Development of a computerised version of the Children's Gambling Task for the evaluation of affective decision-making in Brazilian preschool children

Fernanda Mata
Isabela Sallum
Paulo Henrique Paiva de Moraes
Débora Marques Miranda
Leandro Fernandes Malloy-Diniz
Federal University of Minas Gerais

Abstract

Despite the large number of instruments developed to assess the more purely cognitive executive functions in Brazilian children, few studies have developed instruments for the assessment of the most motivational components of these functions. The primary aim of this study was to develop a computerised version of the Children's Gambling Task (CGT) to assess affective decision-making in preschoolers. The present study also aimed to investigate whether this version of the task is sensitive to developmental changes across the preschool period and to examine gender differences in decision-making. We administered the CGT and the Columbia Mental Maturity Scale (CMMS) to 137 Brazilian children between the ages of three and five years old. Age differences between three-and four-year-olds, but not between four-and five-year-olds were found. Gender differences were not found. From this preliminary study, the computerised version of the CGT for Brazilian child population proved to be suitable for Brazilian child population.

Keywords: children´s gambling task; hot executive functions; kindergartens.

Resumo

Desenvolvimento de uma versão computadorizada da Children´s Gambling Task para avaliação da tomada de decisão afetiva em crianças pré-escolares brasileiras. Apesar do grande número de instrumentos desenvolvidos para avaliação das funções executivas mais puramente cognitivas em crianças brasileiras, há poucos estudos que desenvolveram medidas para avaliação dos componentes mais motivacionais dessas funções. O principal objetivo deste estudo foi desenvolver uma versão computadorizada da Children´s Gambling Task (CGT) para avaliação da tomada de decisão afetiva em crianças pré-escolares. Também se buscou avaliar se a versão desenvolvida é capaz de discriminar grupos etários e examinar as diferenças entre gêneros na tomada de decisão. A versão brasileira da CGT e a Escala de Maturidade Mental Colúmbia foram aplicadas em 137 crianças de três a cinco anos. Observou-se que crianças de quatro e cinco anos obtiveram desempenho superior às de três, entretanto não houve diferença entre o desempenho das crianças de quatro e cinco anos, nem entre meninos e meninas. A partir deste estudo preliminar, a CGT mostrou-se apta à utilização na população brasileira.

Palavras-chave: *children´s gambling task*; funções executivas quentes; crianças pré-escolares.

The executive functions consist of a set of cognitive processes that allow an individual to initiate and monitor a goal-directed behavior (Fuster, 1997). The term executive functions is an umbrella concept that comprises several processes related to self-regulation and intentional behavior (Pennington, 1991). According to Zelazo and Müller (2002), the elements that compose executive functions can be classified in two groups: hot – required in the solution of problems involving affect and motivation – and cool – mainly cognitive processes related to more abstract and un-contextualized problem solving. While the "hot" components of the executive functions are related to the Orbitofrontal Prefrontal Cortex, the "cool" components are associated to the Dorsolateral Prefrontal Cortex (Kerr & Zelazo, 2004). It is important to notice that Hongwanishkul, Happaney, Lee and Zelazo (2005) emphasize that measures of executive functions always require a combination of cool and hot aspects, and therefore such distinction of executive functions is related to the intensity of each of these components

in a given task. As highlighted by Hongwanishkul et al. (2005), the classification of the executive functions proposed by Zelazo and Müller (2002) and the current interest in the hot components of those functions can contribute to elucidate the role of the mainly affective and motivational aspects and the more purely cognitive ones in different developmental disorders. It is known that several disorders with an onset in childhood (e.g. autism, attention deficit hyperactivity disorder, oppositional defiant disorder, etc.) are characterized by deficits in executive functions (Johnson, 2012). However, it is unlikely that the same components of the executive functions are impaired in the various disorders (Schoemaker et al., 2012). Schoemaker and colleagues (2012), for example, found that preschool children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) presented deficits in the purely cognitive inhibitory control, while preschoolers with Oppositional Defiant Disorder (ODD) presented more difficulties in tasks of inhibitory control that involved motivational contents, that is, hot components of executive functions.

Among the mainly hot executive functions, affective decision-making – decision about events with significant emotional consequences, in the other words, decisions that have gain and loss consequences – has received special attention (Kerr & Zelazo, 2004). The emotional nature and not solely dependent on logical reasoning of decision-making allows its emergency early on in the development, and is thus an adaptive ability. Since preschool years, kids already face decisions that involve considering future circumstances (Garon & Moore, 2007). When a child has to decide between sharing a snack with a colleague in order to strengthen the bonds of friendship in the long-run or enjoy the whole snack by himself/herself, for example, he/she must already weigh the consequences fraught with emotional meanings in long-term of his/her actions. The development of the ability of decision-making still in preschool years allows the possibility of children to interact in their environment with greater independence and being able to interpret and make decisions without the constant help of caregivers.

The Iowa Gambling Task (IGT) (Bechara, Damasio, Damasio & Anderson, 1994) is one of the most used instruments to evaluate affective decision-making in adolescents and adults worldwide (Mata et al., 2011). In this task, the examinee is given a credit of $2.000,00 (play money) that must be gambled throughout a set of a hundred choices among four decks (A, B, C and D). The participants are instructed to try to accumulate the biggest amount of money possible. The 'A' and 'B' decks are considered disadvantageous in the long-run since choosing more cards from those decks result in an negative financial balance at the end of the task, while the decks 'C' and 'D' are considered advantageous in the long-run. Cards from the 'A' and 'B' decks provide rewards twice as large as the cards from the 'C' and 'D' decks; however, they present unpredictable and variable losses, which are comparatively much larger than the losses presented on the advantageous decks. The initial studies from Bechara and colleagues (1994) showed that while healthy individuals develop a preference for the 'C' and 'D' decks throughout the task, patients with lesions in the ventromedial prefrontal cortex select more cards from the 'A' and 'B' decks,

which implies in a negative balance at the ending of the task, despite the large immediate gains provided by these decks. Since these initial researches, several studies have investigated affective decision-making in childhood and adolescence and shown the development of this ability since the first years of life through tasks adapted from the IGT (Mata et al., 2011).

Kerr and Zelazo (2004) developed a simpler version of the IGT, the Children's Gambling Task (CGT), in order to evaluate affective decision-making in preschool children. In the CGT, two decks are used instead of four and the rewards are M&Ms candies instead of play money. The gains and losses are represented in the cards by happy and sad faces, respectively. As the version of the paradigm developed for the evaluation of adults, the disadvantageous deck provides twice the candies provided by the advantageous deck, however, the losses can be much higher, so a larger number of choices in this deck results in a negative balance at the ending of the task. Spite of offering only one candy for each card, the advantageous deck presents less losses, and thus larger choices in this deck imply in a positive balance at the ending of the task. Three-year-olds children present a significantly lower performance in this task in comparison to four and five-year-olds (Gao, Wei, Bai, Lin, & Li, 2009; Hongwanishkul et al., 2005; Kerr & Zelazo, 2004). Kerr and Zelazo (2004) observed that the preference of younger children for choosing cards from the disadvantageous deck throughout the task resembles the performance of patients with orbitofrontal and amygdala lesions in the IGT (Bechara et al., 1994) and, therefore, they also seem to present, at some extent, what has been called "myopia for the future" (Damasio, 1994). Garon and Moore (2007) found that the performance on a task adapted from the IGT was associated to negative affectivity in four-year-olds, and children who were more easily frustrated and had difficulties regulating emotions chose more cards from the deck with higher immediate gains.

The gender differences in the performance of the IGT are well established, as shown in a recent critical review by van den Bos, Homberg and Visser (2012) on the topic. When the whole 100 choices of the task are considered, the scores distributions of men and women are strongly overlapped, although the male scores are slightly skewed to the right. The review indicates, however, that the pattern of performance is different for each gender. While men exhibit a preference for either the advantageous or the disadvantageous deck already in the initial blocks, women only consolidate this preference in the final blocks of the task. However, there are inconsistencies in the findings of studies investigating gender differences in the performance of tasks adapted from the IGT for children and adolescents. Overman and colleagues (2004) investigated gender differences in the reversal learning task, known to be dependent on the integrity of the orbitofrontal cortex, in small children, adolescents and adults. In this task that aims to assess reversal learning, the participants are initially instructed to learn how to discriminate two objects, one of them provides food as a reward and the other doesn't. Furthermore, a compliment is given for each correct answer. Thereafter, the contingency of reinforcement is inverted and the participants must learn the new contingency. This ability appears first in boys (Overman,

2004). The superiority of boys in the first years of life in the reversal learning task is in line with studies that indicate better performance of male children and adolescents in affective decision-making tasks (Blair, Colledge, & Mitchell, 2001; Crone, Bunge, Latenstein, & Van Der Molen, 2005; Gao et al., 2009; Kerr & Zelazo, 2004), which are also dependent on the orbitofrontal cortex. Other studies, however, indicate female superiority in affective decisions making tasks (Garon & Moore, 2004; Heilman, Miu, & Benga, 2009; Hooper, Luciana, Conklin, & Yarger, 2004). Although there are several initiatives in Brazil in terms of developing instruments to assess cool executive functions (e.g. Natale, Teodoro, Barreto, & Haase, 2008), such actions do not address the development of measures to evaluate the hot components of executive functions. It is important to notice that the authors of the present study are unaware of studies that investigate the development of affective decision-making in Brazilian preschool children. Within this context, the main goal of this study is to develop a computerised version of the CGT for the evaluation of these children. Secondly, the research attempts to evaluate if the computerised version of the task is capable to identify the age differences previously reported by Kerr and Zelazo (2004). Finally, the possible differences between boys and girls in the performance of the Brazilian version of the task were also investigated.

Methods

Participants

The sample of the present study is composed by 137 children between the ages of 3 and 5 years old. There were 37 children aged 3 years old (mean age = 44. 05 months, *SD* = 2.581; 19 boys, 21 from private kindergartens), 50 children aged 4 years old (mean age = 53.64 months, *SD* = 3.515; 29 boys, 25 from private kindergartens) e 50 children aged 5 years old (mean age = 65.24 months, *SD* = 3.36; 29 boys, 25 from private kindergartens) from four public and three private kindergartens of Belo Horizonte – Minas Gerais – Brazil.

Instruments

The instruments used in the present cross-sectional study are the following:

Children´s Gambling Task-Br (CGT-Br). Affective decision-making was evaluated by the Brazilian version of the Children´s Gambling Task. The differences between the original version of the task (Kerr & Zelazo, 2004) and the Brazilian version lie in its application. The original version of the task is applied manually, while the Brazilian version was developed in Delphi (7th Version) and is compatible with Windows software and thus, its application is computerised. The Children´s Gambling Task-Br (figure 1) consists in two decks with 53 cards each and a box placed between them representing the 10 ml cylinder that contains the candies in the original version. One of the decks has its back covered by diagonal lines, while the back of the other deck is covered by horizontal and vertical lines. The front of the cards from both decks is divided in two parts, an upper one and a bottom one.

Figure 1
Example of a card from the disadvantageous deck.

In this task, the examinee first sees the reward of his choice and then verifies if there are any losses. Thus, the upper part of the cards presents happy faces (gains) right when the child selects the desired deck, while the bottom part is covered by a virtual post-it. The examiner must click this post-it to reveal possible sad faces on the bottom part of the card, which simulates the procedure performed by Kerr and Zelazo (2004). The deck with the vertical and horizontal lines in the back contains cards that always provide one reward, represented by one happy yellow face, while the number of losses, represented by sad red faces, is always zero or one. The deck with the diagonal lines in the back, on the other hand, contains cards that always provide two rewards and losses of zero, four, five or six candies. Thus, the deck with diagonal lines is disadvantageous in the long-run, while the deck with vertical and horizontal lines is advantageous. The order of the cards in each deck is the same as the one formulated by Kerr and Zelazo (2004), as shown in figure 2.

The rewards used in the task are M&Ms candies, the same used in the original task (Kerr & Zelazo, 2004). When children received the rewards, the examiner would take the amount of candies won from an M&Ms box and put them next to the child, on the table where the computer was placed. Furthermore, virtual candies were added to the cylinder in the computer screen placed between the two decks to force children to focus on the candies gained. When children lost the rewards, the candies were removed from the table and placed back in the M&Ms box. Besides, virtual candies were also removed from the cylinder in the computer screen.

The procedure and instructions for the task were also based in Kerr and Zelazo (2004). The child initially received a candy to get motivated to do the task and then would go through six demonstration trials, in which the examiner would choose three cards from each deck and show the child the gains and losses from each choice. Thereafter, the task trials would start, and the child would receive an initial amount of 10 M&Ms candies (also represented as virtual candies in the cylinder in the computer screen) and would have to make 50 choices between the two decks. Those choices were then divided into five blocks of 10 choices each, and each block comprised 10 consecutive choices. At the ending of the task, the child was asked about what was the best deck and why, and received a package of M&Ms candies. For the statistical analyses, the proportion of advantageous choices minus the number of advantageous choices made on the 50 trials was used as the dependent variable.

Columbia Mental Maturity Scale (CMMS). The general

Card n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Disadvantageous Decks	0	0	-4	0	-6	0	-4	0	-5	-6	0	-6	0	-5	-4	0	-6	-4	0	0	0	-6	0	-6	0	-4	-5	-4	0	0	-6	-4	-5	0	0	0	-4	-6	0	0	0	0	-4	0	-6	0	-4	0	-5	-6
Advantageous Decks	0	0	-1	0	-1	0	-1	0	-1	-1	0	-1	-1	0	0	0	-1	-1	0	-1	0	0	0	-1	-1	-1	0	0	-1	-1	0	0	0	-1	-1	0	0	-1	-1	0	0	-1	0	-1	0	-1	0	-1	-1

Figure 2
Output of each card from the disadvantageous and the advantageous deck.

intellectual ability was measured by the Columbia Mental Maturity Scale (Burgemeister, Blum, & Lorge, 1954). The CMMS is a measure of non-verbal cognition suitable for the evaluation of children between the ages three years and six months and nine years and 11 months. The test includes 92 items organized in eight age levels (A,B,C,D,E,F,G and H), from which each child performs the segment of the test according to his or her chronological age. Therefore, depending on the level of the child, 55 to 66 items are presented. Each item consists in a group of three to five concrete or abstract figures presented on a 6x9 inches card. For every item, the child is instructed to point to the only figure that is not related to the other ones. Since the number of items is different for each child, the raw scores were transformed in z-scores relative to the distribution of the children, considering their ages by 6 to 6 months. As the dependent variable, z-scores were calculated for each age level of the CMMS. Nine children, five three year-olds (three girls), three four-year-olds, (two girls) and one five-year-old girl, were excluded because they couldn't understand the examples. These children are not part of the 137 children who participated in the present study.

Procedures

An informed consent term was sent to the parents of children aged three years and six months to five years and 11 months with the help of school's teachers and coordinators from four private and three public kindergartens contacted by the researchers. After the parents authorized their children to participate, kids were individually evaluated using the Columbia Mental Maturity Scale (CMMS) and the Children's Gambling Task-Br (CGT-Br) in a silent room in their schools by a psychologist and a Psychology undergraduate student properly trained. Half of the children were first evaluated with the CMMS, while the other half started the session with the CGT-Br. Children were allowed to make a small pause between the two tasks. The present study was approved by the Research Ethics Committee of the Federal University of Minas Gerais (ETIC 511-09-UFMG), Belo Horizonte, Minas Gerais - Brazil.

Statistical analysis

The data were analyzed using SPSS for Windows 17.0. In order to test the interaction between performance on the CGT, age and sex, a mixed model analysis of variance (ANOVA) was used. T-tests were used to compare mean values for each age group and blocks to the expected mean values based on random responding (i.e., 0). The Binomial Theorem was used to investigate the individual performance of the children.

Results

The data were analyzed as proposed by Kerr and Zelazo (2004). The dependent variable used was whether the children made an advantageous or disadvantageous choice for each trial. The fifty choices made throughout the task were divided in five blocks of ten cards each. The proportion of advantageous choices minus disadvantageous choices was calculated for each block of the task; positive scores represent a higher number of advantageous choices, while negative scores reveal a larger number of disadvantageous choices. Table 1 presents descriptive values of the performance in the CGT-Br considering the different age groups.

Table 1
Descriptive Statistics of the Scores of the Number of Advantageous Choices Minus Number of Disadvantageous Choices in the CGT by Age Groups.

CGT (A-D)	3 year-olds (n = 37)	4 year-olds (n = 50)	5 year-olds (n = 50)
Mean	-1.30	5.12	6.36
SD	7.50	7.68	9.16
Median	0	2	4
Minimum Value	-24	-10	-18
Maximum Value	18	26	26

In order to analyze differences in scores, a 3 (age: 3 vs. 4 vs. 5 years) X 2 (sex: male vs. Female) X 5 (blocks: 1-5) mixed model ANOVA was used. A significant main effect of age $F(2, 131) = 9.889$, $p < 0.001$, and block, $F(4.524) = 8.762$, $p < 0.001$, was found, which shows that, independently from other variables, the performance on CGT-Br is associated with age, and the number of advantageous choices minus disadvantageous choices differs among the blocks of the task. There was also a significant interaction between age and block $F(8, 524) = 4.211$, $p < 0.001$ (using Greenhouse-Geisser correction). This indicates that the performance among distinct blocks of the task differed according to the age of the child. No other significant interactions were found.

Tests of simple effects indicated that scores increased across the blocks of the task for children aged four, $F(4, 196) = 8.64$,

$p < 0.001$, and five years old, $F(4, 196) = 8.31$, $p < 0.001$, but not for children aged three years old, $F(4, 144) = 1.97$, $p = 0.113$. Five-year-olds made more advantageous choices than three-year-olds only on the fifth block of the task, $F(1, 85) = 20.88$, $p < 0.001$. In order to control for the probability of a type I error due to the effect of multiple tests, a Bonferroni correction for five tests $(0.05/15 = 0.003)$ was used, and a significance cut-off of $p < 0.003$ was adopted. Four-year-olds made more advantageous choices than three-year-olds in the fourth and fifth blocks of the task, $F(1, 85) = 9.13$, $p < 0.003$, $F(1, 85) = 20.46$, $p < 0.001$, respectively. In contrast, four and five-year-old children performed similarly in all the blocks. Means and standard deviations for each block according to different age groups are presented in Figure 3.
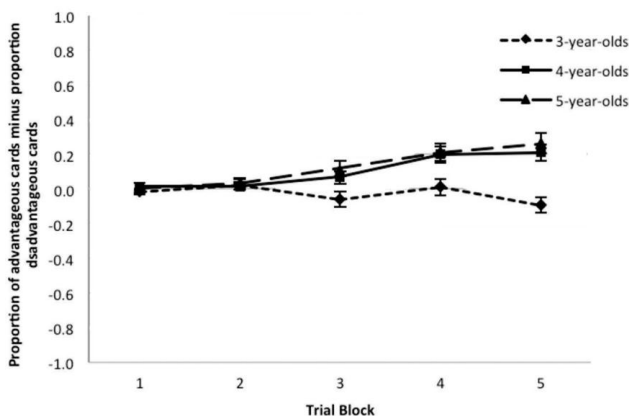

Figure 3

Mean (and standard error) of the proportion of advantageous choices minus the proportion of disadvantageous choices by age and blocks of 10 consecutive choices

The *t*-distribution was used to compare the mean scores for each block and age group to the expected mean values based on the random response (i.e., 0). The scores of three-year-olds did not differ from chance. Mean scores from four-year-olds were significantly higher than expected by chance on the fourth, $t(49) = 4.18$, $p < 0.001$, and fifth blocks, $t(49) = 4.55$, $p < 0.001$. For five-year-olds, the mean scores were significantly higher than expected by chance in the third, $t(49) = 2.69$, $p < 0.01$, fourth, $t(49) = 4.16$, $p < 0.001$, and fifth blocks, $t(49) = 4.59$, $p < 0.001$, on the CGT-Br.

The individual performance of the children was also investigated. The Binomial Theorem was used to verify if each of the children made more advantageous or disadvantageous choices across the blocks of the task than it would be expected by a random response based on an alpha of 0.05 (i.e., 32 or more choices). Among three-year-olds, one boy and two girls made significantly larger disadvantageous choices than it would be expected by chance, while two girls made significantly more advantageous choices. In the four-year-olds group, none did more disadvantageous choices, while seven of them (five boys) made more advantageous choices. Among five-year-olds, two of them (one boy) made significantly more disadvantageous choices, while fourteen of them made more advantageous choices (eight boys).

Discussion

The present study sought to elaborate a computerised version of the Children´s Gambling Task in order to evaluate the development of affective decision-making in preschool years. To our knowledge, there is no similar task developed in Brazil to evaluate decision-making in preschoolers. The use of computerised tasks not only facilitates data recording, but also standardizes the application and minimizes factors related to the examiner that may in some way influence the child's performance (Tien et al., 1996). In this study, besides the virtual candies added and removed from the cylinder placed on the computer screen, the kids earned and lost M&Ms candies during the task according to the happy and sad faces present in each of the cards chosen. Future studies must evaluate if the computerised version of the tasks accompanied only by virtual rewards would be also able to distinct the different age groups.

The findings of this study indicated that the computerised version of the Children's Gambling Task was capable of distinguishing age differences found in previous studies (Hongwanishkul et al., 2005; Kerr & Zelazo, 2004). Four-year-olds children performed significantly better than expected by chance in blocks 4 and 5 of the task, and five-year-olds performed significantly better than expected in blocks 3, 4 and 5. Conversely, the performance of three-year-olds did not differ from what would be expected by chance in any of the blocks. It is important to notice that the difference between the age groups appears to be due to the difference between children who developed a preference for the advantageous deck and those who made random choices throughout the task. The performance of Brazilian children aged four and five years was similar to that of children of the same age evaluated in previous studies (Gao et al., 2009; Hongwanishkul et al., 2005; Kerr & Zelazo, 2004). Similar to the study carried out by Kerr and Zelazo (2004), analysis of individual performance showed that there is great variability in the performance of children in CGT-Br in each of the age groups. Future studies should investigate whether measures of cool executive function, such as working memory, can explain the variability in performance in the CGT.

The development of affective decision making in the first five years of life can be interpreted through the development of neural systems related to the orbitofrontal cortex (Kerr & Zelazo, 2004). It is also worth noting that the findings of Garon and Moore (2004) showed improved performance on a task slightly more complex than the CGT until the age of six years. The superior performance of children aged four and five years old in the task of the present study can also be interpreted considering the development of cool components of executive functions, such as working memory and inhibitory control, as well as other predominantly hot executive functions, like reversal learning, which are important to the performance in the CGT (Hongwanishkul et al., 2005; Toplak, Sorge, Benoit, West, & Stanovich, 2010) and follow a similar pattern to the development of affective decision-making (Garon & Moore, 2007; Hongwanishkul et al., 2005; Overman, 2004). Thus, the superior performance of children aged four and five years in the CGT can be explained by a better ability of these children to

inhibit and reverse the prior learning of the contingency of gains and losses, and to adjust their performance across the choices based on the previous results.

In the present study, significant differences between girls and boys in the affective decision-making task were not found. The findings of previous studies that indicate superior performance of boys over girls in gambling tasks can be confirmed in studies with rhesus monkeys (Bachevalier & Hagger, 1991; Clark & Goldman- Rakic, 1989) and small children (Overman, 2004) that showed that the obitofrontal cortex develops earlier in boys, presumably as a result of pre, perinatal and postnatal testosterone levels (Happaney, Zelazo, & Stuss, 2004. Few studies with adults that were evaluated with the IGT (e.g. Bolla, Eldreth, Matochik, & Cadet, 2004; Reavis & Overman, 2001) also showed a better performance of male participants over females in the task. However, there is evidence that women have a higher volume of orbitofrontal cortex, devoted to emotional modulation, relative to the volume of the amygdala, which would imply better performance on the task of affective decision-making (Gur, Gunning- Dixon, Bilker, & Gur, 2002). Finally, research on the influence of gender on performance on decision-making tasks in preschoolers should be addressed in future studies, since results from previous studies are fairly inconsistent.

The development of the executive functions in the first years of life seems to be crucial to the adaptation of the child in the different contexts where he or she is inserted, as well as it appears to be an important predictor of the development of future cognitive and socioaffective abilities. Although there are no longitudinal studies that specifically address the development of decision-making in preschool years and its future outcomes, there are several evidences that cool and hot executive functions are related to school performance (Willoughby, Blair, Wirth, & Greenberg, 2012), social skills (Denham, Warren- Khot, Bassett, & Wyatt, 2012) and emotional development (Sabol & Pianta, 2012). The development of predominantly hot executive function in the preschool years, such as self-regulation and delay of gratification, it is an important predictor of social and emotional abilities even in adolescence and adulthood (Casey et al., 2011; McCabe, Cranford, Morales, & Young, 2006). Moreover, the presence of executive disfunctions in preschool children with developmental disorders may be an important risk factor for greater cognitive and behavioral problems in the future (Johnson, 2012). Thus, early identification of deficits in executive functions can be very useful in structuring programs to train and habilitate such functions (Diamond & Lee, 2011). In this scenario, given the lack of predominantly hot executive function tasks developed for neuropsychological assessment of Brazilian children, it is particularly important to conduct studies like this that aim to adapt and develop tools to evaluate, since preschool years, the mainly affective and motivational components of executive functions.

References

Bachevalier, J., & Hagger, C. (1991). Sex differences in the development of learning abilities in primates. *Psychoneuroendocrinology*, *16*, 177–88.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*, 7-15.

Blair, R. J. R., Colledge, E., & Mitchell, D. G. V. (2001). Somatic markers and response reversal: Is there orbitofrontal cortex dysfunction in boys with psychopathic tendencies? *Journal of Abnormal Child Psychology*, *29*(6), 499-511.

Bolla, K. I., Eldreth, D. A., Matochik, J. A., & Cadet, J. L. (2004). Sex-related differences in a gambling task and its neurological correlates. *Cerebral Cortex, 14*(11), 1226-32.

Burgemeister, B. B., Blum, L. H., & Lorge, I. (1954). *Manual for Columbia Mental Maturity Scale*. Yonkers, N. Y.: World Book Co.

Casey, B., Somerville, L., Gotlibb, I., Ayduck, O., Franklin, N., Askren, M., … Shoda Y. (2011). Behavioral and neural correlates of delay of gratification 40 years later. *PNAS, 108*(36): 14998-15003.

Clark, A. S., & Goldman-Rakic, P. S. (1989). Gonadal hormones influence the emergence of cortical function in nonhuman primates. *Behavioral Neuroscience*, *103*, 1287–1295.

Crone, E. A., Bunge, S. A., Latenstein, H., & Van Der Molen, M. W. (2005). Characterization of Children's Decision-making: Sensitivity to punishment frequency, not task complexity. *Child Neuropsychology*, *11*, 245-263.

Damasio, A. R. (1994). *Descartes' error: Emotion, reason, and the human brain*. New York: Putnam.

Denham, D., Warren-Khot, K. Bassett, H. Wyatt, T., & Perna, A. (2012). Factor structure of self-regulation in preschoolers: Testing models of a field-based assessment for predicting early school readiness. *Journal of Experimental Child Psychology*, *111* (2012) 386–404.

Diamond, A. & Lee, K. (2011) Interventions shown to aid executive function development in children 4–12 years old. *Science*, *333*(6045), 959–964.

Fuster, J. (1997). *The prefrontal cortex: Anatomy, physiology, and neuropsychology of the executive lobe*. New York: Lippincott-Raven Press.

Gao, S., Wei, Y., Bai, J., Lin, C., & Li, H. (2009). Young children' affective decision-making in a gambling task: Does difficulty in learning the gain/loss schedule matter? *Cognitive Development*, *24*, 183-91.

Garon, N., & Moore, C. (2004). Complex decision-making in early childhood. *Brain Cognition, 55*, 158–70.

Garon, N., & Moore, C. (2007). Negative affectivity predicts individual differences in decision-making for preschoolers. *The Journal of Genetic Psychology, 167*, 443-62.

Gur, R. C., Gunning-Dixon, F., Bilker, W. B., & Gur, R. E. (2002). Sex differences in temporo-limbic and frontal brain volumes of healthy adults. *Cerebral Cortex, 12*(9), 998-1003.

Happaney, K., Zelazo, P. D., & Stuss, D. T. (2004). Development of orbitofrontal function: current themes and future directions. *Brain Cognition*, *55*(1), 1-10.

Heilman, R. M., Miu, A. C., & Benga, O. (2009). Developmental and sex-related differences in preschoolers' affective decision making. *Child Neuropsychology : a Journal on Normal and Abnormal Development in Childhood and Adolescence, 15(*1), 73-84.

Hongwanishkul, D., Happaney, K. R., Lee, W. S. C., & Zelazo, P. D. (2005). Assessment of hot and cool executive function in young children: age-related changes and individual differences. *Developmental Neuropsychology, 28*, 617-644.

Hooper, C. J., Luciana, M., Conklin, H. M., & Yarger, R. S. (2004). Adolescents' performance on the Iowa Gambling Task: Implications for the development of decision-making and ventromedial prefrontal cortex. *Developmental Psychology. 40*, 1148–1158.

Johnson, M. H. (2012). Executive function and developmental disorders: The flip side of the coin. *Trends in Cognitive Sciences*, *16*(9), 454-457.

Kerr, A., & Zelazo, P. D. (2004). Development of "hot" executive function: The

Children's Gambling Task. *Brain Cognition, 55*, 148-157.

Mata, F. G., Neves, F. S., Lage, G. M., Moraes, P. H. P., Mattos, P., Fuentes, D., … Malloy-Diniz, L. (2011) Neuropsychological assessment of the decision-making process in children and adolescents: An integrative review of the literature. *Revista Brasileira de Psiquiatria, 38*(3), 106-115.

McCabe, S., Cranford, J., Morales, M., & Young, A. (2006). Simultaneous and concurrent polydrug use of alcohol and prescription drugs: Prevalence, correlates, and consequences. *Journal of Studies on Alcohol and Drugs*, *67*(4), 529–537.

Natale, L. L., Teodoro, M. L. M., Barreto, G. V., & Haase, V. G. (2008). Propriedades psicométricas de tarefas para avaliar funções executivas em pré-escolares. *Psicologia em pesquisa*, *2*(2), 23-35.

Overman W. H. (2004). Sex differences in early childhood, adolescence, and adulthood on cognitive tasks that rely on orbital prefrontal cortex. *Brain Cognition*, *55*(1), 134-147.

Overman, W., Frassrand, K., Ansel, S., Trawalter, S., Bies, B., & Redmond, A. (2004). Performance on the IOWA card task by adolescents and adults. *Neuropsychologia, 42*(13), 1838-1851.

Pennington, B. (1991) *Diagnosing learning disorders*. New York : Guilford Press.

Sabol, T., & Pianta, R. (2012). Patterns of school readiness forecast achievement and socioemotional development at the end of elementary school. *Child Development*, *83*(1), 282–299.

Reavis, R., & Overman, W. H. (2001). Adult sex differences on a decision-making task previously shown to depend on the orbital prefrontal cortex. *Behavioral Neuroscience, 115* (1), 196-206.

Schoemaker, K., Bunte, T., Wiebe, S., Espy, K., Deković, M., & Matthys, W. (2012). Executive function deficits in preschool children with ADHD and DBD. *Journal of Child Psychology and Psychiatry*, *53*(2), 111-119.

Tien, A. Y., Spevack, T. V., Jones, D. W., Pearlson, G. D., Schlaepfer, T. E., & Strauss, M. E. (1996). Computerized Wisconsin Card Sorting Test: Comparison with manual administration. *Journal of Medical Sciences*, *12*, 479-485.

Toplak, M. E., Sorge, G. B., Benoit, A., West, R. F., & Stanovich, K. E. (2010) Decision-making and cognitive abilities: A review of associations between Iowa Gambling Task performance, executive functions, and intelligence. *Clinical Psychology Review*, *30*, 562-581.

van den Bos, R., Homberg, J., & de Visser, L. (2012). A critical review of sex differences in decision-making tasks: Focus on the Iowa Gambling Task. *Behavioural Brain Research*, *16*.

Willoughby. M., Blair, C., Wirth, R. J., & Greenberg, M. (2012) The Measurement of executive function at age 5: Psychometric properties and relationship to academic achievement. *Psychological Assessment*, *24*(1), 226–239.

Zelazo, P. D., & Müller, U. (2002). The balance beam in the balance: reflections on rules, relational complexity, and developmental processes. *Journal of Experimental Child Psychology*, *81*(4), 458-465.

Fernanda Mata, Master degree in Neurosciences (UFMG), attenting PhD course of Monash University Neuroscience Program, researcher at Laboratory of Neuropsychological Investigation, Medical School (UFMG).

Isabela Sallum, researcher at Laboratory of Neuropsychological Investigation, Medical School (UFMG).

Paulo Henrique Paiva de Moraes, Master degree in Neurosciences (UFMG), researcher at Laboratory of Neuropsychological Investigation, Medical School (UFMG).

Débora Marques Miranda, professor of Pediatrics at the Medical School (UFMG), professor of Health Sciences Post-graduation Program at UFMG, professor of Molecular Medicine Post-graduation Program at UFMG.

Leandro Fernandes Malloy-Diniz, professor of Mental Health at the Medical School (UFMG), professor of Molecular Medicine Post-graduation Program at UFMG, coordinator of the Laboratory of Neuropsychological Investigation at Medical School (UFMG). Email: malloy@ufmg.br