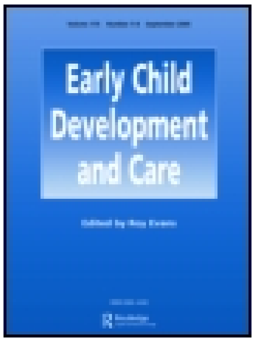

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Assessing hot and cool executive functions in preschoolers: affective flexibility predicts emotion regulation

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ABSTRACT

Affective flexibility (AF) is the ability to alternate between processing emotional and non-emotional information. This hot executive function has been understudied during early development. The first aim of our investigation was to generate preliminary construct validity evidence for a new measure of AF: the Emotional Flexible Item Selection Task (EM-FIST). Second, to investigate if AF represented a better predictor of preschoolers' emotion regulation (ER) compared to, cognitive flexibility (CF). Preschoolers ($N = 56$; 48.2% girls) completed AF and CF measures (also working memory and inhibitory control). ER was measured through maternal report. We found evidence of EM-FIST's validity, as an appropriate measure of AF for preschoolers, by showing that it is related to cool executive functions' measures and to children's ER. Both AF and maternal level of education predicted children's ER while CF did not. Our investigation highlights a stronger relation between ER and AF in preschoolers than with CF.

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Affective flexibility; cool and hot executive functions; emotion regulation; preschoolers; construct validity

Introduction

For many years, developmental research on cognitive control has mostly been conducted without considering that children's effortful goal-directed behaviour takes place in an environment which includes emotional stimuli. From a young age, children are confronted with complex emotional contexts, especially within social interactions. Therefore, they are required to learn how to rapidly switch from focusing on the emotional content of a situation, such as an emotionally negative angry face or an overly arousing positive face, to a neutral interpretation (e.g. the colour of the glasses the person is wearing) to decrease the intensity of a distressing emotion. This is an example of what has been termed as affective flexibility: the ability to flexibly attend to, and disengage from emotional material (Genet & Siemer, 2011).

Affective flexibility can be conceptualized within the executive functioning model which distinguished between cool-cognitive and hot-affective skills (Zelazo & Muller, 2002). Cool executive functions are top-down processes that promote goal-directed behaviour (e.g. cognitive flexibility, inhibition, working memory) within a decontextualized, non-emotional setting (Welsh & Peterson, 2014). Traditionally, research has focused on studying cool executive functions (Welsh & Peterson, 2014; Zelazo & Carlson, 2012). However, understanding behaviour in real-world settings implies

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studying top-down processes as they are influenced by motivational (e.g. rewards, punishment) and emotional characteristics of a given situation, that is, hot executive functions (Welsh & Peterson, 2014; Zelazo & Carlson, 2012). Affective flexibility is one of such hot executive functions.

So far, few studies have analysed the development of affective flexibility in children and the effects of different ways of processing emotional information on the ability to be flexible. In one study, Qu and Zelazo (2007) assessed both affective flexibility and cognitive flexibility in 3- to 4-year old children. The standard Dimensional Change Card Sort Task (DCCS) was used to assess cognitive flexibility. An emotional version of this task was designed and the emotion of each face (happy, neutral and sad) during a display was kept constant. Hence the face was task-irrelevant, and children had to apply two non-emotional rules: to sort cards by gender (female or male) and then switch to sorting them by age (young children or adults). Participants had a significantly higher performance on the happy, compared to the other emotional conditions of this task, including the standard DCCS. These findings offered preliminary support for the idea that the simple presentation of positive stimuli can increase affective flexibility performance even when emotion is not directly relevant to the task at hand (Qu & Zelazo, 2007 Experiment 2).

In another study, conducted by Visu-Petra, Stanciu, Benga, Miclea, and Cheie (2014) with preschoolers, affective flexibility was measured using an emotional version of the DCCS (EM-DCCS). Children had to sort schematic emotional faces consisting of a happy red face and a sad blue face according to colour or emotion (emotion was task relevant). This study reported gender differences in terms of affective flexibility as measured with the EM-DCCS task so that preschool girls outperformed boys in this emotional task version. This finding is in line with previous evidence indicating that girls outperform boys in affective flexibility performance during middle childhood (Mocan, Stanciu, & Visu-Petra, 2014) and preadolescence (Mărcuş, Stanciu, MacLeod, Liebregts, & Visu-Petra, 2016). However, Qu and Zelazo's study (2007) did not find this gender difference with preschoolers.

A limitation of this affective flexibility task (EM-DCCS) is its simplified format, as children are required to switch between two different perspectives only once during the entire emotional DCCS task. In real-life scenarios, children may be required to switch repeatedly between such emotional perspectives. Therefore, a promising task for assessing affective flexibility in children is the Emotional Flexible Item Selection Task (EM-FIST) (Mărcuş et al., 2016; based on Wong, Jacques, & Zelazo, 2008). In the version for very young children, they are presented with three emotional faces and are instructed to find a pair of items that 'go together in one way' (e.g. have the same gender), and then to select a pair of items 'that go together, but in another way' (e.g. same hair colour) from the exact same group of faces. This type of task is appropriate for measuring real-life affective flexibility, because it captures an individual's ability to alternate between different perspectives of a single object or event (Jacques & Zelazo, 2001; Smidts, Jacobs, & Anderson, 2004), and requires the use of problem-solving strategies in a trial by trial manner (Yerys, Wolff, Moody, Pennington, & Hepburn, 2012). In comparison, the EM-DCCS perspectives (i.e. rules) are alternated in separate blocks which might not mimic everyday flexibility demands.

Versions of the Emotional Flexible Item Selection Task (EM-FIST) have been used in one study with school-aged children (11–14 year-olds) (Mărcuş et al., 2016) and in a preliminary study with preschoolers (Wong et al., 2008). In the preschool sample a simplified card version in which children had to select matching pairs of faces in terms of gender, hair colour or size while ignoring task-irrelevant emotional information was used. In this study, Wong and colleagues (2008) showed that the EM-FIST was more demanding (i.e. lower accuracy performance) than the standard FIST, but only when angry or neutral faces were presented. The happy faces condition of the EM-FIST task was the less demanding task version. This result offers additional support for the idea that the employment of positive emotional stimuli exerts a facilitative effect on affective flexibility performance, probably by inducing a transient, mildly positive mood in preschoolers (emotion was task-irrelevant). However, none of the prior studies aimed to provide validation evidence for these children's versions of EM-FIST.

The development of a wider variety of valid affective flexibility tasks for young children is necessary for understanding how cognitive and emotional processes influence children's development and for comparisons with adult research. In this study, we developed a new version of the EM-FIST task that is appropriate for young children, adapting the task developed by Mărcuş et al. (2016) for school-age children. Our first aim was to provide preliminary validity evidence for this simplified affective flexibility task by studying its relation with a cool measure of cognitive flexibility, as well as with other measures of executive functioning such as working memory, cognitive and behavioural inhibitory control. Prior research identified close relations between hot and cool executive functions even in young children (O'Toole, Monks, & Tsermentseli, 2017; Welsh & Peterson, 2014). To our knowledge, none of the preliminary existing studies on preschoolers' affective flexibility have set out to validate an affective flexibility measure by looking at its relation to a range of cool executive functioning measures such as cognitive flexibility, inhibitory control and working memory. This was the first aim of our study.

Across development, executive functioning has been linked to better emotion regulation, but questions remain regarding which specific function might be predominantly involved in emotion regulation (Schmeichel & Tang, 2014). Emotion regulation comprises intrinsic and extrinsic processes associated with the activation of an emotion and its management over time, impacting the valence of the emotion and its intensity or duration (Cole, Martin, & Dennis, 2004; Gross, 2014; Thompson, 1994). Experiencing strong negative or positive emotions may be incompatible with children's ability to flexibly attain their goals. Therefore, children may often choose to decrease the intensity of their emotion by changing the way in which they view a specific situation, and for that matter affective flexibility may be particularly important for emotion regulation.

Adaptive emotion regulation is described as using a range of regulatory strategies in a flexible fashion that allows the individual to deal with changes in the environment and to fulfil his/her personal objectives (Gross, 2014). Therefore, studying the relationship between emotion regulation and flexibility in preschool children is highly relevant as both competencies have a rapid development during this early stage (Eisenberg & Morris, 2002; Zelazo & Carlson, 2012) and may even share common neurological underpinnings (Cunningham & Zelazo, 2010).

So far, research conducted with adults has provided evidence that the ability to flexibly alternate between different emotional perspectives is crucial for effective emotion regulation (Johnson, 2009; Malooly, Genet, & Siemer, 2013). Developmental research parallels these studies showing that optimal affective flexibility skills during the preschool years predict greater emotion regulation and academic achievement during the early school years (Wilson, Derryberry, & Kroeker, 2006). These findings go in line with previous studies linking emotion regulation (parent and teacher reports) to children's ability to manage attention effectively (Eisenberg et al., 1994). However, a link between cool executive functioning and emotion regulation has not always been confirmed. For instance, in one study (Leerkes, Paradise, O'Brien, Calkins, & Lange, 2008) and its replication (Blankson, O'Brien, Leerkes, Marcovitch, & Calkins, 2012) emotion regulation (parent report) and cool executive functions (inhibitory control, working memory) were not found to be significantly associated. Another study that assessed the relation between hot and cool inhibitory control and emotion regulation in preschoolers offered conflicting results. While researchers found a stronger positive association between emotion regulation (laboratory behavioural assessments) and hot executive functions (Gift Delay) than with cool executive functions (Simon Says), a different scenario emerged when emotion regulation was assessed through parental report (Carlson & Wang, 2007). In this case, cool executive functions predicted emotion regulation, whilst hot executive functions did not.

In light of the findings obtained with adults (Johnson, 2009; Malooly et al., 2013), and the few existing developmental evidence (Wilson et al., 2006) we can hypothesize that affective flexibility may predict emotion regulation strategies in preschoolers. Moreover, it might be the case that affective flexibility is particularly relevant for emotion regulation. Some authors have hypothesized this, as emotion regulation strategies rely on the capacity to attend and disengage from emotional stimuli (Genet & Siemer, 2011). Hence, our second aim was to analyze if affective flexibility represents a better predictor of preschoolers' emotion regulation compared to cognitive flexibility.

In summary, the present investigation had two main aims. The first, to provide preliminary evidence for the construct validity of our version of the EM-FIST. Research has shown intricate relations between hot and cool executive functions (O'Toole et al., 2017; Welsh & Peterson, 2014). Therefore, relations between affective flexibility and cognitive flexibility, inhibitory control, and working memory would provide supportive evidence for the construct validity of the affective flexibility task. Existing studies with affective flexibility in preschool and childhood (Mărcuş et al., 2016; Wong et al., 2008) have been limited to studying the relation between affective flexibility and cognitive flexibility, without placing them in the broader context of other cool executive functions. In the attempt to offer a more integrative perspective, we also tested for the positive emotion and gender effects on affective flexibility performance, since studies have yielded contradictory results during early development (e.g. Visu-Petra et al., 2014; cf., Qu & Zelazo, 2007).

The second aim of this investigation was to analyze if affective flexibility, represented a better predictor of preschoolers' emotion regulation compared to cognitive flexibility. Accumulating evidence has shown a link between better executive functions and better emotion regulation, but questions remain regarding which specific executive function might be predominantly involved in emotion regulation (Schmeichel & Tang, 2014). Affective flexibility appears to be a likely candidate. To the best of our knowledge, no prior research has tried to disentangle the role played by both hot and cool flexibility in preschoolers' emotion regulation, by testing both constructs simultaneously. Due to the aforementioned close relation between executive functions in preschool children, we also controlled for the predictive role of cool inhibitory control and working memory in emotion regulation.

Materials and methods

Participants

We recruited 56 Portuguese preschool children aged between 3 and 6 years old ($M = 63.55$ months $SD = 9.28$; 27 girls, 48.2%) from public day care centres in Maia, Portugal. Children were Caucasian and Portuguese speaking. Most parents had a high-school education (mothers: $n = 35$, 62.5%; fathers: $n = 35$, 63.7%) or higher education: undergraduate degree (mothers: $n = 18$, 32.1%; fathers: $n = 8$, 14.3%) or graduate degree (mothers: $n = 1$;1.8%). Only 1 mother (1.8%) and 11 fathers (19.6%) had not completed high school. We have missing demographics data from one mother and two fathers (see Table 1 for age).

Recruitment was conducted through the Health Office of Maia (Gabinete de Saúde da Maia), from Maia City Hall. The Health Office of Maia offers a series of health promotion programmes for schools in collaboration with researchers in different universities (see Supplemental online material with study plan). We partnered with the Health Office of Maia in this initiative by offering a socio-emotional promotion programme for preschoolers. The teachers from the public daycare centres in Maia with 3–6-year-old children who chose our programme were explained the study objectives and procedures. Before testing, parents that allowed their children to be involved in this study were presented with the study objectives and they were then required to fill in an informed consent form. Participants were assigned a code to ensure confidentiality. The enrolment in the socio-emotional programme took place after the testing was completed.

Procedure

The current data is part of a broader study regarding the interplay of socio-emotional and cognitive competencies in preschoolers. This paper focused on children's behavioural measures of cool and hot executive functions collected in a private, quiet room in the day-care centres. The experimenters were two master students who were properly trained to ensure consistency in the task administration procedure. The experimenters were randomly assigned to a particular class to ensure continuity between testing sessions. Prior to testing, the experimenters participated in a preschool class activity, conducted by the class teacher, to increase preschoolers' familiarity with them (see Supplemental online material with study plan). Children were tested in two different sessions which were, on average, 17 days apart ($SD = 19$). In the first assessment session, each child completed the Head Toes Knees Shoulders Task, Day-Night and the Executive Function Scale for Early Childhood. During the second assessment, children completed the Emotion Flexible Item Task and the Backward Digit Span. We conducted these two sessions because the broader assessment protocol was long. Tasks were chosen based on the following requirements: 1) sessions should have a similar duration (60 min. long) and 2) tasks were delivered in a specific order (shorter tasks interspersed with longer and repetitive tasks) to avoid preschoolers' fatigue and boredom. We also collected mothers' reports on sociodemographics and children's emotion regulation skills. These questionnaires were sent home through the class teacher. All the tasks used to assess hot and cool executive functioning were appropriate for preschoolers.

Measures

Affective flexibility

This hot executive function was measured using the 3-item Emotional Flexible Item Selection Task (3-item EM-FIST). The instrument was adapted from Mărcuş et al. (2016) school-age children version. Children's affective flexibility was operationalized by their ability to shift their attention between different non-emotional characteristics of emotional stimuli. On each trial, children were shown cards with three faces (all happy, angry or neutral) varying in three non-emotional dimensions (see Figure 1): gender (male or female), hair colour (yellow or red) or stimulus size (small and large). Participants were asked to select two cards that 'go together in one way' and then to select two cards that 'go together, but in another way', without mentioning the faces' emotional expression. One male and one female identity from the FACES Stimulus Set from Max Planck Institute for Human Development was used in all task versions, even though the emotional expression varied as a function of the condition presented (Ebner, Riediger, & Lindenberger, 2010).

The experimenter provided children with two demonstration trials, followed by four practice trials. Then the three emotional conditions (neutral, happy and angry) were administered in a counterbalanced order in a block manner (each condition included 12 trials).

During each trial, the answers were recorded by the experimenter. On each trial, we computed a score for the first selection (the first pair of items identified) and for the second selection (the second pair of items identified). Each child received a score of 1 for successfully selecting the first pair and a score of 1 for successfully selecting the second pair of items. Hence, in each trial, a child could have obtained a score of 1 for correctly selecting a single pair of items and a score of 2 for correctly selecting two subsequent different pairs of items. In each emotional condition of the EM-FIST task, the highest score that a child could obtain was 24: happy (Kuder-Richardson

Figure 1. Depiction of the 3-item EM-FIST. Example of stimuli: A = angry condition, in which children could select the first two items (same size) and then shift to choose the second and the third items (same gender); B = happy condition, in which children could select the first two items (same gender) and then shift to choose the first and the third items (same hair colour); C = neutral condition, in which children could select the first two items (same gender) and then shift to choose the second and the third items (same hair colour).

= .76), neutral (Kuder-Richardson = .73), angry (Kuder-Richardson = .63). We also computed a total score for the entire EM-FIST task (Kuder-Richardson = .89).

Emotion regulation

The Emotion Regulation Checklist (ERC; Shields & Cicchetti, 1997) contains a number of 24 items (4-point Likert scale) measuring children's emotion regulation skills. Mothers' report was used in this study. The ERC is comprised of two different scales: the Negativity/Lability scale and the Emotion Regulation Scale. For the purpose of this study we used only the Emotion Regulation Scale that includes items describing situationally appropriate affective displays, empathy, and emotional self-awareness (average of items 1, 3, 7, 15, 21, 23, and inverted 18), $\alpha = .63$. Higher values represent better emotion regulation (score range: 1 – 4).

Inhibitory control: behavioural

The *Head-Toes-Knees-Shoulders* task (HTKS; Ponitz, McClelland, Matthews, & Morrison, 2009) was used to assess behavioural inhibitory control (cool executive function). In this procedure, children were asked to perform the opposite of the researcher's oral prompts. The HTKS includes 20 test trials and has two parts. Part I consisted of four practice trials with feedback followed by 10 test trials. If the researcher said 'touch your head', the child was required to touch his/her toes. If the researcher said 'touch your toes', the child had to touch his/her head. Part II was only administered to children who responded correctly to five or more test trials. In the second part, two new prompts were added –'touch your shoulders' and 'touch your knees', thus resulting in a total of four rules. Again, the child was instructed to do the opposite of what the experimenter's requested. Four practice trials with feedback were administered followed by 10 test trials. On each trial, a score of 0 was provided for an incorrect response, a score of 1 was provided for an incorrect response followed by a spontaneous correction, and lastly, a score of 2 was provided for a correct response. Final task scores represented the sum of the children's performance on Part I (10 items) and on Part II (10 items) and the total score ranged from 0 to 40, with higher values showing higher levels of behavioural inhibitory control, $\alpha = .98$.

Inhibitory control: cognitive

Cognitive inhibitory control (cool executive function) was assessed using the *Day-Night Task* (Carlson, 2005; Gerstadt, Hong, & Diamond, 1994). During this procedure, children were asked to say 'sun' when they saw a card depicting a moon and stars, and to say 'moon' when they saw a card with a sun. The experimenter firstly asked the child 'When does the sun appear? During the day, or during the night?'. Next, the experimenter asked 'When do the stars and the moon appear? During the day, or during the night?' (the correct answer was provided if the child didn't offer a response). After this initial instruction, the experimenter told the child that they would be playing a 'silly' game. Children received the following instructions: 'When you see this card (blue card with the moon and stars on it), I want you to say "day".' The experimenter asked the child to repeat the word 'day'. The experimenter then removed the card and instructed the child: 'When you see this card (white card with the drawing of a yellow sun), I want you to say "night".' The experimenter asked the child to repeat the word 'night'. After two practice trials with corrective feedback, 16 test trials were delivered (no feedback). The number of correct answers was recorded, with total scores ranging from 0 to 16 points, Kuder-Richardson = .92.

Cognitive flexibility

Set shifting (cool executive function) was assessed using the Executive Function Scale for Early Childhood (Carlson & Schaefer, 2012). The experimenter showed children two boxes with target cards affixed to the front and then gave children a series of cards to sort. There were several sorting games delivered to each child in an order of increasing difficulty.

Level 1 *categorization, one rule.* Children had to put cards depicting 'fish' and 'elephants' in the corresponding boxes – one with an attached 'fish' and another with an 'elephant'. In Level 1A, children were asked to put 'cards with a fish' in the box with a fish. In Level 1B children were asked to put 'cards with an elephant' in the box with an elephant.

Level 2A *Categorization*: Children had to sort 'big kitty' and 'little kitty' cards into the corresponding boxes – one with a 'big kitty' attached and another with a 'little kitty' attached. Level 2B *Reverse Categorization*: Children were asked to put the 'little kitty' cards in the 'big kitty' box and vice-versa.

Level 3A *Separated Shape*: Children were asked to sort cards according to shape. Children were instructed to put the 'yellow cards with a black heart' in the box with a 'rose card with a black heart' attached to it and to put 'pink cards with a black flower' in the box with a 'yellow card with a black flower' attached to it.

Level 3B *Separated Colour*: The same cards and boxes were used, but now children had to sort cards according to colour. Level 4A *Integrated Colour*: Children were asked to sort by colour. The trial cards were 'white with a blue truck' and 'white with a red star'. Both target cards affixed to boxes were white, but one had a 'red truck' and the other had a 'blue star'.

Level 4B *Integrated Shape*: The same cards and boxes were used, but the child was asked to sort cards according to shape.

Level 5 *Mixed*: The cards used and boxes were the same as those used in the Level 4 Integrated test. The children were instructed that sometimes they were going to play the shape game and sometimes the colour game, depending on the experimenter's instructions, 'Play the shape game' versus 'Play the colour game'.

Level 6 *Advanced Border:* The target cards attached to the boxes were the same as those used in the Level 4 and 5, but there were four different types of test cards: 'white cards with a blue truck'; 'white cards with a blue truck and black borders'; 'white cards with a red star' and 'white cards with a red star and black borders'. Children were instructed to play the colour game if there was a border and to play the shape game if there was no border.

Level 6B *Reverse Border*: Children were instructed to reverse the rule, that is, to play the shape game if the card had a black border and play the colour game if the card had no border.

For each child, test administration differed as a function of participant's age. If children failed to complete a given number of trials in their starting level, levels with lower difficulty were administered following the test's manual directives (Carlson & Schaefer, 2012). Children's final scores were the sum of the total number of correct trials plus the total number of correct answers on the tests with lower levels of difficulty that were not administered (total score range: 0 – 70), Kuder-Richardson = .95.

Working memory. Working memory (cool executive function) was assessed using the *Backward Digit Span task* (BDS; Davis & Pratt, 1995). In the BDS, children were invited to verbally repeat, in reverse order, sequences of single-digit numbers. The sequences increased in length, starting with 2 numbers (e.g. 2–5). Following a practice trial with a 2-number-sequence, children were given two different trials for each test sequence. Testing stopped when children failed to respond on one of the trials of a given sequence. Span was taken to be the greatest length of the sequence in which the child responded correctly at both trials.

Analytic plan

The IBM SPSS 25 software was used for data analysis. We presented descriptive statistics for all study variables and their associations with sociodemographic variables (children's age and gender; mothers' age and level of education). This was done to determine if there was a gender effect on affective flexibility accuracy, and possible covariates of emotional regulation to include in the later regression analysis. Within our first main aim, to provide preliminary evidence for the construct validity of the EM-FIST, we tested for the positive emotion effect on AF performance by conducting a repeated measures ANOVA to verify if there were differences in terms of performance accuracy between the three emotional conditions of the EM-FIST (happy, angry and neutral). Next, we performed Pearson Correlations between affective flexibility and cool executive functions (cognitive flexibility, inhibitory control, and working memory) as positive associations are expected between hot and cool executive functions. Regarding the second and last aim of this investigation, to analyze if affective flexibility represented a better predictor of preschoolers' emotion regulation compared to cognitive flexibility, we firstly conducted Pearson correlations between emotion regulation and affective flexibility and cool executive functions. This procedure allowed us to determine which executive functions should be included in the following regression analysis. Finally, we conducted a hierarchical regression analysis with emotion regulation as the outcome. In the first step we included the covariates identified in the preliminary analysis (maternal education). In the second step, we included cognitive flexibility as no other cool EF emerged as significantly associated with emotion regulation. Since our hypothesis was that affective flexibility would be a better predictor of emotion regulation, we included it in the final step, after controlling for the effect of the other cool executive functions and covariates. We used the total score for affective flexibility (affective flexibility total) instead of the happy, sad and angry scores to avoid multicollinearity problems.

Results

Descriptive statistics for study variables and correlations with demographics

Descriptive statistics for study variables and their correlations with demographics are presented in Table 1. Children's age was positively correlated with all executive functions, but not with emotion regulation. Gender was not significantly associated with any of the study outcomes. Maternal education level was positively associated with only one executive function, working memory, and with children's emotion regulation skills. Having mothers with higher education levels was associated with children having better working memory capacity and better emotion regulation skills. The educational level of the fathers was positively associated with, except for the happy condition. Fathers' educational level was also positively associated with inhibitory control (behavioural and cognitive) and working memory, but not with cognitive flexibility.

Affective flexibility validity evidence: relations with cool executive functions

First, we conducted a repeated measures ANOVA to verify if there were differences in terms of performance accuracy between the three emotional conditions (happy, angry or neutral) within the EM-

Table 1. Descriptive statistics for study variables and correlations with sociodemographic variables.

	Descriptives						Correlation with sociodemographics					
								Education level[b]		Age[c]		
Affect. Flex.	*N*	*Min*	*Max*	*Range*	*M*	*SD*	Gender[a]	Mother	Father	Mother	Father	Child
Happy	56	12.00	24.00	12.00	19.46	3.74	.09	.24	.17	.18	.14	.35*
Neutral	56	12.00	24.00	12.00	18.84	3.63	.07	.20	.37*	.14	.12	.28*
Angry	56	12.00	23.00	11.00	18.86	3.05	−.03	.19	.33*	.15	.17	.33*
Total	56	36.00	70.00	34.00	57.16	9.49	.06	.25	.32*	.17	.16	.35*
Cool EF												
IC beh	56	0	40	40	20.14	15.02	−.03	.10	.27*	.17	.00	.54***
IC cog	55	0	16	16	12.80	4.36	−.06	.21	.42**	.09	.02	.53***
CF	56	23	66	43	49.00	9.27	.11	.20	.15	.23	.09	.49***
WM	56	1	3	2	1.45	.66	−.06	.27*	.28*	.00	−.02	.27*
Emotion Reg.	56	2.29	4.00	1.71	3.25	.43	−.15	.404**	.24	.16	.15	.24

[a]All correlations with gender are Point-biserial.
[b]All correlations with mother and father educational level are Spearman correlation.
[c]Mother/father age in years, child in days. Affect. Flex. = Affective Flexibility; Cool EF = Cool Executive Functions; IC beh = Behavioural Inhibitory Control; IC cog = Cognitive Inhibitory Control; CF = Cognitive Flexibility; WM = Working Memory; Emotion Reg. = Emotion Regulation.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table 2. Intercorrelations between affective flexibility, cool executive functions and emotion regulation.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Affective Flexibility									
1. Happy AF	_								
2. Neutral AF	.66***	_							
3. Angry AF	.72***	.86***	_						
4. Total AF	.88***	.92***	.94***	_					
Cool EF									
5. IC beh	.44**	.49***	.47***	.51***	_				
6. IC cog	.49***	.50***	.49***	.54***	.52***	_			
7. CF	.50***	.51***	.51***	.56***	.63***	.56***	_		
8. WM	.18	.27*	.28*	.27*	.56***	.39**	.45***	_	
9. Emotion Reg.	.46***	.40**	.44**	.47***	.21	.15	.26†	−.17	–

Note: AF = Affective Flexibility; Cool EF = Cool Executive Functions; IC beh = Behavioural Inhibitory Control; IC cog = Cognitive Inhibitory Control; CF = Cognitive Flexibility; WM = Working Memory; Emotion Reg. = Emotion Regulation.
†$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

FIST task. The analyses showed that there are no mean differences between the happy, neutral and angry emotional conditions in terms of accuracy performance (see Table 1 for descriptives), $F(1.58, 86.63) = 2.20$, $p > .05$ (Greenhouse-Geisser corrected).

Next, we looked at the association between affective flexibility accuracy and cool executive functioning measures. Affective flexibility total, and also the neutral and angry conditions of the affective flexibility task were positively related to all cool executive functions (see Table 2): cognitive flexibility, behavioural inhibitory control, cognitive inhibitory control, and working memory. Thus, children that were better able to shift between different non-emotional perspectives while processing neutral or angry faces also exhibited better cognitive flexibility, higher levels of cognitive and behavioural inhibitory control and better working memory capacity. Regarding the happy condition of the affective flexibility task, positive associations with the cool executive functions were also found, except for working memory. Hence, children that were better able to shift between different non-emotional perspectives while processing happy faces also exhibited higher levels of cognitive flexibility, higher levels of cognitive and behavioural inhibitory control.

Emotion regulation: disentangling links with affective flexibility and cognitive flexibility

As shown in Table 2, the emotion regulation score was positively associated with affective flexibility total and the happy, neutral and angry conditions of the affective flexibility task. None of the cool executive functions measures were associated with emotion regulation. Yet, a marginally significant association was found between emotion regulation and cognitive flexibility.

Predicting emotion regulation

In order to predict emotion regulation, we conducted a hierarchical regression analysis (Table 3). We controlled for maternal education in the first step, as we found a positive association between this sociodemographic variable and emotion regulation in our sample. As predictors, we included cognitive flexibility in the second step, as its correlation with emotion regulation approached significance. In the final step, we included the total score for affective flexibility (affective flexibility total) in order to avoid multicollinearity problems that would appear if we included the three affective flexibility emotional conditions separately.

As shown in Table 3, in step 1, maternal education level emerged as a significant predictor of emotion regulation. In step 2, maternal education level and cognitive flexibility were introduced, but only the first remained a significant predictor. In step 3, affective flexibility was introduced, and affective flexibility emerged as a significant predictor. The inclusion of this last variable resulted in a significant increase in R^2 from .18 to .26.

Table 3. Hierarchical regression analysis summary for maternal education level, cognitive flexibility and affective flexibility predicting emotion regulation ($N = 55$).

	R^2	(Adjusted R^2)	F change	B
Step I:	.14	(.13)	8.72*	
Maternal education level				.16*
Step II:	.18	(.15)	5.70*	
Maternal education level				.15*
Cognitive flexibility				.01
Step III:	.26	(.22)	5.93**	
Maternal education level				.13*
Cognitive flexibility				.00
Affective Flexibility total				.02*

*$p < .05$, **$p < .01$.

Discussion

The first goal of this study was to provide preliminary validity evidence for the preschool version of the EM-FIST. Our investigation generated evidence of construct validity for the EM-FIST as a measure of affective flexibility. Better accuracy on the neutral and angry conditions of this task was associated, as predicted, with better performance in all cool executive functioning tasks: cognitive flexibility, cognitive and behavioural inhibitory control, and working memory. Regarding the happy condition of the affective flexibility task the same relations emerged with the sole exception of working memory. Greater accuracy during the happy condition was not associated with better performance during the working memory task. Knowing that executive functions have a marked development during the preschool years (Zelazo & Carlson, 2012), complementary evidence of the validity of this measure comes from the positive association of performance with age: older preschoolers performed better on the EM-FIST compared to their younger counterparts. Also, this measure seems to be adequate for this age range (3–6-year-olds) as no ceiling effects were found.

Currently there are few available instruments to assess affective flexibility early on. The existing ones display limited psychometric support, consisting in documented relations with cognitive flexibility alone, and no other executive functions (Qu & Zelazo, 2007; Wong et al., 2008). Developmental research on cognitive control has primarily focused on cool executive function. Yet it has been increasingly recognized that children's effortful goal-directed behaviour takes place in a real-life environment which also includes emotional stimuli, and for that matter research must move forward by including hot executive functions (Carlson, Faja, & Beck, 2016; Welsh & Peterson, 2014). Our study contributes to this exciting research endeavour by demonstrating that this EM-FIST is a valid affective flexibility measure that may be used in future studies with preschoolers.

We also tested for a possible gender and positive emotion effect on affective flexibility and found no confirming evidence in our sample. The absence of gender effects contradicts previous findings with preschoolers (Visu-Petra et al., 2014) and with older children (Mărcuş et al., 2016; Mocan et al., 2014). However, Qu and Zelazo's (2007) and Wong et al. (2008) affective flexibility studies with preschoolers haven't reported any gender differences as well.

The absence of a facilitative effect of using positive stimuli is apparently at odds with past research using the EM-FIST (Wong et al., 2008) and EM-DCCS (Qu & Zelazo, 2007). Researchers have inferred that these positively laden stimuli induced a transient, mildly positive mood, which could have increased cognitive performance (Gruber, Devlin, & Moskowitz, 2014). On the other hand, however, a study in which positive emotion was induced in adults did not support this explanatory hypothesis, as no association between positive emotions and cognitive flexibility was found (Nath & Pradhan, 2014). There are also investigations that have not documented the positive emotion effect on affective flexibility in preschoolers (Visu-Petra et al., 2014). Therefore, our study adds to mixed findings in the literature. The precise conditions and explanatory hypothesis regarding this effect are still elusive.

Another surprising result was the nonsignificant association between the happy condition of the EM-FIST and working memory. It seems that although performance was not statistically significantly higher in the happy condition, some different mechanisms may be in place when children perform this condition. Specifically, working memory capacity may be less relevant for affective flexibility when positive stimuli are processed, in contrast with negative or neutral stimuli. This result may prove to be a path of inquiry for the clarification of the processes associated with the positive emotion effect. Due to the limited number of studies on affective flexibility in preschoolers we cannot advance any additional explanations. We can, however, question if the positive emotion effect would be visible in a larger sample, as performance accuracy on the happy condition of the EM-FIST tended to be higher, compared with the angry and neutral ones, although not statistically significant. In fact, by conducting a power analysis with our study design, results suggest that the sample size is adequate for detecting a large-medium effect size, as in the case of the final regression model, but it is not for a medium or low effect size. Therefore, the sample size may be one of the limitations of the present study, and future research should address this limitation by focusing on affective flexibility and cognitive flexibility in larger samples of preschoolers.

To our knowledge, this is the first study that set out to clarify the relation between hot and cool expressions of flexibility and emotion regulation. This was the second aim of this investigation. We specifically hypothesized that affective flexibility represents a better predictor of preschoolers' emotion regulation compared to cognitive flexibility, while also controlling for the effect of other core cool executive functions (cognitive and behavioural inhibitory control, and working memory). Our results supported this hypothesis.

We theorized that affective flexibility would be particularly relevant for preschoolers' ability to regulate emotions, as better affective flexibility would also make them more capable of attending and disengaging attention from emotional stimuli (Genet & Siemer, 2011) in emotionally laden situations. In fact, affective flexibility may be a fundamental constituent of emotion regulation strategies included in the broader construct of attentional deployment. Attentional deployment is a family of emotion regulation strategies that are characterized by directing attention within a given situation in order to influence one's emotions and is one of the first regulatory strategies to emerge during human development (Gross, 2014). Moreover, it continues to be one of the most relevant strategies used throughout development when modifying or escaping from an emotionally charged situation is not a viable option. Our results point to the crucial role of affective flexibility for emotion regulation from an early age.

Taking a brother approach to our results, they may also support that hot executive functions may constitute better assessments of control processes that are indeed recruited for emotion regulation as they approximate real-world settings, by including emotional and motivational components (Welsh & Peterson, 2014). Developmental psychopathology research seems to support this stronger link. Researchers have found that hot executive functioning tasks are more sensitive in distinguishing 7 and 12 year-olds with disruptive behaviour problems from typically developing children than cool executive functions (Woltering, Lishak, Hodgson, Granic, & Zelazo, 2016). This is important for the present discussion because emotion regulation difficulties have been previously associated with externalizing and internalizing disorders (Aldao, Gee, De Los Reyes, & Seager, 2016).

The crucial role played by affective flexibility in comparison with other hot executive functions was not directly addressed by the current design and represents a future direction to be pursued. Hot inhibitory control will most certainly be recruited when redirecting ones' attention away from an emotionally arousing prepotent stimulus. Taken into consideration that the different hot executive functions may have distinct impacts on emotional regulation as performance on various hot executive functioning tasks can differ significantly (O'Toole et al., 2017), future studies should include other hot executive functions so that the specific role of affective flexibility can be analysed. Also, developmental studies should be pursued so that directionality between hot executive functions and emotion regulation can also be determined. Our study's framework is based on the assumption that affective flexibility will be recruited when emotion regulation takes place in preschoolers.

However, we acknowledge that the association between constructs may be due to their shared common neural substrates, with no causality involved. Another possibility is that regulating emotions may foster the development of affective flexibility, so that emotion regulation is indeed causing affective flexibility to develop. Another possibility is that there may be bidirectionality between executive functions and emotion regulation (Cunningham & Zelazo, 2010). Since our study was cross-sectional it doesn't offer support for any of these explanations.

Finally, we also found that having mothers with higher education levels was associated with children having better emotion regulation skills. This result adds to previous research showing an association between maternal higher education levels and preschoolers' better physical development, academic skills (e.g. literacy-numeracy), cognitive (e.g. language), and socioemotional outcomes (Jeong, Kim, & Subramanian, 2018). Maternal higher education may be related with these diverse child outcomes through superior investment in parenting and by providing mothers with resources to meet the changing developmental needs of their children (Prickett & Augustine, 2016). This may well be the mechanism behind the link between maternal educational level and better child emotion regulation, as previous research has documented the importance of the mother-child relations for the development of emotion regulation skills (Martins, Soares, Martins, Tereno, & Osório, 2012; Morris, Criss, Silk, & Houltberg, 2017).

Conclusion

This investigation provided construct validity evidence for an affective flexibility task: the EM-FIST. This is relevant because there are few instruments available for measuring this construct in preschoolers, and their psychometric properties are understudied. This is a problem because hot executive functions are increasingly recognized as fundamental measures of cognitive control, as having motivational and emotional dimensions that better approximate real-life behaviours (Welsh & Peterson, 2014).

We may also hypothesize that affective flexibility taps into different executive mechanisms as it predicted preschooler' emotion regulation, while the others cool measures did not. We contributed to fill a gap in the literature by showing that when analysing affective flexibility and cognitive flexibility simultaneously, only affective flexibility emerges as a predictor of emotion regulation in prescholers.

Our findings may have important implications for both fundamental and applied research. We provided evidence of the link between affective flexibility and emotion regulation during an early stage in development which may help refine existing theories and inform interventions that aim to improve children's emotion regulation skills via developing effective affective flexibility training programs.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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