awareness scores.

The overall regression for Step 3 was significant,  $F(5,72) = 5.53, p < .001$ , where predictors accounted for 29.2% of the variability in the PGT awareness scores. Moreover, the  $F$  change was significant, which meant that the addition of ‘conceptual’ scores was helpful to the model in predicting better scores on PGT. The examination of individual predictors indicates ‘conceptual’ scores of the matching game was significant ( $B = 1.17, p = .007$ ) and explained about 8.2% of individual variability when controlling for other variables.

These results indicate that children who had a better grasp on the abstract idea and understood the concept of what to look for (as the last five items were the hardest and the most

abstract items) on the Matching game were more aware in PGT about which was the good deck and bad deck in PGT.

Table 3

*Summary of the Hierarchical Regression Analysis for Variables Predicting Awareness Scores on Preschool Gambling Task*

Predictors	B	Significance	F-change	R	R <sup>2</sup>	ΔR <sup>2</sup>
Model 1			16.25**	.432	.186	.186
Age in months	0.16**	<.001				
Model 2			0.89	.455	.207	.02
Age in months	0.15**	.001				
Matching game total learning level correct	-0.01	.868				
Non-Matching game total learning level correct	0.09	.191				
Model 3			4.05*	.541	.292	.086
Age in months	0.11*	.011				
Matching game total learning level correct	-0.15	.098				
Non-Matching game total learning level correct	0.11	.216				
Matching game Conceptual correct	1.17*	.007				
Non-Matching game Conceptual correct	-0.07	.809				

*Note:* \* indicates  $p < .05$ , \*\* indicates  $p < .01$ . The N for all calculations was 72.

Another hierarchical regression was run with the PGT index of learning (average increase in the choice of good cards over the first three blocks) as the dependent variable with age in months and scores on the DMS and DNMS as predictors. The results of the regression analyses are shown in Table 4.

Step 1 was not significant  $F(1,72) = 0.72, p < .400$  for the PGT index of learning, suggesting that age was not a significant predictor of the index of learning on Preschool Gambling Task. Step 2 was almost significant  $F(3,72) = 2.73, p < .051$ , and accounted for 3% of the variability in the index of learning scores on PGT. However, when individual predictors were

examined, it could be seen that Non-Matching game learning level scores was significant ( $B = 0.08, p = .017$ ) and accounted for 7.84% of unique variability in scores of PGT when controlling for other variables. Moreover, the F change was significant, which meant this was a better model than the first model. Furthermore, Step 3 was not significant,  $F(1,72) = 2.02, p < .088$ , with the F change indicating that conceptual scores of the two games did not contribute to the prediction of the PGT learning index. Therefore, this was not a better predictor model than the second model. The only significant individual predictor was again Non-Matching game learning level scores ( $B = 0.10, p = .012$ ). These results could be interpreted as children who did better on the DNMS task overall, had a good grasp of which cards were good and bad in the preschool gambling task, therefore made better choices as the game progressed.

Table 4

*Summary of Hierarchical Regression Analysis for Variables Predicting Index of learning on PGT*

Predictors	B	Significance	F-change	R	R <sup>2</sup>	$\Delta R^2$
Model 1			0.72	.100	.010	.010
Age in months	0.02	.400				
Model 2			3.70*	.326	.030	.096
Age in months	0.002	.913				
Matching game total learning level correct	0.02	.647				
Non-Matching game total learning level correct	0.08*	.017				
Model 3			0.95	.362	.131	.025
Age in months	0.01	.626				
Matching game total learning level correct	0.04	.351				
Non-Matching game total learning level correct	0.10	.012				
Matching game Conceptual correct	-0.19	.330				
Non-Matching game Conceptual correct	-0.13	.294				

*Note:* \* indicates  $p < .05$ . The N for all calculations was 72.

## **Empathic Response Descriptive**

Table 5 shows the correlations among the variables and the age in months correlations. The correlations indicated that age in months correlates significantly with game attention after the bottle loss in all the games, which means that as age increases, the attention in the game overall increases after each loss.

It could also be seen that game attention focus before the games for both games one and two were significantly positively correlated with helping behavior. This meant that the focus child has before the game can predict if the child will be helpful or not throughout the game. Game attention focus before the first game was also negatively correlated with game attention after the loss of game one and game two. These results indicate that the more attentive children were before the game began, the less attentive they were after the puppet lost his/her bottle. However, the same relationship could not be seen with how attentive the child was before game two and their game attention after the loss of the bottle.

Moreover, the results also indicated that there was a marginal significance for the scores in the matching and non-matching with helping behavior of game one, loss two. The results indicate that children who performed better overall in both the DMS and DNMS tasks were the most helpful when it came to helping baby Sam. It can also be seen that game attention after game one, loss one, and two is significantly positively correlated with the mean scores of matching and non-matching game overall performance.

Table 5

*Pearson coefficient correlation for overall scores on Matching and Non-matching game with Behavior on the empathetic response task.*

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Age in Months											
2. Helping behavior in game 1, loss 1	.06										
3. Helping behavior in game 1, loss 2	.03	.71**									
4. Helping behavior in game 2, loss 1	-.12	.71**	.75**								
5. Helping behavior in game 2, loss 2	-.13	.59**	.74**	.82**							
6. Game Attention after the loss game 1, loss 1	.33**	-.02	-.09	-.21	-.017						
7. Game Attention after the loss game 1, loss 2	.26*	-.04	.001	-.04	-.010	.50**					
8. Game Attention after the loss game 2, loss 1	.29**	-.05	-.17	-.11	-.014	.42**	.33**				
9. Game Attention after the loss game 2, loss 2	.29*	-.12	-.16	-.17	-.24*	.51**	.44**	.44**			
10. Game Attention before losses begin - Game 1	-.16	.44**	.49**	.68**	.63**	-.27*	-.33**	-.24*	-.31**		
11. Game Attention before losses begin - Game 2	-.30**	.43**	.58**	.70**	.70**	-.19	-.20	-.21	-.29*	.73**	
12. Mean of the Matching and Non-Matching game overall performance	.34*	-.03	.23	.03	.16	.28*	.26*	.09	0.21	-.07	-.14

*Note:* \* indicates  $p < .05$ , \*\* indicates  $p < .01$ . The N for all calculations was 72.

## Association of Hot EF and Empathy Response

In order to explore the association of performance on the DMS and DNMS games and subsequent helping behavior towards baby Sam, four hierarchical regression analyses were conducted. The dependent variable for each regression was the helping behavior (i.e., giving Sam the bottle) during each of four loss episodes. For all regressions, age in months was entered in the first step. Looking behavior, Game Attention before and after the loss was entered in the second step. The overall score on both the DMS and the DNMS games was added in the third step. All assumptions were met.

The results of the regression analyses are shown in Table 6. For the first game, first loss, Step 1 did not contribute significantly to the prediction of variance in helping behavior,  $F(1, 66) = .74, p = .393$ . In other words, age in months did not predict whether children helped Sam during the first loss in Game 1. Step 2 was significant,  $F(4, 66) = 3.90, p = .007$ , predicting 20.1% of the variance in helping behavior. Moreover, the  $F$  change was also significant, which meant that this model significantly predicted helping behavior better than the previous model. When individual variables were examined, only Focus Before the first loss was significant,  $B = 0.73, p < .001$ , as it significantly predicted individual differences in helping behavior and accounted for 18.06% unique variability helping behavior when controlling for other variables. In other words, children who were the most helpful to Sam were more strongly focused on the Popping Pig game before Sam lost the bottle. Overall, Step 3 was significant,  $F(5, 66) = 3.08, p = .015$ . However,  $F$  change was not significant; therefore, the addition of Matching and Non-Matching games did not contribute to the model as the only predictor that was significant in model three was Focus Before losses began. In other words, children's performance on the

Matching and Non-Matching games were not predictive of how helpful they were during the first loss of the first game.

For the first game, second loss, Step 1 did not contribute significantly to the prediction of variance in helping behavior,  $F(1,66) = 0.04, p = .851$ , which indicated that age in months did not predict whether children helped Sam during the second loss of the first game. However, Step 2 was significant  $F(4,66) = 4.79, p = .002$ , predicting 23.6% of variance in helping behavior. The  $F$  change for the second model was also significant, which meant this was a better predictor of helping behavior than the first model. Moreover, it was seen that Focus Before the first loss was significant,  $B = 0.81, p < .001$ , accounting for 23.4% individual variance in helping behavior when controlling for other variables. These results can be interpreted as children who were most helpful to Sam were very focused on the Popping Pig game before Sam lost the bottle. Moreover, Step 3 was significant,  $F(5,66) = 4.76, p = .001$ ; however,  $F$  change was almost significant, which meant that the addition of performance on the games as a variable did not make a difference to the model as it only accounted for 4.41% of the unique variability in helping behavior when controlling for other variables.

For the second game, first loss, age in months was not a significant predictor of helping behavior,  $F(1,66) = 0.44, p = .508$ . However, Step 2 was significant,  $F(4,66) = 15.68, p < .001$ , predicting 50.3% of variance in helping behavior. The significant  $F$  change also suggested this was a better model. Both Looking and Stopping,  $B = 0.45, p = .023$ , and Focus Before first loss,  $B = 0.63, p < .001$ , were significant predictors of helping behavior by children. The partial coefficient for Focus Before games suggested 19.18% of the unique variability in helping behavior when controlling for other variables and 4.36% of unique variability in helping behavior when controlling for other variables can be attributed to Looking and Stopping. These

results indicate that children who were very focused before the loss of bottle and children who looked at Sam and stopped as soon as Sam lost his bottle were more empathetic. The overall model in Step 3 was significant  $F(5,66) = 12.53, p < .001$ , However,  $F$  change was not significant; therefore, this model was not a better predictor model than the second one where the addition of performance on both the games only accounted for 6.1% of the variability in the model.

For the second game, second loss, age was not a significant predictor of helping behavior  $F(1,66) = 0.97, p = .328$ . However, Step 2 was significant,  $F(4,66) = 14.81, p < .001$ . Moreover, the  $F$  change was also significant, with this model predicting 48.9% of the variance in helping behavior. When individual variables were examined, only Focus Before the first loss was significant,  $B = 0.61, p < .001$ , which accounted for 11.63% of unique variability in helping behavior when controlling other variables. These results indicate that children who were the most helpful to Sam were those who were strongly focused on the Popping Pig game before Sam lost the bottle. Step 3 was significant,  $F(5,66) = 14.38, p < .001$ . Moreover,  $F$  change was also significant, which meant that the addition of performance on both the Matching and Non-matching task made this model a better predictor of helping behavior. The partial coefficients suggested that performance in both these games accounted for 5.24% of unique variability in helping behavior when controlling for other variables. In other words, children's performance on the DMS and DNMS was predictive of how helpful they were during the first loss of the first game, and the overall model accounted for 54.1% of the variance in individual helping behavior.

Table 6

*Summary of the Hierarchical Regression Analysis for Variables Predicting Helping Behavior*

First Game, First Loss							
	Predictor	B	Significance	F-change	R	R <sup>2</sup>	$\Delta R^2$
Model 1				0.74	.106	.011	.011
	Age in months	0.01	.393				
Model 2				4.32*	.448	.201	.19
	Looking & Stopping Focus before first loss	0.33	.197				
	Focus after first loss	0.73**	<.001				
Model 3				0.04	.449	.202	.001
	Match/Non-Match Performance	-0.05	.839				
First Game, Second Loss							
	Predictor	B	Significance	F-change	R	R <sup>2</sup>	$\Delta R^2$
Model 1				0.04	.023	.001	.001
	Age in months	0.001	.851				
Model 2				4.32*	.486	.236	.236
	Looking & Stopping Focus before first loss	0.40	.211				
	Focus after first loss	0.81**	<.001				
Model 3				3.76 ±	.53	.281	.044
	Match/Non-Match Performance	0.40±	.057				
Second Game, First Loss							
	Predictor	B	Significance	F-change	R	R <sup>2</sup>	$\Delta R^2$
Model 1				0.44	.082	.007	.007
	Age in months	-0.004	.508				
Model 2				20.63**	.709	.503	.496
	Looking & Stopping Focus before first loss	0.45	.023				
	Focus after first loss	0.63**	<.001				
Model 3				0.46	.712	.507	.004
	Match/Non-Match Performance	0.11	.503				
Second Game, Second Loss							
	Predictor	B	Significance	F-change	R	R <sup>2</sup>	$\Delta R^2$
Model 1				0.97	.121	.015	.015
	Age in months	-0.01	.328				
Model 2				19.15**	.699	.489	.474
	Looking & Stopping Focus before first loss	0.21	.236				
	Focus after first loss	0.61**	<.001				
Model 3				6.97*	.736	.541	.052
	Match/Non-Match Performance	0.41*	.011				

Note: ± indicates  $p$  almost .05 (less than .06) \* indicates  $p < .05$ , \*\* indicates  $p < .01$ . The N for all calculations was 67.

## Discussion

The purpose of this study was to examine whether two new preschool-friendly versions of the Delayed Match to Sample (DMS) and Delayed Non-Match to Sample (DNMS) would be useful as a measure for hot executive function. Three hypotheses were examined. The first hypothesis was that there would be a significant age difference in the performance in the tasks that can be seen between three and four-year-old children. Moreover, it was also hypothesised that children would perform better on DNMS than DMS. The second hypothesis was that there would be an association between the DMS and DNMS and preschool gambling task (PGT). Specifically, it was expected that performance on the DNMS would be associated with the learning phase of the preschool gambling task (first 30 cards) whereas performance on the DMS would be associated to performance on the last block of the preschool gambling task. The third hypothesis examined the association of DMS and DNMS with an empathy induction task. A summary of the hypothesis testing can be found in Table 7.

Table 7

*Summary of Hypothesis Testing*

Hypothesis	Supported or Not Supported
1. Age and performance difference	
a. There will be an age difference in performance of the tasks	Supported
b. Performance on DNMS would be better than on DMS	Not supported
2. Association between the novel tasks and PGT	
a. DNMS will be associated with learning phase (first 30 cards) of PGT	Supported
b. DMS will be associated with awareness phase (last block) of PGT	Supported
3. DNMS and DMS will be positively related to empathy tasks	Supported

### **Age differences in the novel tasks**

The first hypothesis, that there would be a significant age difference in the performance on DMS and DNMS was supported. Analyses revealed that four-year-old children overall performed better on both the tasks compared to three-year-old children. Moreover, it was also hypothesised that children would perform better on DNMS based on the findings by Overman (1990); however, this hypothesis was not supported. The findings indicated that both age groups showed better performance on Matching to Sample task when compared to Non-match to Sample task. These results were contradictory to the results found by Overman (1990), where they found that children mastered the DNMS at the age of 21 months whereas only mastered the DMS task at the age of three. Based on Overman's findings, three-year-old children in the current study were expected to be better at DNMS. In contrast to Overman's findings on young children, Lamar, Yousem and Resnick (2004) found that adults performed better on the DMS task when compared to the DNMS task. It seems that children in the current study behaved more like the adults in the Lamar et al. study (2004) than they did like the participants in the Overman (1990) study.

There are numerous possibilities to explain the discrepancies in the findings from the current study and those of Overman (1990). First, the children in Overman's study were younger in comparison to our participants. It is possible that children in this age group approach the task in a different manner. Overman (1990) had suggested that very young children are better at the DNMS in comparison to the DMS task because their preference for novelty leads them naturally to choose the item they have not seen before. Alternatively, inconsistencies could have been due to the differences in methodology between the tasks used for this age group in comparison to that of adults. Moreover, Overman's methodology has been criticized. Diamond et al. (1999) found that changing the methodology of the DNMS task resulted in children as old as six months

mastering the task. Unfortunately, no such studies have been performed using the DMS task. Therefore, further research will be required to conclude the age at which children start to master the DMS task, and it could be before three years of age. Further research is necessary to examine when children stop having a preference for novelty.

### **Association between the tasks (DMS & DNMS) and the Preschool Gambling Task (PGT)**

The second hypothesis tested whether performance on DMS and DNMS was predictive of performance on PGT, which is an already established measure of hot executive function (Garon, 2016; Kerr & Zelazo, 2004). Moreover, performance on the two tasks was predicted to be differentially associated with different phases of PGT performance. Previous work indicates partially dissociable systems involved in two stages of making decisions in the adult version of the PGT (Brand, Recknor, Grabenhorst, & Bechara, 2006). The first stage involves making decisions under ambiguity (when contingencies are unknown), and the second stage involves making decisions under risk (using knowledge to guide choices). The first stage has been associated with the first portion of the IGT while the second stage has been associated with later blocks. The first stage involves learning about the choices through feedback (i.e., rewards and losses) while the second stage involves retrieving and using this acquired knowledge to make good decisions (Brand et al., 2006). Furthermore, these two stages of the IGT are associated with different neural networks (Lawrence et al., 2009). Moreover, this first stage has been associated with the lateral OFC network while this second stage has been associated with a medial OFC network. In parallel to this, the DMS and DNMS tasks have been hypothesized to assess two different types of hot EF systems (Elliott, Dolan & Firth, 2000). While DNMS has been associated with a lateral OFC network, the DMS has been more strongly associated with a medial OFC network (Elliott et al., 2000).

Therefore, past research indicates that there are two partially dissociable OFC networks and that these networks underlie different components of decision making and hot EF. Medial OFC has been associated with the recall of emotional memories and the use of these memories to make good decisions (Elliott et al., 2000). Benoit, Gilbert and Burgess (2011) found that the medial OFC was implicated in using and comparing values to make the best choice, maintain strategies/rules for reward, and recall and use emotional imagery to make a decision. These are the abilities that underlie the last phase of the PGT. Similarly, the DMS for adults is thought to rely on an ability to recall and use a matching rule to each choice (Elliott et al., 2000). As a result, it was expected that performance on the DMS would be associated with the last block of the PGT and the awareness phase of PGT. The hypothesis was supported as the results indicated that conceptual correct responses (sum of correct in the last five items) in matching games were predictive of the PGT awareness scores. However, the 'learning' scores on the DMS (sum of three or more consecutive correct trials) did not significantly predict the PGT awareness scores. These results stand to reason as the conceptual score in the DMS task tests the understanding and the memory of the participant as the children have to understand the rule, memorise the rule and apply it to a more abstract concept. The DMS task in the study progressively got more difficult, and the last five items were the most abstract and challenging for the participants. If they had not understood and remembered the rule that they were following, they would have performed poorly on this section. Therefore, it makes sense that this score, which was associated with the understanding and memory of the DMS, significantly predicted the scores on the section of the PGT hypothesized to assess a parallel ability.

The second OFC network, the lateral OFC, has been found particularly important for ambiguous situations (Elliott et al., 2000), being involved in making quick changes and adapting

to the situation. These are the same abilities thought to underlie the first phase of the PGT when children learn the difference between advantageous and disadvantageous deck in PGT. Similarly, good performance on the DNMS is thought to involve learning a novel rule (i.e., choose the one you did not see) through feedback (Elliott et al., 2000). As a result, it was predicted that DNMS would be associated with the learning phase (first 30 cards) of PGT. This hypothesis was supported as the regression analyses indicated the DNMS total learning level score (sum of three or more consecutive correct trials) predicted the PGT index of learning. However, the same was not the case for the DMS game total learning score.

These results were supportive of a dissociable OFC system and parallel the findings by Benoit, Gilbert and Burgess (2011), Elliot et al. (2000), and Fellows (2016). These results also provide further insight into the bigger picture about decision making as we can find two distinct processes being used to succeed in these games. Before one makes a decision, one has first to learn the rule and adapt to the environment by learning and making associations among specific cues from the environment, and lateral OFC network seems to be associated with this ability. After one has learned the rule, one needs to be able to remember the rule and apply it to the situation, and medial OFC network seems to be associated with this ability. This fits with the finding concerning the developmental progression of the DMS and the DNMS task. As mentioned previously, the children in this study behaved more like adults than younger children. Therefore, they were not strongly influenced by the presence of a novel object, which is reflected in the finding that indicates that children did not perform well on the DNMS in comparison to the DMS. This suggested that matching to sample came inherently to them. Thus, they had to inhibit their response to something that they naturally prefer. This inhibition is dependent on

lateral OFC (Elliot et al., 2000); therefore, it would be interesting to see if there is a correlation between inhibition tasks and the DMS and DNMS tasks.

Moreover, these results can be explained by the fact that by age three, children usually have a lot of exposure to using the matching rule, which could be another reason why they were not as influenced by novelty. Moreover, Deak, Ray and Pick (2002) tested preschoolers' use of abstract principles to classify and label objects by matching shapes or functions. They found that three and four-year-old children differed in their ability to follow the matching rules. They found that four-year-olds easily adopted both the shapes and the function rules and could match objects without much effort. However, three-year-olds could only follow the shape rule, suggesting that the younger children tended to use rules in a more concrete manner. In the current study using DMS and DNMS, it was found that the four-year-olds had a better grasp on conceptual responses (the last five items on DMS) than the three-year-olds. These results can be explained by the fact that three-year-olds had trouble using 'function' of the item as an abstract basis of comparison which is what the last five items on the DMS tasks required the participant to do (Deak, Ray & Pick, 2002).

To summarise, it can be concluded that performance on the DMS and DNMS is associated with the performance on the PGT. Although it taps into different aspects of PGT, the two tasks are associated with hot executive function measure Preschool Gambling Task.

### **Association between empathy and DMS and DNMS**

Previous research had associated empathy and prosocial behaviour with hot EF (Di Norcia et al., 2014; Hao, 2017; Kim et al., 2012). Schneider and Koenigs (2017), in their study, found that the neural networks that underlie hot executive function overlap with the neural networks which underlie empathy. Therefore, if DMS and DNMS were to tap in and measure the hot executive

function, it would be associated with prosocial behaviour, and in turn, it would be related to empathy. This hypothesis was supported where the results indicated that performance on the empathy task was positively correlated with performance on the DMS and DNMS tasks.

The empathy task was divided into four parts: a) scores on first game after the first loss, b) the first game after the second loss, c) second game after the first loss, and d) second game after the second loss. It was found that pre-loss attention to the game predicted empathetic behaviour. These results indicated that children who were the most attentive to the games were also the ones who were the most empathetic (prosocial) towards Sam. These results are congruent with previous research, where it has been found that attention is an essential precursor for empathy (van Zonneveld et al., 2017). Previous research has also found that the deficit in hot EF can lead to lower attention, which in turn can lead to disadvantageous risky behaviour (Dolan & Lennox, 2013).

Moreover, the results indicated that performance on both the DMS and DNMS were predictors of empathy only during the second loss of the second game (and marginally the first game). This is a novel finding, which can be explained in terms of the self-regulation required. Maintaining empathy for loss 2 when the child is closer to the goal (i.e., popping the belly) is more complicated and, therefore, requires some additional “hot skills” such as higher levels of self-regulation. Therefore, DMS and DNMS are significant predictors of empathy during the second loss. However, it will be intriguing to see if having more participants makes a difference in the results in terms of significance.

There are no studies that directly explore the relationship between empathy and DMS and DNMS. However, Bechara et al. (1994) found that participants with lesions to VM-PFC/OFC performed poorly on IGT, and they displayed poor social adjustment and a lack of empathy.

These results were supported further by Schneider and Koenigs (2017), who found that patients with damage to VM-PFC had severe social difficulties such as lower empathy. Therefore, it would be interesting to explore this relationship between empathy, DMS and DNMS further in future research.

### **Limitations**

The study had many limitations that should be addressed. The study used a cross-sectional design where the differences found might be due to pre-existing differences between the participants instead of development. Moreover, the children completed seven other unrelated tasks in addition to the three that were administered in the study. The number of tasks the children completed in a sitting was not controlled and depended on the child's attention level or the schedule of the daycare. There were participants who completed all 10 tasks in one sitting, which could have possibly resulted in fatigue or habituation effects. On the other hand, there were participants who could not complete the tasks on the same day, which could have introduced extraneous situational variables that could have potentially altered the results.

The number of participants was another limitation; there were 60 four-year-old children and only 34 three-year-old children. Some of the results in the regression analyses for association between DMS, DNMS and PGT were very close to being statistically significant. If there was a bigger sample size, there would have been enough power to run those analyses.

Moreover, there were variations in the administration of the empathy task where there were differences in the time at which the experimenter made the puppet lose the bottle. There were variations where some experimenters dropped the bottles after a specific time or after a certain number of burgers. Therefore, there should have been more consistency in the time at which the puppet loses its bottle to get more reliable data.

## **Future Directions and Implications**

Future researchers may wish to address the limitations mentioned above. The number of tasks that a participant completed in a sitting should be standardized. Moreover, switching to a longitudinal design will provide rich information about how DMS and DNMS interact with hot EF.

One of the most intriguing findings in this study is the performance of three-year-old in the DMS and DNMS task, where it was found that they performed better in DMS compared to DNMS (more like adults). Therefore, one potential for future research could be at what age do children stop preferring novelty as the findings in this study marginally contradict the findings by Overman (1990). Moreover, it could also be interesting just to study when children mastered the DMS task using the methodology by Diamond et al., (1999). Another potential research direction could be examining how the three and four-year-old children perform when there is a delay in the DMS and DNMS task as this could provide some interesting findings of how it measures hot EF.

The current study provides foundational evidence for DMS and DNMS as new measures of hot EF. As there have been relatively fewer studies on hot EF in comparison to cool EF, the addition of these two tasks as a predictor of hot EF, there can be a lot more understood about the developmental progression of hot EF. The study also provides insights into the process of decision making. It provides evidence for two dissociable processes of decision making, one involved in learning (associated with lateral OFC) and one involved in remembering and applying while making the decision (associated with medial OFC).

## **Conclusions**

The current study was the first study to look at DMS and DNMS as potential measures for hot EF in preschoolers. The results from the study do indicate that DMS and DNMS measure attributes that are associated with hot EF. Moreover, the current study was also the first one to explore the association of empathy with DMS and DNMS measures. While the study found that there was a positive relationship between empathy and these two tasks, further research is required to assess the extent of this relationship. To conclude, the results of the current study do support the use of DMS and DNMS tasks as measures of hot EF. However, additional research is necessary to replicate and expand on these results.

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## Appendix A: Consent form and Demographics questionnaire



Psychology Department, Mount Allison University

Study Title: **Helping and Sharing in Preschoolers**

Researchers: **Nancy Garon, Sarah English, Clare Maguire, Sruthi Sridhar, and Natalie Lagace**

Our names are Sarah English, Clare Maguire, Sruthi Sridhar and Natalie Lagace. We are students completing an honours thesis under the supervision of Dr. Nancy Garon. **We are inviting you to participate in our study. Below is a summary of the study. If you agree to participate, please fill out the form on the back of this sheet and return to your daycare provider.**

**Purpose of the Study:** In this study, we are looking at skills that are linked to prosocial and behavior in preschoolers. One type of skills is the ability to use your “gut feeling” to make decisions. Another type of skills is the ability to hold ideas in mind and use these ideas to guide behavior. Both types of ability have been found to help social adjustment and school readiness. In this study, we are interested in whether these skills are important for preschoolers’ prosocial behavior. For example, when a child is being bullied, a child might use their emotional response (e.g., sadness) to guide their response or they might use their memory of a strategy suggested by their parent (e.g., walk away) to guide their response. Each is likely to result in a different outcome.

**What will my child do?** To look at these things, our study involves 10 short tasks that are presented in a game-like format to make it fun for children. Two of the tasks will consist of a series of simple choices. For Zebra & Giraffe game, children will choose cards from two animals that will let them go up and down stairs. The Favourite Toy game will involve choosing between pairs of toys. In the Story Game, children will say whether the main character was doing something bad (e.g., child teasing another). In the Rule Learning Game, children will be asked to guess what pets the Purple Puff people are allowed to have. One of the tasks will involve helping puppets while another will involve feeding and playing with an electronic baby doll. Two tasks will involve retrieving animals from behind a door in a house. Two of the tasks, (helping the puppet and taking care of the baby doll) will be video-taped. Finally, in one of the tasks, children will decide how to divide up stickers and toys with a puppet. We will divide the tasks into 2 sessions and each session will take about 20-30 minutes. Note that the study will be done *at the daycare* during a time that does not conflict with important activities such as naptime. At the end of the session, children will receive a small gift and all the stickers accumulated during the tasks.

**Potential Harms:** Although there are no known risks, it is possible that some of the children will become tired or frustrated during the sessions. If your child indicates that he or she is tired, the examiner will take a break and only return to the task when your child is ready. Every effort will be taken to make this an enjoyable experience for your child. As well, during the activities, a member of the daycare staff will be present to insure an enjoyable experience.

**Possible Benefits:** Although we don’t expect your child to benefit directly from participating in this research, we do expect the games to be interesting and the experience of interacting with the experimenter to be enjoyable for him or her. This study also gives you and your child the opportunity to benefit others in that the results of this study may provide useful information about how children’s social abilities develop.

**Termination:** Your participation and that of your child is completely voluntary. You and your child may withdraw from this study at any time without penalty.

**Confidentiality:** *All information obtained in this study will be kept strictly confidential. Additionally, assigning each child a code rather than name will protect the confidentiality of you and your child at all times.* Written records of your child’s performance will be stored in a locked cabinet for 5 years after publication of this study. Whereas average group results from this project may be published, no individual children will be identified. Please note that at the end of the study, we will send parents a summary of group results, but the results of any individual child’s performance will not be provided.



Appendix B: Match to Sample games

Figure 1a. The clue that will be provided to the child in the Rascally Raccoon Task as a practice.

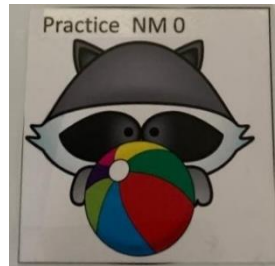


Figure 1b. The two options that will be provided to the child on the next page



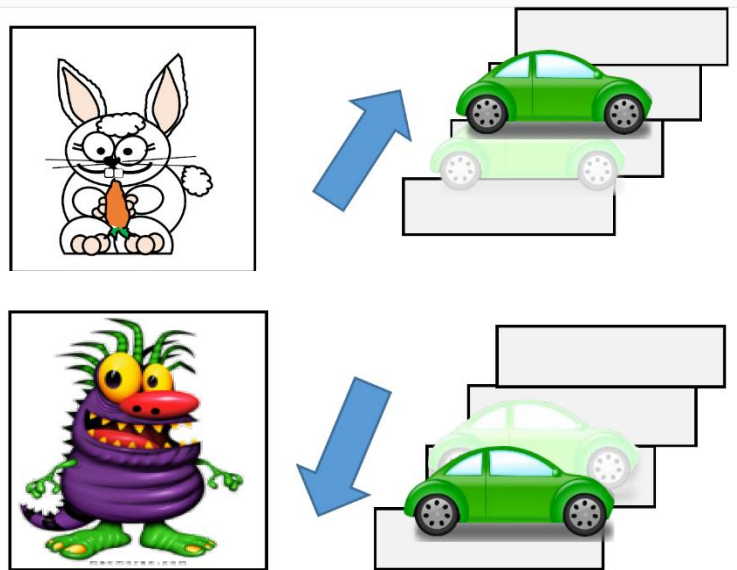
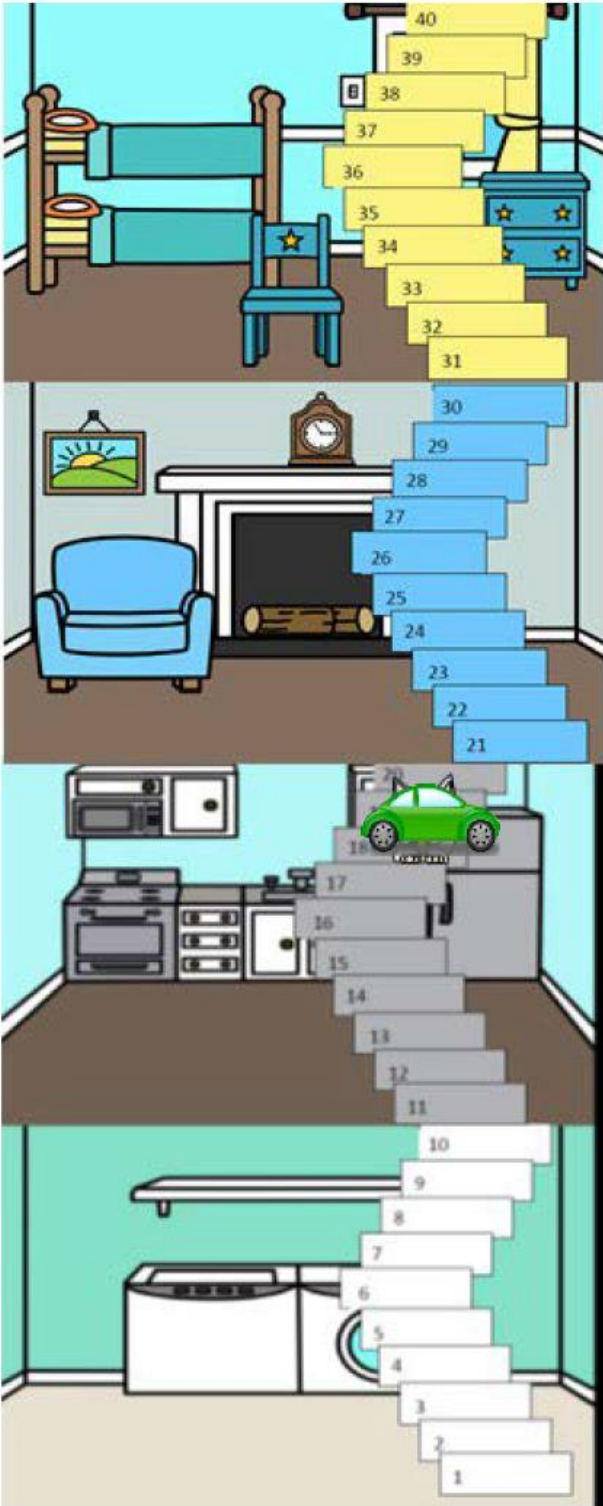
Figure 1c. The reward that is offered to the child (gold coin) when they flip the right picture.



Appendix C: Matching task score sheet

5. Matching Game					
ID	Age	Gender			
Place ✓ for correct or X for wrong					
Order 1			Order 2		
Match to Sample			Non-Match to Sample		
1	Shoe		1	Red pepper	
2	Bug		2	Milk	
3	Flashlight		3	Tomato	
4	Sleeping bag		4	Corn can	
5	Tackle box		5	Corn on cob	
6	Rain jacket		6	cloud	
7	Ball of yarn		7	mouse	
8	Dog house		8	lamp	
9	lamp		9	Hot dog	
10	Mitts		10	strawberries	
11	Flowers		11	nuggets	
12	kite		12	bear	
13	Sundae		13	coffee	
14	pointer		14	angry	
15	backpack		15	bookcase	
↓			↓		
Non-Match to Sample			Match to Sample		
1	Red pepper		1	Shoe	
2	Milk		2	Bug	
3	Tomato		3	Flashlight	
4	Corn can		4	Sleeping bag	
5	Corn on cob		5	Tackle box	
6	cloud		6	Rain jacket	
7	mouse		7	Ball of yarn	
8	lamp		8	Dog house	
9	Hot dog		9	lamp	
10	strawberries		10	Mitts	
11	nuggets		11	Flowers	
12	bear		12	kite	
13	coffee		13	Sundae	
14	angry		14	pointer	
15	bookcase		15	backpack	

Appendix D: Preschool Gambling Task



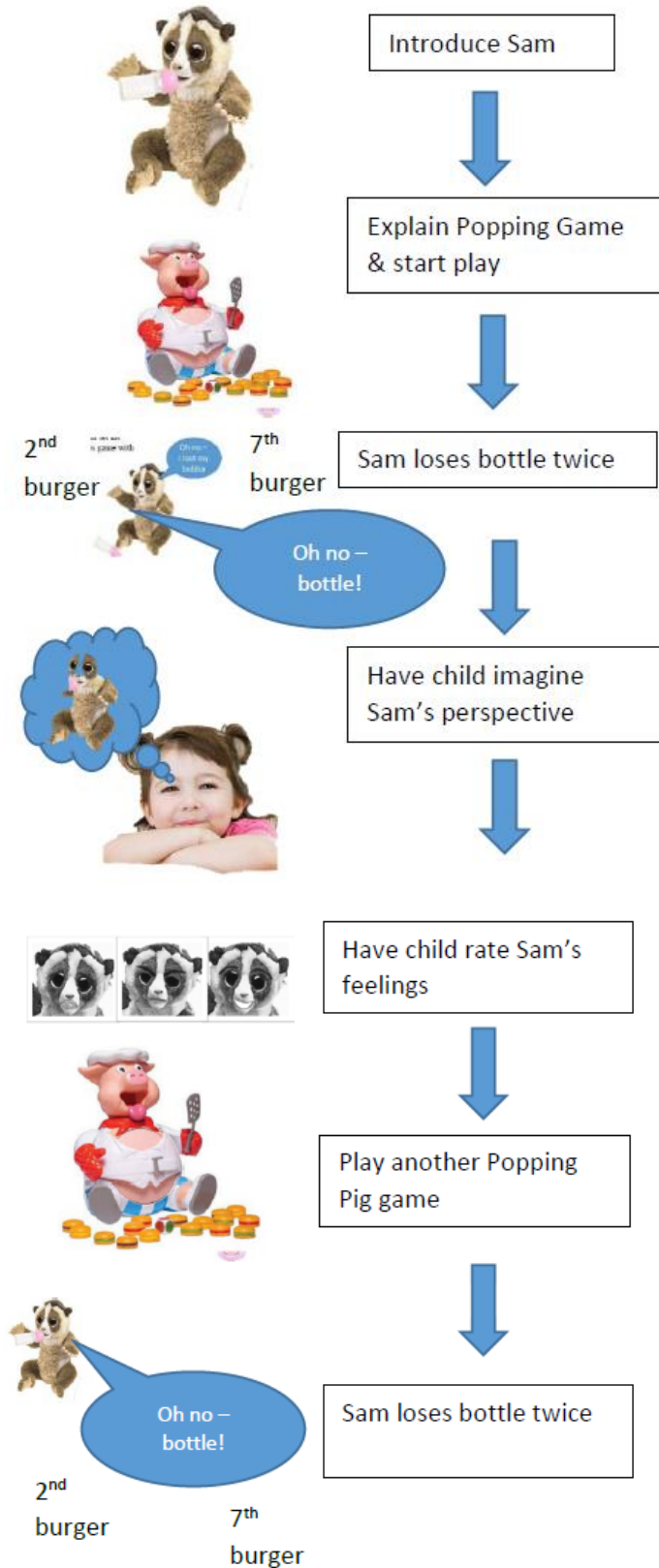
Appendix E: Preschool Gambling Task Scoring sheet

**9. Preschool Gambling Task Score Sheet**

ID \_\_\_\_\_ M/F \_\_\_\_\_ Age \_\_\_\_\_ Daycare \_\_\_\_\_

Card	Deck			Card			
1	Zebra		Giraffe	21	Zebra		Giraffe
2	Zebra		Giraffe	22	Zebra		Giraffe
3	Zebra		Giraffe	23	Zebra		Giraffe
4	Zebra		Giraffe	24	Zebra		Giraffe
5	Zebra		Giraffe	25	Zebra		Giraffe
6	Zebra		Giraffe	26	Zebra		Giraffe
7	Zebra		Giraffe	27	Zebra		Giraffe
8	Zebra		Giraffe	28	Zebra		Giraffe
9	Zebra		Giraffe	29	Zebra		Giraffe
10	Zebra		Giraffe	30	Zebra		Giraffe
11	Zebra		Giraffe	First Awareness test			
12	Zebra		Giraffe	31	Zebra		Giraffe
13	Zebra		Giraffe	32	Zebra		Giraffe
14	Zebra		Giraffe	33	Zebra		Giraffe
15	Zebra		Giraffe	34	Zebra		Giraffe
16	Zebra		Giraffe	35	Zebra		Giraffe
17	Zebra		Giraffe	36	Zebra		Giraffe
18	Zebra		Giraffe	37	Zebra		Giraffe
19	Zebra		Giraffe	38	Zebra		Giraffe
20	Zebra		Giraffe	39	Zebra		Giraffe
				40	Zebra		Giraffe
Second Awareness test							
Awareness tests							
1. Which is best?		Zebra	Giraffe	2. Which is best?		Zebra	Giraffe
Why is it best?				Why is it best?			
Which is worse?		Zebra	Giraffe	Which is worse?		Zebra	Giraffe
Why is it worse?				Why is it worse?			

Appendix F: Empathetic Responding Task



Appendix G: Scoring Sheet for Empathic Responding task

ID		Age		Daycare	
6. Empathic Responding Task					
Sad    happy    angry					
Baby Sam & Popping Pig Trials					
1. Child Game Focus				2. Sam focus	
Sam loses bottle 1	Ignores _____	Sam loses bottle 1	Ignores _____		
	Looks _____		Looks _____		
	Gives bottle _____		Gives bottle _____		
	Other _____		Other _____		
Sam losses bottle 2	Ignores _____	Sam losses bottle 2	Ignores _____		
	Looks _____		Looks _____		
	Gives bottle _____		Gives bottle _____		
	Other _____		Other _____		

Appendix H: Video Coding Sheet for Empathetic Responding Task

<b>Empathy Video Coding</b>	
<b>First Popping Pig Episode</b>	
<b>Behavior during game explanation and introduction of Sam</b>	
1.	Social Referencing (check marks):
2.	Child affect to Sam: sad ___ happy ___ surprise ___ confused ___ angry ___ neutral ___
3.	Child Attention during instruction: distracted ___ moderate ___ focused ___
<b>Behavior during hungry pig before first loss of bottle</b>	
1.	Social Referencing (check marks):
2.	Child affect: sad ___ happy ___ surprise ___ confused ___ angry ___ neutral ___
3.	Child look at Sam: none ___ a little ___ moderately ___ constantly ___
4.	Child focus on game: distracted/not engaged ___ somewhat ___ focused ___
5.	Speed of feeding: slow ___ moderate ___ fast ___
<b>Behavior during first loss of bottle</b>	
1.	Social Referencing (check marks):
	Child look: ignores ___ moderately ___ consistently ___
2.	Child look timing: immediately ___ relatively quick ___ slow ___ n/a ___
3.	Game behaviour: stops immediately ___ stops slowly ___ stops briefly ___ No stopping ___
4.	Expression during whining: sad ___ happy ___ surprise ___ confused ___ angry ___ neutral ___
5.	Bottle Behaviour: no giving ___ reluctant give ___ angry give ___ next to ___ put on puppet
6.	Expressing during give (if app): sad ___ happy ___ surprise ___ confused ___ angry ___ neutral ___
<b>Behavior after first loss of bottle</b>	
1.	Social Referencing (check marks):
2.	Child affect: sad ___ happy ___ surprise ___ confused ___ angry ___ neutral ___
3.	Child look at Sam: none ___ a little ___ moderately ___ constantly ___
4.	Child focus on game: distracted/not engaged ___ somewhat ___ focused ___
5.	Speed of feeding: slow ___ moderate ___ fast ___
<b>Behavior during second loss of bottle</b>	
1.	Social Referencing (check marks):
2.	Child look: ignores ___ moderately ___ consistently ___
3.	Child look timing: immediately ___ relatively quick ___ slow ___ n/a ___
4.	Game behaviour: stops immediately ___ stops slowly ___ stops briefly ___ No stopping ___
5.	Expression during whining: sad ___ happy ___ surprise ___ confused ___ angry ___ neutral ___
6.	Bottle Behaviour: no giving ___ reluctant give ___ angry give ___ next to ___ put on puppet
7.	Expressing during give (if app): sad ___ happy ___ surprise ___ confused ___ angry ___ neutral ___
<b>Behavior after second loss of bottle</b>	
1.	Social Referencing (check marks):
2.	Child affect: sad ___ happy ___ surprise ___ confused ___ angry ___ neutral ___
3.	Child look at Sam: none ___ a little ___ moderately ___ constantly ___
4.	Child focus on game: distracted/not engaged ___ somewhat ___ focused ___
5.	Speed of feeding: slow ___ moderate ___ fast ___

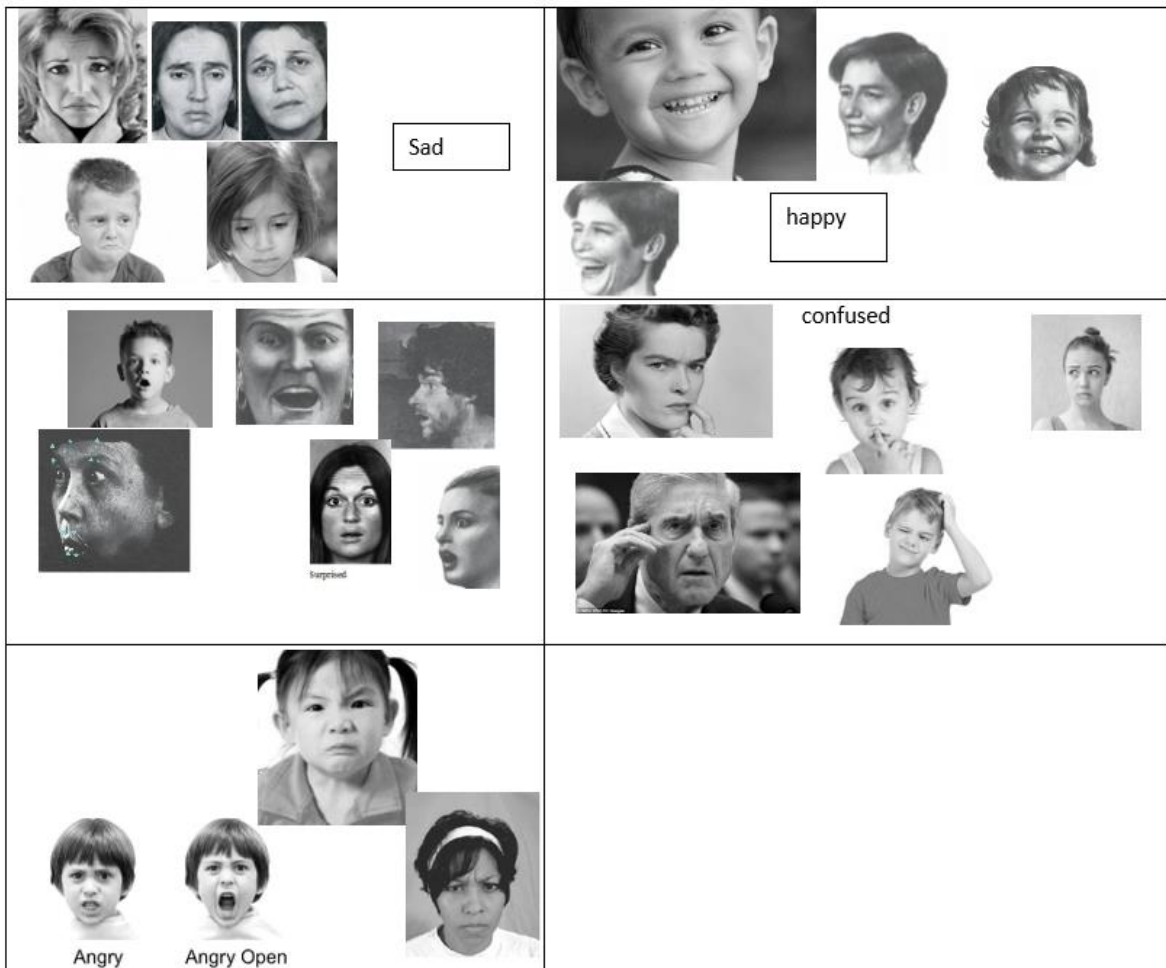
<b>Empathy Video Coding</b>	
<b>Second Popping Pig Episode</b>	
<b>Behavior during hungry pig before first loss of bottle</b>	
1.	Social Referencing (check marks):
2.	Child affect: sad    happy    surprise    confused    angry    neutral
3.	Child look at Sam: none    a little    moderately    constantly
4.	Child focus on game: distracted/not engaged _____ somewhat _____ focused _____
5.	Speed of feeding: slow _____ moderate _____ fast _____
<b>Behavior during first loss of bottle</b>	
1.	Social Referencing (check marks):
	Child look: ignores _____ moderately _____ consistently _____
2.	Child look timing: immediately _____ relatively quick _____ slow _____ n/a _____
3.	Game behaviour: stops immediately _____ stops slowly _____ stops briefly _____ No stopping _____
4.	Expression during whining: sad    happy    surprise    confused    angry    neutral
5.	Bottle Behaviour: no giving _____ reluctant give _____ angry give _____ next to _____ put on puppet _____
6.	Expressing during give (if app): sad    happy    surprise    confused    angry    neutral
<b>Behavior after first loss of bottle</b>	
1.	Social Referencing (check marks):
2.	Child affect: sad    happy    surprise    confused    angry    neutral
3.	Child look at Sam: none _____ a little _____ moderately _____ constantly _____
4.	Child focus on game: distracted/not engaged _____ somewhat _____ focused _____
5.	Speed of feeding: slow _____ moderate _____ fast _____
<b>Behavior during second loss of bottle</b>	
1.	Social Referencing (check marks):
2.	Child look: ignores _____ moderately _____ consistently _____
3.	Child look timing: immediately _____ relatively quick _____ slow _____ n/a _____
4.	Game behaviour: stops immediately _____ stops slowly _____ stops briefly _____ No stopping _____
5.	Expression during whining: sad    happy    surprise    confused    angry    neutral
6.	Bottle Behaviour: no giving _____ reluctant give _____ angry give _____ next to _____ put on puppet _____
7.	Expressing during give (if app): sad    happy    surprise    confused    angry    neutral
<b>Behavior after second loss of bottle</b>	
1.	Social Referencing (check marks):
2.	Child affect: sad    happy    surprise    confused    angry    neutral
3.	Child look at Sam: none _____ a little _____ moderately _____ constantly _____
4.	Child focus on game: distracted/not engaged _____ somewhat _____ focused _____
5.	Speed of feeding: slow _____ moderate _____ fast _____

# Appendix I: Definitions for coding the Empathy Responding task

## Empathy Definitions

### For all episodes:

- Social Referencing – looks at examiner during instructions, during a point where appears unsure of what to do or may ask examiner for further information (e.g., if the baby cries, child may say, “she’s crying?” and look for guidance). Put a check mark for each instance.
- Expression
  - Sad – eyebrows drawn, downturned lips, could be frown but neutral lips
  - Happy- crinkle under eyes, lips drawn up
  - Surprised – eyes widen, eyebrows up, mouth open slightly—very quick
  - Confused/uncertain - is depicted by having one eyebrow higher than the other. The wrinkled nose and crease between the eyebrows also help to convey the sense of confusion. There is also a raised corner of the mouth on the side of the lower eyebrow during the confused face expression.
  - Anger – frown, lips straight or corners of mouth down
  - Neutral –child shows or expresses very little negative or positive affect



### **During Instructions:**

- Child Attention during instructions
  - Distracted – child looks around or is fidgeting – very little looking at the researcher
  - Moderate – child shows some distraction, but appears to be attending most of the time
  - Focused – Pays attention for most of the instructions. Shows very little fidgeting.

### **During play – not when puppet loses bottle:**

- Child look at Sam
  - None – completely ignores Sam during this time
  - A little – shows occasional glances at Sam (1-2) while feeding the pig
  - Moderate – child looks at Sam more than twice, but pays attention to the pig most of the time
  - Constantly – child appears very distracted by puppet while playing with the pig – seems to be distributing attention between the task and looking at Sam
- Child focus on game
  - Distracted – child looks around most of the time or keeps stopping while feeding the pig.
  - Somewhat – child focuses on the task about half of the time, but seems not enthusiastic
  - Focused – child shows enthusiasm for the task, stops very little
- Speed of feeding
  - Slow – in comparison to other children – child has to be reminded many times
  - Moderate – average in comparison to other children – very little reminders necessary
  - Fast – faster than average – may appear almost hurried or impulsive

### **During loss of bottle:**

- Child look at Sam
  - Ignores – child does not glance at all at the puppet
  - Moderately – child looks briefly at the puppet – less than half of the episode
  - Constantly – child looks very concerned and looks at the puppet for most of the episode
- Child look timing
  - Immediately – as soon as child hears the puppet whine
  - Relatively quickly – there is a few seconds before child turns to look
  - Slow – child resists looking – more than a few seconds before looks at puppet
  - N/A – child ignored the puppet
- Game behavior
  - Stops immediately – no hesitation as soon as hears the puppet
  - Stops Relatively quickly – there is a few seconds before child stops feeding the pig
  - Stop Slow – child reluctantly stops game – takes more than a few seconds
  - Stops briefly – stops a few seconds but resumes play
  - No stopping
- Bottle Behavior
  - No giving – does not give the puppet the bottle
  - Reluctant – gives the bottle but does so in a reluctant manner
  - Angry give – gives the bottle back in an aggressive way – may sign loudly
  - Next to – may slide it to puppet or throw it at him
  - Put on puppet – clearly gives it to puppet – either in hand or close to hands or mouth