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On the importance of being flexible: early interrelations between affective flexibility, executive functions and anxiety symptoms in preschoolers

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ABSTRACT

When children are confronted with an emotional problem, affective flexibility mobilizes their cognitive and emotional resources to optimally address it. We investigated the contribution of executive functions to cognitive and affective flexibility in preschoolers. We assessed affective flexibility in 67 preschoolers (30 girls; $M_{months} = 61.77$, $SD = 11.08$ months) using an innovative measure – the Emotional Flexible Item Selection Task (EM-FIST), plus cool measures of executive functions (working memory, inhibition and cognitive flexibility), anxiety symptoms and intelligence. Findings revealed that affective flexibility improves during the preschool years. While individual differences in age and proactive inhibition predicted cognitive flexibility, a different constellation of predictors (maternal education, proactive inhibition, working memory and age) were significant for affective flexibility. Cognitive flexibility didn't contribute to affective flexibility beyond the predictors mentioned above. Anxiety exerted a negative effect on affective flexibility in a high anxious subgroup of preschoolers, but only when processing negative, relative to happy faces, supporting the Attentional Control Theory which predicts valence-related executive impairments.

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Introduction

From a young age, in order to successfully navigate in an emotionally charged environment, children make use of *affective flexibility* – the ability to transition between alternative ways of processing emotional information (Genet & Siemer, 2011). Through the use of this ability, children cope with socially distressing contexts by swiftly switching their attention between processing the affective and the non-affective aspects of distressing emotional stimuli. For example, in kindergarten, after receiving a negative feedback, a child can switch his/her attention away from processing the negative content to finding ways in which he/she could further improve based upon the feedback received, or simply engage in an entertaining game as a distraction. In the present paper, we conceptualize affective flexibility as being part of the hot executive functions framework. Executive functions refer to a set of cognitive processes considered paramount for goal-directed thought, action and emotion (Best & Miller, 2010; Diamond & Lee, 2011; Miyake et al., 2000). According to the Miyake et al. (2000) seminal framework, the core executive functions are cognitive flexibility, inhibition,

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and working memory. Initially, executive functions have been studied 'through a purely cognitive lens' (Poon, 2018), so the role played by emotions and motivation wasn't properly addressed. Later on, a valuable distinction has been proposed between hot and cool executive functions (for a review see Zelazo & Carlson, 2012), which acknowledges that executive functions may operate differently across contexts. Cool executive functions rely on top-down processing elicited in non-emotional contexts, while hot executive functions are best captured by looking at top-down control processes in motivationally and emotionally significant contexts (Qu & Zelazo, 2007; Peterson & Welsh, 2014). This differentiation was partially based upon evidence suggesting that cool executive functions are associated with the lateral prefrontal cortex, while hot executive functions are associated with the orbitofrontal cortex and other medial regions (Happaney, Zelazo, & Stuss, 2004), although in the context of everyday situations the two dynamically interact. Currently, we still lack strong evidence for the distinction of cool and hot executive functions across development. There is growing consensus in the literature that cool and hot executive functions are more unidimensional in early childhood and they evolve into distinct functions with development (Poon, 2018; Peterson & Welsh, 2014; Zelazo & Carlson, 2012), however their early differentiation is not fully elucidated.

Across studies, affective flexibility has been measured using tasks in which emotion is task relevant (i.e. children have to judge the emotional expression of the faces) or tasks in which emotion is task irrelevant (i.e. children are not required to judge the emotional expression of the faces, but instead they have to judge other non-emotional features such as gender). The latter type is very relevant for ecological settings in which children are rarely explicitly asked to detect the emotion conveyed by a face or a voice, their task being to focus on the message. In such contexts, the emotion that is displayed inevitably affects the way in which children receive and react to the message/image. An exciting task for capturing affective flexibility is the Emotional Flexible Item Selection Task (EM-FIST), designed to include emotional faces as task relevant or task irrelevant stimuli (Mărcuş, Stanciu, MacLeod, Liebregts, & Visu-Petra, 2016; based on Wong, Jacques, & Zelazo, 2008). The version that we employed with preschoolers is the simplified 3-item EM-FIST version (where emotion is task irrelevant). Children are first presented with three faces that share the same emotion (happy, angry or neutral) and required to select a pair of faces that 'go together in one way' (e.g. same size), and then to select a second pair of faces 'that go together, but in another way' (e.g. same gender). Thus they engage in problem-solving strategies (Yerys, Wolff, Moody, Pennington, & Hepburn, 2012) which allow them to conceptualize an emotional stimulus in two different ways – during the first selection involving a given stimulus feature (e.g. size) and during the second selection involving a different stimulus feature (e.g. gender). Hence, preschoolers have to infer the features on which the two selected pairs match (and thus view an emotional stimulus in two different ways) and then flexibly switch between these representations in order to successfully solve the task. The task measures children's flexibility when they are not provided with all the necessary information to solve a challenging task and they need to generate the matching criteria between elements and alternate between them. In real life scenarios, the requirement to transition swiftly between different ways of processing emotional information is extremely important for our successful social interactions. A prior study provided preliminary validation evidence for the use of this affective flexibility task in preschoolers (Martins, Mărcuș, Leal, & Visu-Petra, 2018) and its predictive value for children's emotion regulation skills.

Even though affective flexibility plays an important role in emotion regulation and long term adjustment (Bonanno, Papa, Lalande, Westphal, & Coifman, 2004; Martins et al., 2018; Wilson, Derryberry, & Kroeker, 2006), or in academic achievement (Wilson et al., 2006), we still lack a deeper understanding of the way in which this ability develops early on and of its relation to other individual differences factors such as anxiety. Regarding age-related differences in affective flexibility, preliminary work conducted with older children indicates that affective flexibility significantly improves during middle school (Mocan, Stanciu, & Visu-Petra, 2014) and preadolescence (Mărcuş et al., 2016), but to our knowledge, no study has yet looked at the way in which this ability develops during the preschool years. The present study aims to address this gap by studying whether affective flexibility undergoes significant improvements during this sensitive developmental window.

When looking at developmental precursors of *cognitive flexibility*, a growing body of research provided support for the presence of two basic underlying mechanisms: inhibition and working memory. Inhibition is a crucial building block for successful cognitive flexibility, because it allows children to overcome the tendency to respond based on the previous rule when receiving feedback that their response is no longer correct (Diamond, 2013). Working memory is also considered vital for successful cognitive flexibility, and the development of working memory explains the gains observed in cognitive flexibility performance (Blackwell, Cepeda, & Munakata, 2009; Marcovitch & Zelazo, 2009; Zelazo et al., 2003). An ingenious study investigated whether inhibition and working memory predicted cognitive flexibility in preschoolers (Chevalier et al., 2012). Results indicated that working memory and inhibition were important predictors for the goal-representation component of cognitive flexibility (i.e. to monitor for the necessity to switch and to select the relevant task rule), while no relation was found between working memory, inhibition and the switch implementation component of cognitive flexibility (i.e. actual switch to the newly relevant task-rule when needed). These findings were replicated in an older sample of 5–14 year-old children, showing that inhibition and working memory processes explained variance in cognitive flexibility in general and its underlying goal representation component in particular (Brocki & Tilman, 2014). Further support comes from a study that showed a relation between working memory and inhibition and aspects of cognitive flexibility in preschoolers (2-4 years old). Findings indicated that cognitive flexibility, in the presence of distraction, developed intensively between 2 and 3 years, and was associated with superior inhibitory control. Furthermore, cognitive flexibility in the presence of conflict improved rapidly between the ages of 3-3.5 years, and was associated with better working memory performance (Blakey, Visser, & Carroll, 2016). A more recent study looked at the contribution of both inhibition and working memory to two different types of cognitive flexibility: reactive flexibility (i.e. the ability to change behaviours when the external demands change) and spontaneous flexibility (i.e. the ability to generate various ideas and novel responses). The results showed that inhibition and working memory contributed to spontaneous flexibility, whereas only inhibition contributed to reactive flexibility (Arán Filippetti & Krumm, 2020). Departing from this literature, we wanted to address the potential distinction between cognitive and affective flexibility in preschoolers by identifying their underlying mechanisms. Although the existing literature pinpoints to the central role played by inhibition and working memory as underlying processes in the case of cognitive flexibility, the degree to which the same relation holds true when children process emotional content is still unclear. The current study was designed to address this issue and explore the contribution of cool aspects of inhibition and working memory to affective flexibility and cognitive flexibility, respectively, during the preschool years. Nevertheless, we also wanted to see if cognitive flexibility contributes to affective flexibility beyond inhibition and working memory processes.

An individual differences factor that is consistently related to affective flexibility across the lifespan is *anxiety*. It is considered that individuals experiencing emotional difficulties are characterised by a rigid pattern of information processing and by a reduced and stereotyped repertory of behavioural responses (Kashdan & Rottenberg, 2010). Theories including the Attentional Control Theory (Eysenck, Derakshan, Santos, & Calvo, 2007; see also Berggren & Derakshan, 2013; Derakshan & Eysenck, 2009; Eysenck & Derakshan, 2011) point to the fact that higher levels of anxiety disrupt attentional control by reducing the cognitive resources available to the task at hand, due to the detrimental effect of worrisome thoughts. Conversely, affective inflexibility has also been seen as a potential cause or maintaining factor in emotional disorders, especially anxiety (Coifman & Summers, 2019). The relation between anxiety and hot aspects of flexibility during early development remains largely underinvestigated (Mărcuș & Visu-Petra, 2019). In the case of older children, two studies offer preliminary support for the hindering effect of anxiety upon affective flexibility performance. Mocan et al. (2014) showed that higher levels of internalizing symptoms (anxiety and depression) had a detrimental specific effect on affective flexibility that was only present when school age children (7-11 years old) had to repeat an emotional judgement (e.g. judging the emotional valence of a given face) and when trial by trial feedback was provided. Given that attention was allocated to the emotional stimuli, this resulted in a lower performance on pairs of emotional trials that explicitly require the repeated employment of the emotional rule, which involved switching attention between different emotional valences. Also, Mărcuş et al. (2016) investigated the impact of anxiety upon cognitive and affective flexibility performance using the Flexible Item Selection Task and its emotional version (EM-FIST) in preadolescents (ages 11-14). Findings showed that anxiety was negatively related to affective flexibility, and not to cognitive flexibility performance. Intriguingly, this effect was specific as it was only found during trials when participants had to alternate between two different perspectives of the same emotional object (flexible trials) and not when participants had to alternate between two perspectives of two different emotional objects. This is in line with a recent study showing that adolescents with high levels of mental health problems were characterized by very poor affective control performance on an affective sorting task (Schweizer, Parker, Leung, Griffin, & Blakemore, 2020) which required them to sort cards depicting emotional faces according to continuously changing rules (colour, number, or item type). We wanted to shed more light into this research topic by extending this anxiety-related finding to a much younger sample and explore if these anxiety-related effects vary as a function of the emotion being processed (happy, angry or neutral).

Current study

Our first aim was to address a *developmental question* regarding age-related differences in affective flexibility during the preschool years. We expected to find age-related improvements in affective flexibility performance in preschoolers, which would suggest that during this time frame this ability undergoes developmental progress. Previous studies have only reported age-related changes in affective flexibility performance for older children (Mărcuş et al., 2016; Mocan et al., 2014b) and we wanted to extend this findings to a younger sample of preschoolers.

Our second aim was to explore the potential distinction between cognitive and affective flexibility in preschoolers. In order to deepen our understanding of the mechanisms involved in affective flexibility, we wanted to investigate if *executive functions* (inhibition, working memory and cognitive flexibility) have independent (and potentially distinct) contributions to affective flexibility. Also, we wanted to investigate if *executive functions* (inhibition and working memory) have independent (and potentially distinct) contributions to cognitive flexibility. No study, to our knowledge, has investigated whether inhibition, working memory and cognitive flexibility predicted affective flexibility performance during early development. Based on previous studies focusing on cool aspects of executive functions which revealed a contribution of both inhibition and working memory to cognitive flexibility (Arán Filippetti & Krumm, 2020; Blakey et al., 2016; Brocki & Tilman, 2014; Chevalier et al., 2012), we hypothesized that inhibition and working memory processes will significantly predict cognitive flexibility. In terms of inhibition, working memory and cognitive flexibility predicting affective flexibility, our investigation was mainly exploratory.

Lastly, the present study sought to investigate the role of *individual differences in anxiety* on affective flexibility in preschoolers. Following the predictions advanced by the Attentional Control Theory (Eysenck et al., 2007; see also Berggren & Derakshan, 2013; Derakshan & Eysenck, 2009; Eysenck & Derakshan, 2011) we aimed to investigate if higher levels of anxiety are negatively associated with affective flexibility performance and if this effect differs as a function of the emotion being processed. The design employed in this study allowed us to disentangle the impact of each emotional valence (which was task-irrelevant) upon affective flexibility performance as a function of anxiety. We hypothesized that children with high levels of anxiety will exhibit a hindered affective flexibility performance especially when processing threatening (angry) stimuli, and not when processing neutral or happy stimuli.

Materials and methods

Participants

The study initially included 71 preschoolers (30 girls) aged between 3 and 6 years ($M_{months} = 61.29$, $SD = 11.03$ months) recruited from two local kindergartens in North-West Romania. Written informed consent was obtained from parents and verbal assent from children before testing. All children had Romanian as their first language and came from similar socioeconomic backgrounds (i.e. urban area). All children included in this study were healthy, as parents didn't report the presence of any major health problems (e.g. chronic disease or other health-related problems). In terms of maternal education levels, 19.4% of the mothers had a master or a PhD degree, 46.3 had a university degree, 28.3% had a high school diploma, and another 6% did not graduate from high school. When looking at paternal education levels, 21.2% of the fathers had a master degree or a PhD degree, 25.8 had a university degree, 33.3% had received a high school diploma and 19.7% did not graduate from high school. During the testing sessions, we excluded four children out of 71 because they dropped out of the study before all the measures were delivered, thus completing only 20% of the executive functioning tasks. As a result, our final sample consisted of 67 preschoolers (30 girls; $M_{months} = 61.77$, $SD = 11.08$ months).

Procedure

Parents who agreed for their child to participate in this study completed the anxiety questionnaire and provided written consent to allow their children to take part in this research. Preschoolers were then individually administered the battery of executive tasks designed to measure intelligence, affective flexibility, cognitive flexibility, inhibition, and working memory by a trained examiner in a quiet room in the kindergarten. The battery of tasks was administered in a fixed order during three different days and each testing session lasted approximately 20–25 minutes. During the first session, children were delivered the intelligence test. During the second session, children first completed the working memory task, followed by the EM-FIST. Lastly, during the last session, children completed the FIST, followed by the cognitive flexibility (DCCS) task, the Borders DCCS task and then the inhibition (Whack-the-mole) task. During the second and the third session, short breaks were introduced between tasks to preserve children's cooperation and interest. To assess the test–retest reliability of the newly developed 3-item EM-FIST, a subsample of children ($N = 41$) were administered the affective flexibility task and its non-emotional version (FIST) on two different occasions, across a one month interval.

Measures

The Spence Children's Anxiety Scale (Spence, Rapee, McDonald, & Ingram, 2001; Benga, Ţincaş, & Visu-Petra, 2010) was used as a measure of trait anxiety. This scale assesses children's symptoms of separation anxiety, social phobia, obsessive-compulsive disorder, generalized anxiety and fear of physical injury. Parents report on a four-point scale (1 = never; 2 = sometimes; 3 = often; 4 = always), the frequency with which their children experienced various anxiety symptoms. The Romanian version of this scale (Benga, Ţincaş, & Visu-Petra, 2010) has good internal consistency (Cronbach's alpha = .87 for mother reports). In the present study this scale had good internal consistency (Cronbach's alpha = .83).

The Colored Raven Progressive Matrices test (Dobrean, Rusu, Comsa, & Balazsi, 2005; Raven, 1986) was used as a measure of general intelligence developed for 4–11-year-old children. Children were presented with three series (A, Ab and B) and each series included 12 coloured matrices. Each matrix displays a figure or a succession of abstract figures that have a missing part. Children are required to find the missing part by analyzing a set of available options. The difficulty of the task increases gradually, with the highest raw score possible being 36.

The Dimensional Change Card Sort task and the Borders DCCS (DCCS; Zelazo, 2006) is a measure of cognitive flexibility performance in young children. During the DCCS task, participants were required to sort cards according to a colour rule or a shape rule. Hence, children were provided with cards depicting a rabbit or a boat of different colours (red or blue) and they were required to put them in one of the two boxes according to one of the two rules. The testing procedure included: (1) the pre-switch phase, (2) the post-switch phase, and (3) the borders phase (measuring the ability to switch between two rules on a trial by trial manner). In this study, we employed the standard DCCS task followed by the DCCS borders and we computed a total accuracy score for these two measures separately (the maximum value that could be obtained was 12 for each task). For a more detailed task description please see Zelazo (2006).

The 3-item Flexible Item Selection Task (FIST, Jacques & Zelazo, 2001) was used as a measure of cognitive flexibility performance (see Figure 1). During this task participants were required to shift between two different ways of sorting an item, in a trial-by-trial manner. On each trial participants were presented with three cards and were first told to select a pair of cards that "go together in one way" (first selection). Then participants were required to select another pair of cards that "go together, but in a different way" (second selection). In a trial-by-trial manner, participants were presented with three coloured cards that varied as a function of shape (a kettle, a boat and a shoe), size (big, medium and small) and colour (red, blue and yellow). The 3-item FIST task was comprised of two demonstration trials, two practice trials and 15 test trials. The total score was computed by taking into account the correct number of first selections and also the total number of second selections. Children received 1 point for each correct selection. As a result, the maximum score that could be obtained on this task, by summing up the correct answers provided on first selections and second selections, was 30. In our sample, the cognitive flexibility task indicated an adequate test-retest reliability over a one month period ($r = .56$).

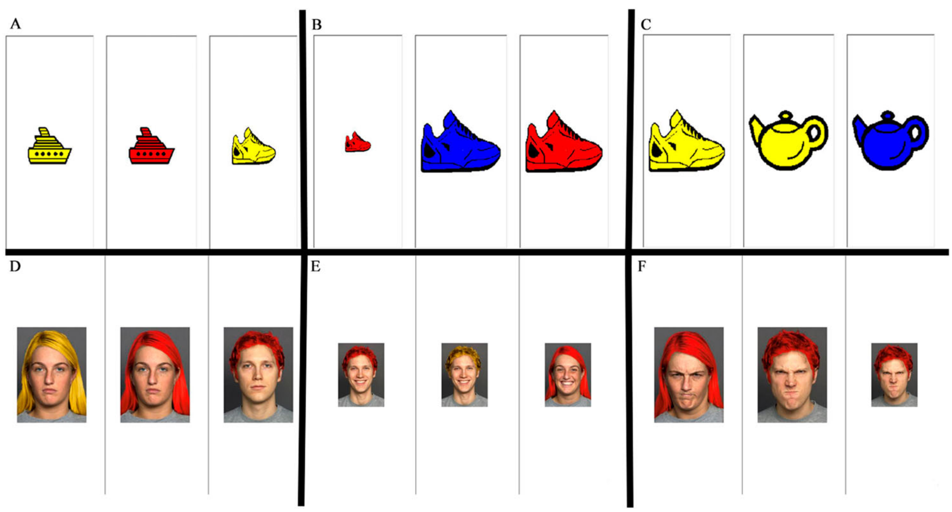

Figure 1. A depiction of the 3-item Flexible Item Selection Task (FIST) and a depiction of the 3-item Emotional Flexible Item Selection Task (EM-FIST): A – Participants had to select the first two items (shape) and the first and third item (colour). B – Participants had to select the first and the third image (colour), and then select the second and the third image (size). C – Participants had to select the first and the second image (colour) and then select the second and the third image (shape). D - Neutral condition: children had to select the first two items (identity) and the second and the third item (hair colour); E – Happy condition: children had to select the first two items (identity) and the second and the third item (hair colour); F – Angry condition: children had to select the first two items (size) and the second and the third item (identity). Note. Although named according to emotional valence of the stimuli, for the three emotional conditions the emotional dimension was not task relevant. Instead, across all conditions, children were simply instructed to select two cards that "go together in one way" (selection one) and then to select two cards that "go together, but in another way".

The 3-item Emotional Flexible Item Selection Task (3-item EM-FIST, adapted after Mărcuş et al., 2016; but see also Martins et al., 2018 for a recent study using this task) was used to measure children's affective flexibility performance (see Figure 1) namely their ability to alternate between two different ways of processing emotional information. On any given trial, three emotionally congruent faces (happy, angry or neutral) were presented and participants were asked to select two cards that "go together in one way" (selection one) and then to select two cards that "go together, but in another way" (selection two). Hence, on each trial, children were required to view one emotional stimulus in two different ways and to successfully alternate between these two ways of processing this emotional information. Each trial presented cards depicting different faces that varied as a function of three non-emotional dimensions: gender (male or female), hair colour (blonde or red) and stimulus size (small and large). Three emotional conditions of this task were created: a neutral face condition, a happy face condition and an angry face condition. The only difference between these conditions was the emotion presented in each trial (happy, angry or neutral), which was task-irrelevant as children were not required to judge the emotional expression of the faces. The experimenter provided children with 2 demonstration trials followed by 4 practice trials. Following this, the three emotional task conditions included 12 trials each and were delivered in a counterbalanced order. For a more detailed description of the scoring procedure please see Martins et al. (2018). In our sample, the affective flexibility measure proved to have relatively good test-retest reliability over a one month period ($r = .58$).

The Listening Recall Task was used to measure verbal working memory (Alloway, Gathercole, Willis, & Adams, 2004) and was designed as a "complex span" task. The task started with the first block which contains six lists with one sentence each. At first, the child was presented with one list consisting of one sentence presented at a time (e.g. "*Humans have two eyes*" or "*Bicycles eat grass*") and was asked to indicate whether the sentence was true or false by responding with „*yes*" or „*no*". Next, the child was asked to recall the last word of that sentence (e.g. „*eyes*"). Afterwards, for each block that contained lists with two or more sentences, the child had to mention for each sentence, whether it was true or false, and then had to recall the last word of each sentence in the same order as it was presented. The total score for this task consisted in the summed scores obtained for each block. For children aged between 4.5 and 11.5 years, the reported test-retest reliability was .81 for the Listening Recall task (Alloway, Gathercole, & Pickering, 2006).

The Wack-a-mole Task (Casey et al., 1997; Shapiro, Wong, & Simon, 2013) is a child version of a Go/NoGo response inhibition task. Children were required to press the blue button (i.e. the space bar) as quickly as possible when a mole cartoon appeared onscreen (Go trial) and to avoid pressing that same button when a vegetable cartoon appeared onscreen (NoGo trial). We modified the task to be age-appropriate and thus the stimuli were presented for a longer period of time (2000 ms) with an inter-stimulus interval of 5 milliseconds. Participants completed 20 trials of each NoGo trial type (preceded by one, three, or five Go trials, respectively) in a random sequence. The NoGo trials were randomized and presented for an equal number of times across four blocks. In order to prevent participants from learning the response pattern the task also contained 12 filler trials. The filler trials were NoGo trials preceded by two or four Go trials. These filler trials were not taken into account in the final analysis. In the analysis only NoGo trials and Go trials were included. This task allowed us to investigate two types of inhibition: proactive and reactive inhibition. *Proactive inhibition* is defined as the preparation needed before a future inhibitory response. It is measured as accuracy for five different types of Go trials (the first, second, third, fourth and fifth Go trial following a NoGo trial). We summed across these five trials types to obtain a total score for proactive inhibition. We also assessed *reactive inhibition*, defined as the ability to perform an inhibitory response when signaled by a visual cue (the presentation of the mole). The task measured response accuracy for three different types of NoGo trials (following one, three or five Go trials). We summed across these three trial types to obtain a total score for reactive inhibition. This experiment was displayed using the E-Prime 2.0. Software and the stimuli were courtesy of Sarah Getz and the Sackler Institute for Developmental Psychobiology.

Table 1. Summary of descriptive statistics and correlations with sociodemographic information for study Variables.

	Descriptives					Correlations			
	N	*Range*	*Min*	*Max*	*M [SD]*	Gender	Age	Maternal education	Paternal education
Affective flexibility									
EM-FIST Happy	67	11.00	13.00	24.00	22.29 [2.36]	.15	.49**	.39**	.28*
EM-FIST Neutral	67	9.00	15.00	24.00	22.34 [2.36]	.22	.46**	.46**	.27*
EM-FIST Angry	67	8.00	16.00	24.00	22.10 [2.27]	.29*	.49**	.38**	.25*
EM-FIST Total	67	27.00	45.00	72.00	66.74 [6.22]	.24*	.52**	.44**	.29*
Inhibition task									
Proactive inhibition	63	101.00	64.00	165.00	149.92 [22.66]	.11	.84**	.35**	.43**
Reactive inhibition	63	30.00	15.00	45.00	35.44 [6.88]	.28*	.47**	.37**	.26*
Cognitive flexibility									
FIST Total	67	10.00	20.00	30.00	27.80 [2.93]	.22	.77**	.37**	.43**
DCCS	66	3.00	9.00	12.00	11.89 [.43]	.15	.26	.17	.22
DCCS Borders	66	12.00	.00	12.00	7.48 [2.95]	.30*	.29*	.15	.15
Working memory	67	18.00	1.00	19.00	8.61 [4.67]	.34**	.69**	.20	.35**
Anxiety Total	67	57.00	2.00	59.00	22.86 [12.07]	−.04	−.07	.05	−.16
Intelligence: Raven	67	27.00	9.00	36.00	22.77 [7.51]	.14	.73**	.37**	.51**

Note: *$p < .05$. **$p < .01$.

Results

Preliminary analyses

First, missing responses on the Spence anxiety scale (< 1%) were replaced with the corresponding participant's mean total score for all the scale's items. 62 children completed all the measures, given that five participants failed to complete the entire Wack-a-mole task, and also one of the participants from this subgroup did not complete the Dimensional Change Card Sort task and the DCCS Borders task.

Table 1 summarizes means and standard deviations for all variables included in this study and their correlations with demographics. Maternal education levels were positively associated with affective flexibility, cognitive flexibility (using the FIST), proactive and reactive inhibition and with intelligence. Paternal education levels were also positively associated the same variables as maternal education and in addition were associated with working memory. Hence, taken together, these preliminary results indicated that high levels of parental education are associated with high levels of both hot and cool executive functions and with intelligence in preschoolers.

We conducted a correlation analysis to explore the associations between affective flexibility and several cool executive functions and intelligence (see Table 2). Significant associations emerged between the affective flexibility total and cognitive flexibility (using the FIST), proactive and reactive inhibition, working memory and intelligence. We also found that all EM-FIST emotional conditions were positively related with cognitive flexibility (using the FIST), proactive and reactive inhibition, working memory and intelligence. However, affective flexibility was not positively correlated with cognitive flexibility as measured with the DCCS and the DCCS Borders tasks.

Age-related differences in affective flexibility

Firstly, we examined *age*-related differences in affective flexibility performance within and across emotional conditions of the EM-FIST. We conducted a repeated measures ANCOVA analysis in which we included the neutral, happy and angry conditions of the EM-FIST as a within factor variable while gender was included as a between factor variable and age as a covariate. The analyses showed that there were no mean differences between the happy, neutral and angry emotional conditions in terms of accuracy performance Wilks' Lambda = .97, $F(2, 63) = .78$, $p = .46$. We didn't find any gender differences in the three emotional conditions in terms of accuracy performance when controlling for

Table 2. Correlations between Affective Flexibility, Cool Executive Functions and Intelligence.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Affective flexibility task												
1. EM-FIST Happy	-											
2. EM-FIST Neutral	.80**	-										
3. EM-FIST Angry	.77**	.78**	-									
4. EM-FIST Total	.93**	.92**	.92**	-								
Cool EF tasks												
5. FIST Total	.52**	.53**	.51**	.56**	-							
6. DCCS	.09	.10	.09	.10	.21	-						
7. Borders DCCS	.15	.21	.21	.20	.29*	.55**	-					
8. Proactive Inhibition	.54**	.62**	.48**	.59**	.76**	.10	.26*	-				
9. Reactive Inhibition	.32**	.42**	.31*	.37**	.46**	.31*	.32**	.49**	-			
10. Working memory	.47**	.49**	.45**	.51**	.58**	.20	.31*	.60**	.46**	-		
11. Intelligence	.50**	.46**	.43**	.50**	.66**	.26*	.43**	.64**	.49**	.68**	-	
12. Total Anxiety	.12	.04	−.11	.02	.02	−.02	.07	.07	.07	−.17	−06	-

Note. Cool EF = Cool Executive Functions; *p* < .05. ***p* < .01.

age Wilks' Lambda = .96, $F(2, 63) = 1.30$, $p = .27$, nor a main effect of gender $F(1, 64) = 1.85$, $p = .17$. However, there was a significant main effect of age $F(1, 64) = 21.32$, $p < .001$, but no significant differences were found between the three emotional conditions as a function of age Wilks' Lambda = .97, $F(2, 63) = .69$, $p = .50$. Therefore, with age, children become more and more flexible in the way in which they process emotional stimuli in general, regardless of the type of emotion being processed.

The contribution of cool EF to cognitive and affective flexibility

We wanted to first explore if children find it more demanding to alternate their attention while processing non-emotional stimuli compared to emotional stimuli. To verify this preliminary hypothesis, we performed a paired sample *t* test in which we compared the EM-FIST percentage accuracy with the FIST percentage accuracy and we found that there were no differences in terms of task difficulty $t(66) = -.016$, $p > .05$. Next, we performed hierarchical multiple regressions to investigate if cognitive and affective flexibility differ in terms of the role played by cool executive functions (proactive and reactive inhibition, working memory), after controlling for age and maternal education. In the case of affective flexibility we also added cognitive flexibility in the regression model to see if it contributes to affective flexibility beyond inhibition and working memory processes. The correlations among the predictor variables (age, proactive and reactive inhibition, working memory) were first examined and presented in Tables 1 and 2.

To predict cognitive flexibility and affective flexibility performance, we conducted two hierarchical multiple regressions. For cognitive flexibility, we conducted a three-stage hierarchical multiple regression in which we added age and maternal education at Step 1, proactive and reactive inhibition were entered at Step 2, while working memory was added in Step 3. To predict affective flexibility, we conducted a four-stage hierarchical multiple regression in which we added age and maternal education at Step 1, proactive and reactive inhibition were entered at Step 2, working memory was

Table 3. Hierarchical multiple regression predicting cognitive and affective flexibility.

		Outcome					
		Cognitive flexibility (*N* = 63)			Affective flexibility (*N* = 63)		
	Step	B	SE	*B*	B	SE	*β*
Step 1	Constant	15.31	1.47		46.18	4.16	
	Age	.19	.02	.73***	.20	.06	.36**
	Maternal education	.09	.17	.05	1.2	.49	.28*
	R^2 (ΔF)	.58 (41.52***)			.30 (13.11***)		
Step 2	Constant	12.96	1.62		38.92	4.48	
	Age	.09	.04	.37*	−.09	.11	−.17
	Maternal education	.07	.17	.03	1.16	.47	.27*
	Proactive inhibition	.04	.01	.39*	.16	.05	.61**
	Reactive inhibition	.02	.39	.07	.04	.10	.05
	R^2 (ΔF)	.63 (4.26*)			.42 (5.78**)		
Step 3	Constant	13.24	1.78		43.34	4.7	
	Age	.09	.04	.35*	−.21	.11	−.37
	Maternal education	.08	.17	.04	1.39	.46	.33**
	Proactive inhibition	.04	.01	.39*	.16	.05	.60**
	Reactive inhibition	.02	.04	.06	−.01	.10	−.01
	Working memory	.02	.06	.04	.42	.18	.32*
	R^2 (ΔF)	.63 (.14)			.47 (5.48*)		
Step 4	Constant				38.56	6.60	
	Age				−.24	.12	−.42*
	Maternal education				1.36	.46	.32**
	Proactive inhibition				.14	.05	.53**
	Reactive inhibition				−.02	.10	−.02
	Working memory				.41	.18	.31*
	Cognitive flexibility				.36	.35	.16
	R^2 (ΔF)			.48 (1.06)			

Note: $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$.

added in Step 3 and cognitive flexibility was added in Step 4 (for coefficients please see Table 3), to check for additional contributions beyond those brought forward by the executive functions. Given that the distribution for the behavioural data wasn't normally distributed, the hierarchical regression models were bootstrapped, with 95% bias corrected and accelerated confidence intervals. Hence, in our regression models, confidence intervals and standard errors were based on 2000 bootstrap samples (Wright, London, & Field, 2011).

When looking at cognitive flexibility, the model was statistically significant at Step 1, $F(2, 62) = 41.52$, $p < .001$, with age alone as a significant predictor ($\beta = .73$, $p < .001$) explaining 58% variance in cognitive flexibility. Maternal education wasn't a significant predictor ($\beta = .05$, $p = .57$). After entering proactive and reactive inhibition at Step 2, the total variance explained by the model as a whole was 63%, $F(4, 62) = 25.15$, $p < .001$, after controlling for age and maternal education. In this second model, two out of four predictors were statistically significant: age ($\beta = .37$, $p = .017$) and proactive inhibition ($\beta = .39$, $p = .012$), but not maternal education ($\beta = .03$, $p = .68$) or reactive inhibition ($\beta = .07$, $p = .46$). At Step 3, working memory was added to the model, yet working memory alone din not bring a significant contribution to explaining children's cognitive flexibility performance ($\beta = .04$, $p = .70$) in addition to proactive inhibition and age.

In the case of affective flexibility, at Step 1 both age and maternal education were significant predictors and explained 30% of the variance in affective flexibility performance F (2, 62) = 13.11, $p < .001$. During Step 2, when proactive and reactive inhibition were entered, the model explained 42% of the variance in affective flexibility performance $F(4, 62) = 10.49$, $p < .001$. The only significant predictors at Step 2 were proactive inhibition ($\beta = .61$, $p = .002$) and maternal education ($\beta = .27$, $p = .017$) while age ($\beta = -.17$, $p = .37$) and reactive inhibition ($\beta = .05$, $p = .67$) didn't bring a significant contribution to affective flexibility performance. During Step 3, working memory was added to the model which now explained 47% of the variance in affective flexibility performance $F(5, 62) = 10.14$, $p < .001$. In this model, working memory significantly explained children's affective flexibility performance ($\beta = .32$, $p = .023$) in addition to proactive inhibition ($\beta = .60$, $p = .002$) and maternal education ($\beta = .33$, $p = .004$) while reactive inhibition ($\beta = -.01$, $p = .87$) and age ($\beta = -.37$, $p = .074$) didn't significantly contribute to affective flexibility performance. Lastly, during Step 4, cognitive flexibility was entered in the model and this final model explained 48% of the variance in affective flexibility performance $F(6, 62) = 8.63$, $p < .001$. In this final model, cognitive flexibility wasn't a significant predictor of affective flexibility performance ($\beta = .16$, $p = .30$) beyond the predictors entered before, and neither was reactive inhibition ($\beta = .02$, $p = .81$). However, working memory ($\beta = .18$, $p = .02$), proactive inhibition ($\beta = .53$, $p = .008$), maternal education ($\beta = .32$, $p = .005$) and age ($\beta = -.42$, $p = .04$) remained significant predictors.

Relating individual differences in anxiety to affective flexibility performance

Looking at *individual differences in affective flexibility*, we also investigated if *anxiety* had an impact on affective flexibility performance when different task-irrelevant emotional stimuli were presented. We performed a repeated measures ANCOVA analysis in which we included the condition (neutral, happy and angry) of the EM-FIST as a within factor variable, while trait anxiety was added as a covariate. We didn't find a main effect of condition F (2, 64) = 2.47, $p = .09$, $\eta_p^2 = .07$, suggesting that there weren't any significant mean differences between the neutral, happy and angry emotional conditions in terms of performance accuracy. We also did not find a main effect of anxiety, F (1, 65) = 0.31, $p = .86$, $\eta_p^2 = .00$.

However, we found a significant interaction between condition and anxiety F (2, 64) = 4.82, $p = .011$, $\eta_p^2 = .13$. To further investigate this interaction effect, we conducted two separate repeated measures ANOVAs for participants with higher levels of anxiety (total anxiety > = 26, $n = 31$) and lower levels of anxiety (total anxiety < 21, $n = 31$), calculated by using a sample median split (*Md* for total anxiety = 21). For the lower anxiety subsample, no significant differences between angry, neutral and happy conditions emerged, $F(1.52, 45.56) = 1.56$, $p = .22$, $\eta_p^2 = 0.05$. In the high anxiety subgroup, we found an

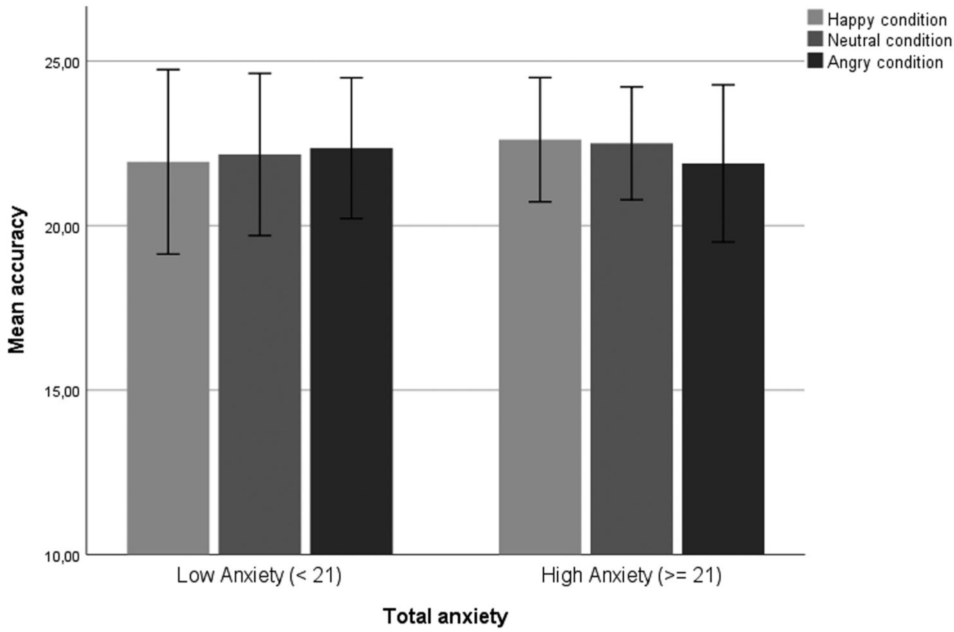

Figure 2. Mean affective flexibility (accuracy) in the three emotional conditions, as a function of Low vs. High anxiety group.

effect of the emotional condition on affective flexibility accuracy performance, $F(1.79, 62.72) = 4.78$, $p = .014$, $\eta_p^2 = .12$. In the high anxiety subgroup, Sidak post-hoc tests revealed that accuracy was higher in the happy condition ($M = 22.61$, $SD = 1.89$) than in the angry condition ($M = 21.89$, $SD = 2.39$), $p = .02$. No differences were found between neutral ($M = 22.50$, $SD = 1.72$) vs. angry, $p = .11$ or neutral vs. happy, $p = .94$, conditions. In sum, the interaction effect between anxiety and performance accuracy reported in the previous ANCOVA is depicted in Figure 2. Lower anxiety was not associated with differences in the performance accuracy in the different emotion conditions, but in those experiencing higher levels of anxiety, accuracy performance was greater in the happy condition than in the angry condition.

Discussion

Our first aim was to investigate age-related improvements in affective flexibility performance during an early developmental window. Although preliminary research has demonstrated age-related improvements in affective flexibility in school age children (Mărcuş et al., 2016; Mocan et al., 2014), to our knowledge no study has yet looked at age-related changes in affective flexibility performance during the preschool years. Our findings show that with increasing age, preschoolers develop their ability to transition between alternative ways of processing emotional stimuli. This result extends previous findings, by indicating the presence of age-related improvements in a much younger sample.

Our second aim was to explore the potential distinction between cognitive and affective flexibility in preschoolers. We explored if preschoolers find it more demanding to be flexible when processing *emotional faces*, as compared to *non-emotional stimuli*. When directly comparing affective flexibility to cognitive flexibility performance, our findings reveal no differences in terms of performance accuracy between the two tasks. Performance on the EM-FIST improved as a function of age in their preschooler sample, but so did performance on the non-affective FIST, indicating that preschoolers found both the affective- and non-affective versions to be similar in terms of task difficulty. This questions the additional processing of emotional content in the EM-FIST and raises the possibility that for preschoolers, the emotional component of the task which was task-irrelevant might not have interfered significantly with the performance on the main task. A version of the EM-FIST used with older children (11-14 years old) in which processing emotion was task relevant did point to a higher overall accuracy on the version containing neutral (shape) as compared to emotional (faces) stimuli, although the paper did not contrast them directly (Mărcuş et al., 2016). Our findings give room for the interpretation that – at least for this early age group – task irrelevant emotional information might not significantly alter flexibility, so that what we are capturing with the EM-FIST may mainly reflect cognitive flexibility. However, the correlation between the tasks is moderate, they have different predictors and the emotional valence of the stimuli also interacts with anxiety levels (as discussed below), so this possibility that the FIST and the EM-FIST tasks are actually equivalent is not supported in a straightforward manner by our results. An alternative explanation (also considering the interaction between anxiety and stimulus valence described below) is that task salience and emotional valence had antagonistic effects. Hence, the EM-FIST while being more demanding in terms of emotional processing interfering with performance, was also more salient or engaging for the children, which could lead to similar levels of performance. An investigation which would employ emotion as both task relevant, and task irrelevant, using more engaging or complex stimuli in the non-emotional condition could address such competitive explanations.

Affective flexibility was significantly correlated with cognitive flexibility as measured by the FIST, but not as measured by DCCS – this could be due to the similarity between task formats in the FIST and EM-FIST, but also to the restricted range and ceiling levels of performance on the DCCS.

Next, we looked at whether cool executive measures predicted affective flexibility and cognitive flexibility performance, while controlling for age and maternal education. No study, to our knowledge, has investigated whether inhibition, working memory and cognitive flexibility contribute to affective flexibility performance during early development. Our findings revealed that in the case of cognitive flexibility, only age and proactive inhibition were significant predictors for children's cognitive flexibility performance while working memory and reactive inhibition didn't bring a significant contribution to cognitive flexibility. When looking at affective flexibility, we found maternal education, proactive inhibition, working memory and age as significant predictors. Hence, proactive inhibition plays an important role in both cognitive and affective flexibility performance during the preschool years. Refining the findings of previous studies showing that both inhibition and working memory contribute to cognitive flexibility (Arán Filippetti & Krumm, 2020; Blakey et al., 2016; Brocki & Tilman, 2014; Chevalier et al., 2012), we show that a specific type of inhibition – proactive, and not reactive – plays a crucial role in the early development of cognitive and affective flexibility. During both flexibility tasks, we could infer that this preparation could be essential as it allows children to be vigilant and prepare in advance for the type of rule that needs to be applied, which in itself facilitates subsequent reactive inhibition inhibiting the rule that is no longer correct (supported by the correlation between the proactive and the reactive inhibition scores in our study).

However, cognitive flexibility and affective flexibility also differed in their predictors, as working memory, maternal education and age contributed to affective flexibility performance, while they appeared less relevant for children's cognitive flexibility. Only one previous study has shown that affective flexibility as measured with the EM-FIST is related to working memory in preschoolers (Martins et al., 2018). We could speculate that while solving the EM-FIST task, preschoolers with higher levels of working memory were better able to keep the task goal in mind, and thus were less distracted by the emotional content of the pictures, which translated into higher levels of affective flexibility performance. It would be interesting to see if working memory for emotional content contributes even more to affective flexibility performance. Future work should investigate the contribution of hot aspects of working memory to affective flexibility performance across development.

Regarding the contribution of maternal education, a longitudinal study by Zeytinoglu, Calkins, and Leerkes (2019) found that maternal education was moderately related to cognitive flexibility in school age children, but strongly related to maternal emotional support. We can infer that such maternal emotional support can be particularly useful for the development of affective flexibility and might explain the stronger predictive role of maternal education for this emotional dimension of flexibility, possibly as a result of increased maternal emotional support associated with a higher educational level. It is for future studies to explore such potential mediators for the impact of maternal education on cognitive and affective flexibility.

Lastly, we aimed to investigate if *anxiety* was negatively associated with affective flexibility performance and if this association differed as a function of the type of emotion (happy, angry or neutral) processed. Our findings indicated that the group of preschoolers experiencing higher levels of anxiety had lower levels of accuracy in the angry condition than in the happy condition of the EM-FIST. However, the group of preschoolers with lower levels of anxiety didn't show any differences in affective flexibility performance in the three emotion conditions. This finding is in line with previous research and theory (Berggren & Derakshan, 2013; Derakshan & Eysenck, 2009) by showing that only participants with high levels of anxiety tended to underperform in terms of affective flexibility accuracy when they process angry faces, as compared to happy faces. Interestingly, this reduced performance only appeared when comparing angry faces to happy faces, and it didn't appear when comparing angry faces to neutral ones. According to the Attentional Control Theory, we would expect high levels of anxiety to be associated with inflexibility in processing task-irrelevant angry faces. Hence, our findings converge with this theory, by showing that preschoolers with high levels of anxiety display a poorer performance during the presentation of angry emotional facial stimuli relative to happy, but not relative to neutral stimuli. This is a preliminary indication that the emotional expression of the faces could influence affective flexibility in preschoolers with sub-clinical levels of anxiety. This finding adds to previous developmental work showing the presence of affective flexibility impairments in older children experiencing anxiety symptoms (Mărcuş et al., 2016; Mocan et al., 2014). These deficits have been reported in both studies including measures of affective flexibility in which the emotion is task relevant (Mărcuş et al., 2016; Mocan et al., 2014).

When interpreting the above mentioned findings we have to take into account that the present research has some limitations. One important limitation of our study is that it has a cross-sectional design, which doesn't allow us to capture the actual developmental trajectory of age-related improvements in affective flexibility performance from the preschool years onwards. Future studies could employ longitudinal designs to be able to capture the developmental trajectory of affective flexibility departing from a young age and continuing to later development (e.g. school entry or even adolescence). Another limitation is that the present research didn't include specific measures of socioeconomic status which has been related to individual differences in executive functioning (Lawson, Hook, & Farah, 2018). Another limitation is related to the appropriateness of the measures used for the age range assessed in this study, especially for the youngest participants. In this younger subsample, the measures may not best capture the underlying skill of interest. For instance, some tasks such as the Wack-A-Mole or the Listening recall task were initially used with an older age group (Shapiro et al., 2013; Alloway & Elsworth, 2012). The revised version of the inhibition task used in this study offered more response time and longer ITI so it was deemed more developmentally appropriate, yet it still included a large number of trials, which might have been demanding for 3- and 4-year old children. The task that we used to assess affective flexibility (EM-FIST) may not be ideally suited for capturing affective flexibility in such a young sample. While completing this task, we can anticipate different underlying emotional and cognitive processes. First, children might experience these emotions themselves while looking at the faces depicting the expressions, via emotional contagion (Prochazkova & Kret, 2017). Alternatively, children could simply understand the emotions of the stimuli presented, this posing an additional load to their main flexibility task. A third possibility is that at this very young age, children may not even be able to clearly understand the emotion of the faces being presented onscreen, for instance the neutral expressions might have been interpreted as aversive by younger children (Mesman, Van IJzendoorn, & Bakermans-Kranenburg, 2009). In the case of older children, it might be more suitable to design an affective flexibility task which will introduce different emotional scenarios instead of emotional faces. This type of task would resemble real life contexts in which children have to deal with emotions in a flexible manner.

Lastly, the distinction between the affective flexibility and cognitive flexibility is not fully supported by the findings presented in this study and these results should be cautiously interpreted. Some results suggest that the two tasks are similar at least in terms of task difficulty and they also show a moderate correlation. Arguments against their similarity come from findings showing that the two tasks have different predictors and that only the affective flexibility task interacts with children's anxiety levels. Nevertheless, cognitive flexibility didn't contribute to affective flexibility ability beyond the predictors that were significant (maternal education, proactive inhibition, working memory) which suggests that these abilities might be different. We can say that the two tasks resemble each other in task structure and demands, even though they use different types of stimuli which might elicit different underlying processes. Future studies should aim to address this limitation by studying the similarities and differences between cognitive and affective flexibility across development.

To summarize, the results of this study suggest that the EM-FIST is a developmentally appropriate and valid measure of affective flexibility in preschoolers. The EM-FIST may also be used in future studies for assessing relations between emotion and cognitive processes during other developmental periods (using age-appropriate versions of it). Secondly, our findings show that proactive inhibition and age contributes to both cognitive and affective flexibility during the preschool years. In addition, maternal education, proactive inhibition and working memory were significant predictors for affective flexibility while cognitive flexibility didn't contribute to affective flexibility. Thirdly, we found that anxiety exerts a negative effect upon affective flexibility, but only for a small group of individuals. More specifically, those children experiencing high levels of anxiety performed worse in the angry condition as compared to the happy condition. This finding suggests that the EM-FIST task could be used in future work for identifying patterns of risk-related emotion processing during development. This type of research endeavour will allow us to improve the reliability of affective flexibility assessments of risk and the efficacy of interventions targeting emotional disorders such as anxiety and depression.

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