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Emotion understanding in preschool children: The role of executive functions

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Abstract

This investigation was aimed at studying the relations between executive functions (EFs) and categorical emotion understanding while controlling for preschoolers' IQ, language ability and theory of mind (ToM). Specifically, we wanted to analyse the association between emotion understanding and set shifting, due to the lack of studies with this EF. Data of 75 children aged 4½ years (52% boys) was collected in two laboratory visits. Emotion understanding was assessed using the *Emotion Recognition Questionnaire*, inhibitory control using the *Head-Toes-Knees-Shoulders task* and set shifting using a version of the *Dimensional Change Card Sort task*. IQ was evaluated using the *WPPSI-R*, language using the *Peabody Picture Vocabulary Test – Revised*; and ToM using six standardized tasks. Set shifting, but not inhibitory control, predicted emotion understanding, over and above mothers' age, and children's IQ, language ability, and ToM. Mothers' age and children's language ability were also significant predictors in the final regression model. Results suggest that the capacity to shift mental sets is linked with inter-individual differences in children's understanding of situational causes of emotion. Therefore studying EFs as correlates of emotion understanding is an important focus of future research.

Keywords

emotion understanding, executive functions, inhibitory control, IQ, language, preschool, set shifting, ToM

Understanding emotion is a key element for the successful social adjustment of children. Children that are more successful at understanding emotional cues are more likely to develop appropriate social skills and prosocial responses to peers and to form positive interpersonal relationships that foster adaptation to social situations (de Rosnay, Harris, & Pons, 2008; Harris, 2006). For example, preschoolers' ability to recognize and understand others' emotions has been linked to their social competence (Trentacosta & Fine, 2010); peer acceptance, popularity and leadership (Harris, 2008); diminished aggressive behaviors (Denham et al., 2002); fewer externalizing and internalizing problems (Trentacosta & Fine, 2010); school readiness and early academic competences (Denham et al., 2012; Garner & Waajid, 2008; Leerkes, Paradise, O'Brien, Calkins, & Lange, 2008). Even though children's understanding of emotion improves with age, early individual differences in the overall level of such understanding persist across development (Pons & Harris, 2005). Accordingly, studying correlates of early emotion understanding is an important focus of investigation. In this study, we focused on children's individual characteristics that may be associated with the development of categorical emotion understanding based on the situational causes of emotions.

Children's emotion understanding comprises the way they identify, predict, and explain emotions with respect to themselves and others (Harris, 2008). Initially, children's understanding of emotions is broad valence-based (Székely et al., 2011; Widen, 2013) and only later emerges in the basic categorical form (e.g., happiness, anger, sadness). Children aged 2 to 3 years use the dimensions of valence (pleasure/feels good—displeasure/feels bad) and arousal/intensity (high arousal – sleepiness) to classify emotions (Widen & Russell, 2008). For instance, research on facial emotion recognition has shown that 3-year-olds are more likely to mistake an emotion facial expression for another with the same valence and similar levels of arousal (e.g., labelling *anger* instead of *sadness*) rather than for an emotion facial expression with different valence (e.g., labelling *sadness* instead of *happiness*) (Székely et al., 2011; Widen, 2013). Therefore, at approximately 3½ years of age, children label all positive expressions as *happy* and use the same label for all negative expressions, for example, *angry* or *sad*. By this age, the label (e.g., *sad*) is used as a broad negative emotion category (e.g., *feels bad*) that is still far from the meaning conveyed by an adult (Widen, 2013). On average, 4-year-olds are able to distinguish *anger* from *sadness* and from *happiness* (Widen, 2013). Next, they develop the capacity to distinguish *happy*, from *sad*, from *angry*, and from *fearful* (or *surprised*). When children approach 6 years of age, they distinguish among *happiness*, *anger*, *sadness*, *fear*, and *surprise*. Research supports this broad-to-differentiated pattern of emotion understanding development in label use as well as when children must identify a character's emotion based on a story depicting causes and consequences associated with that emotion (Widen, 2013).

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The categorical understanding of emotions implies that children develop different scripts for each discrete emotion (Widen & Russell, 2008). Thus, children must develop script-based knowledge that includes the memorization and identification of that emotion, the characteristics of the situations that normally elicit that emotion (e.g., situational causes such as anticipating that a boy will be sad if he loses a favorite toy), and the usual actions (i.e., behavioral consequences) and expressions (e.g., facial expression, vocalization) that follow (Fehr & Russell, 1984; Harris, 2008; Widen & Russell, 2008). Nevertheless, scripts do not emerge fully formed, but rather, different script components are added over time throughout the child's development (Widen, 2013). Interestingly, it seems that younger children use facial expressions as cues for early valence-based emotion understanding. However, as children progress towards categorical understanding, they first master the match between categorical labels of emotion and the situational causes and behavioral consequences, but not the match between categorical labels and typical facial expressions, with the exception of surprise (Widen & Russell, 2010). Furthermore, it seems that preschoolers first develop the understanding of causes of emotion and later the consequences, with the exceptions of anger and surprise (Widen & Russell, 2011). Accordingly, when studying correlates of emerging categorical knowledge of emotions in preschoolers, as is the case of the present study, it is important to focus on the understanding of situational causes of emotions.

Even though several child characteristics have been associated with differences in emotion understanding, language may be fundamental for the development of this ability (Ornaghi & Grazzani, 2013; Pons, Lawson, Harris, & de Rosnay, 2003), as social interactions are heavily dependent on verbal exchanges (Pons et al., 2003). Evidence supporting this hypothesis comes from research relating engagement in family discussions about emotions and children's emotion understanding (Harris, 2008). Furthermore, specific emotional-state language use may impact emotion understanding, as attested by training studies targeting this language component (Ornaghi, Brockmeier, & Gavazzi, 2011). Hence, emotional mental-state literacy allows children to represent, describe, and understand their own and others' emotional internal lives (Ornaghi & Grazzani, 2013).

Another characteristic associated with emotion understanding is IQ (Bennett, Bendersky, & Lewis, 2005; Pears & Fisher, 2005; Sullivan, Bennett, Carpenter, & Lewis, 2008; cf. Montirosso, Peverelli, Frigerio, Crespi, & Borgatti, 2010). Nonverbal intelligence was recently found to predict several key aspects of emotion understanding (Albanese, De Stasio, Di Chiacchio, Fiorilli, & Pons, 2010). Thus, processes that are central to analytical intelligence, such as the ability to address novelty, and the ability to reason and to solve problems involving new information may help children identify the right emotional cues that represent and communicate the emotion present in an emotional task (Albanese et al., 2010).

Another much-studied individual characteristic is theory of mind (ToM; Cutting & Dunn, 1999; de Rosnay, Pons, Harris, & Morrell, 2004; J. Dunn, 2000; O'Brien et al., 2011), though its relation with emotion understanding is controversial. Whereas some argue that these are two distinct domains of children's developing social cognition and that any associations may be due to the influence of shared socio-demographic variables (Cutting & Dunn, 1999), others claim that these are related but different phenomena. According to the latter, the capacity to understand others' emotional states emerges first, which then helps children to develop an understanding of others' cognitive states and thinking (e.g., beliefs) (Bartsch & Estes, 1996; J. Dunn, 2000). By the contrary, de Rosnay et al. (2004) showed that children first develop the capacity to understand false belief and only later master the ability to accurately attribute expressions of emotion based on that false belief. Therefore, it may be that skills related with the understanding of conflicting mental states help children to understand others' emotions and the underlying causes of those emotions (Harwood & Farrar, 2006). In contrast, a recent longitudinal investigation with 3- and 4-year-olds revealed that early emotion understanding predicted later theory-of-mind performance, not the reverse (O'Brien et al., 2011). Trying to reconcile both perspectives that advocate in favor of an interplay between emotion understanding and ToM, the authors hypothesized that, in early development, emotion understanding comes first and influences the development of ToM. However, the reverse may actually occur later on, as these competences become more complex, such as when children begin to reason about beliefs (O'Brien et al., 2011). This framework implies that at least some aspects of emotion understanding cannot be reduced to an emotional ToM and that different pathways of influence may emerge throughout development. The present investigation is accordingly anchored on this assumption.

Based on the literature review, one may conclude that as children add components to pre-existing scripts, they differentiate previous scripts into more precise scripts that gradually resemble adult emotion categories (Widen & Russell, 2011) while co-occurring and related acquisitions in cognition and socio-cognition are taking place. Nevertheless, the role of executive functions (EFs) in emotion understanding remains to be thoroughly investigated. A growing body of literature has highlighted the bidirectional relation between EFs and social interaction, as well as the cognitive skills implicated in such relations (Moriguchi, 2014). For instance, longitudinal and intervention studies indicate that EFs are necessary for the emergence of ToM (Benson, Sabbagh, Carlson, & Zelazo, 2013; Carlson, Koenig, & Harms, 2013). In addition, we argue that EFs may be relevant for emotion understanding for two other reasons. The first is that research has shown intricate relations between language and EFs (Fatzer & Roebers, 2012; Kuhn et al., 2014; S. E. Miller & Marcovitch, 2011), and EFs are, to varying degrees, related to intelligence (Friedman et al., 2006). Second, given that EFs are related with concept formation and identification (Fine et al., 2009), emotions, in their categorical form, imply the development of emotion scripts/concepts. Thus, it is plausible that EFs will also be associated with the development of emotion concepts/scripts.

EFs are a collection of top-down processes that allow for conscious, goal-directed control of thoughts and actions (Diamond, 2013; Zelazo & Carlson, 2012). The three core processes of EFs are inhibitory control, working memory, and cognitive flexibility (i.e., set shifting) (Diamond, 2013). However, there are questions about the tri-component nature of EFs in preschool-aged children. Investigations using confirmatory factor analysis (CFA) have demonstrated that a single or a two-factor model—working memory and inhibitory control—of EFs fits the data (Wiebe, 2014). However, a definite answer regarding this question is still absent considering that most research used working memory and inhibitory control measures but not set shifting (Wiebe, 2014) and the structure of EFs emerging from CFA is influenced by the task and performance indicator selected (M. R. Miller, Giesbrecht, Müller, McInerney, & Kerns, 2012). Hence, our investigation was based on the assumption that, in preschool aged children, EFs can be divided into separate, but related, components.

As in emotion understanding, EFs develop more rapidly for children during their preschool years (i.e., 3–4 years old) (Widen, 2013; Zelazo & Carlson, 2012). For example, although 3-year-olds are unable to inhibit a pre-potent behavioral response to the Head-Toes-Knees-Shoulders task, 4–5-year-olds demonstrate the ability to do so (Ponitz et al., 2008; Ponitz, McClelland, Matthews, & Morrison, 2009). Similarly, 3-year-olds cannot shift rule use in the Dimensional Change Card Sort task, whereas 4½- to 5-year-olds can (Diamond, 2013).

Whereas some studies report on the relation between EFs and emotion understanding (Blankson, O'Brien, Leerkes, Marcovitch, & Calkins, 2012; Carlson & Wang, 2007; Hughes & Ensor, 2009; Leerkes et al., 2008), only Denham and colleagues (2012) designed a study to specifically examine this connection. They investigated the self-regulatory roots ("cool" EFs—inhibitory control of attention/behavior—and "hot" EFs—inhibitory control of emotionally charged behavior) of emotion knowledge (labelling and situational knowledge) in 3- and 4-year-olds and set out to test two opposite directions of influence. On the one hand, EFs might be foundational processes of emotional knowledge, as attentional control may be necessary for children to correctly distinguish among emotions during an emotion recognition task. It might also be the case that EFs help children to better control their behavior, and thus foster positive social interactions that, in turn, are essential for emotion understanding development. On the other hand, it is assumed that knowledge of one's own and others' emotions may facilitate the development of cognitive processes related with the regulation of behaviors (i.e., EFs). The results indicated that the early spring assessment of EFs predicted school-year-end emotion knowledge (only "cool" EF predicted labelling), but the reverse did not occur, thus leading to the conclusion that there is more evidence supporting that EFs impact emotion knowledge development than the reverse (Denham et al., 2012). Albeit not focused primarily on the relations between emotion understanding and EFs, two additional studies are noteworthy. Leerkes et al. (2008) and Blankson et al. (2012) tested the hypothesis that preschoolers' performance on emotion tasks was organized into discrete processes of emotion control (temperament, emotion regulation) and emotion understanding (affective perspective taking, labelling and knowledge of emotion causes), whilst the performance on cognitive tasks was organized into cognitive understanding (ToM) and cognitive control (inhibitory control, working memory). Contrary to their expectations, the strongest correlation among the four factors was found between emotion understanding and EFs, that is, across emotional and cognitive domains. Blankson et al. (2012) provided three interpretations for their findings, which are consistent with those of Denham et al. (2012). First, they hypothesized that throughout development and during emotion-learning events, children who are better able to hold information in their short-term awareness and able to inhibit dominant in favor of subdominant information will be better at regulating their attention in emotion-learning events. These EFs may assist them in increasing their awareness of others' emotions and in strengthening their ability to identify their own and others' emotions. Alternatively, based on the demands of the measures used for assessing emotion understanding, it could be that children must provide an answer based on emotional stories, which, in itself, is cognitively challenging. Thus, children must remember the story and inhibit their own feelings about a situation to accurately identify characters' emotions. The third interpretive hypothesis featured an opposite direction of influences such that emotion understanding would influence the development of EFs. In other words, easy access to the understanding of one's own and others' emotions would help children to more promptly focus attention on the cognitive challenges of the specific tasks at hand rather than to dwell on the emotions accompanying the task.

In summary, the evidence available in typically developing children is suggestive of a relation between EFs and emotion understanding, and the longitudinal investigation of Denham et al. (2012) supports a possible involvement of EFs in the *development* of emotion understanding. However, to the best of our knowledge, there is no available research that has controlled for the effect of other cognitive and socio-cognitive variables and their relation with emotion understanding whilst studying the role of EFs. Therefore, the focus of the present investigation was to study the relation between EFs and emotion understanding whilst controlling for the effect of child's IQ, language, and ToM. IQ and language were controlled not only because these variables have long been known to be related with emotion understanding (Albanese et al., 2010; Ornaghi & Grazzani, 2013; Pons et al., 2003; Sullivan et al., 2008) but also because of their relation with EFs. IQ tests assess a diverse range of cognitive competences, some of which are related to problem solving competencies (Wechsler, 2003). Therefore, although intelligence and EFs do not overlap, associations are found (Friedman et al., 2006). More importantly, language is a foundational element of preschoolers' EF capacities (Kuhn et al., 2014). Some contend that children's language will foster their EF abilities as it permits the formation of a mental representation of the problem, the development of consciousness regarding the rules that govern the resolution of that problem and, in turn, their ability to control their behavior through self-directed speech (Müller, Jacques, Brocki, & Zelazo, 2009). Another account that may provide a lower-level explanation for the previous theory posits the primordial importance of language as representation, such that the use of active, abstract representations rather than latent, stimulus-specific representations is necessary for children to develop the capacity to use and develop complex rule reasoning and higher order rule use associated, for example, with task switching (Fatzer & Roebers, 2012; Kharitonova, Chien, Colunga, & Munakata, 2009). Hence, including language was paramount as we needed to partial out its predictive role on emotion understanding while assessing the role of EFs. Finally, ToM was included as a control variable due to its close relation with some of the cognitive correlates featured in our analyses (for language and EFs see Carlson et al., 2013). In doing so, we offer further clarification into the yet unclear connection between emotion understanding and ToM (de Rosnay et al., 2004; J. Dunn, 2000; O'Brien et al., 2011).

To date, the relation between emotion understanding and EFs remains unclear, even though the study by Denham et al. (2012) provided valuable input on inhibitory control. In fact, additional EFs should be examined and the role of set shifting is of special interest. As emotion understanding develops from valence-based to discrete categorical understanding (Widen, 2013), it may be that this process is supported by developing capacities to shift mental sets, namely, to use complex rules (i.e., embedded rules (Zelazo, Muller, Frye, & Marcovitch, 2003). First, children use mainly one dimension of the script—valence—to categorize emotions. For example, they differentiate anger from happiness based on the negative valence of the first and the positive valence of the second. However, they encounter difficulties when discriminating between anger and sadness because the use

Table 1. Demographic characteristics of participants ($N = 75$) .

	N	%
Child		
Sex		
Female	36	48
Male	39	52
Mother		
Years of education		
9th grade	1	1.3
12th grade	11	14.7
Bachelor degree	51	68
Masters/Doctoral degree	12	16
Marital status		
Married	62	82.7
Unmarried	7	9.3
Divorced	6	8.0
Number of children		
1	26	34.7
2	40	53.3
3	7	9.3
4	2	2.7

of only one script component—valence—does not allow for such distinction. Therefore, only later will they be able to use several components of the script, or several rules, to categorize an emotional situation based on valence *and* on aspects such as behavior consequences or antecedents, a factor that will permit differentiating anger from sadness. Nevertheless, to attend to the different components of the script coordinately and thereby increase categorical adult-like views of emotions, children must be able to shift between the rules, that is, between script components. Such shifting entails using embedded rules (Frye, Zelazo, & Palfai, 1995; Zelazo et al., 2003), and the use of such rules implies establishing a hierarchy in which judgments are arranged hierarchically beneath setting conditions, that is, subordinate to rules that govern the conditions in which lower order rules are chosen (Frye et al., 1995; Zelazo et al., 2003). A hierarchy of this sort is necessary when classifications are in conflict across setting conditions. Specifically, with respect to emotion understanding, the classifications are in conflict across each script component. Considering the example of anger and sadness, both belong to the same category if one is using the rule/script component *valence* ("feeling bad"). However, when sorting by another rule/script component such as *behavioral consequences*, these two emotions belong to different categories. The conflict across setting conditions is instated. Therefore, although situations that cause sadness and anger both make the child feel bad, a usual behavioral consequence for sadness is crying, whereas the consequence for anger is hitting and yelling, thus allocating the stories to different categories (sadness vs. anger). For the aforementioned reasons, we propose that higher capacities to shift mental sets will be linked to better emotion understanding.

In conclusion, the main aim of this investigation was to study if EFs, in general, and set shifting, in particular, are correlates of emotion understanding in 4½-year-olds, whilst controlling for relevant cognitive and socio-cognitive variables. We hypothesized that set shifting would predict preschoolers' performance in an emotion understanding task, above and beyond their language abilities, IQ, ToM and inhibitory control.

Method

Participants

We recruited 75 Portuguese 4½ year-olds ($M = 55.05$ months, $SD = 1.53$) from child-care centers in Oporto to participate in a broad longitudinal study on the developmental predictors of school readiness (see Table 1 for demographics). Mothers were aged 26 to 46 years ($M = 36.84$, $SD = 3.60$), and the majority had higher education qualifications, were married, had two children and were the primary caregivers.

Procedure

Children visited the laboratory twice at 4½ years of age. For the purpose of the present cross-sectional investigation, data collected in the first session (set shifting, inhibitory control and IQ) and in the second session (ToM and emotion understanding) were used. The average elapsed time between sessions was three weeks, which we tried to maintain constant for all children. In each session, parents were explained the purposes and procedures of the study were asked for written informed consent for their child's participation and were asked to complete a socio-demographic questionnaire.

Measures

Emotion understanding. Emotion understanding was assessed using the *Emotion Recognition Questionnaire* (Bierman et al., 2008; Ribordy, Camras, Stefani, & Spaccarelli, 1988). Children were read 16 stories that described characters in emotionally evocative situations. For each story, children were required to associate typical and unequivocal situational causes of emotion to the basic emotion depicted by the characters by pointing to pictures of happy, mad, sad, or scared faces. For each story, a score of 2 was given if children correctly identified the adequate emotion; a score of 1 was attributed if children correctly identified the emotion valence (e.g., mistaking fear for anger); a score of 0 applied if children did not identify the correct emotion or valence. For example, for the story, "Johnny/Susie wanted his/her friends to come over to play. So he/she asked them, and they came to play with him/her at his/her house", children had to choose the happy face to score a 2 for this item. A total score ($\alpha = .69$ for our sample) was calculated (range 0–32).

IQ. IQ was assessed using a short version of the *Wechsler Preschool and Primary Scale of Intelligence – Revised* (WPPSI-R; Wechsler, 2003) that consisted of the Information and Block Design subtests. The Information subtest required children to answer questions addressing general knowledge, and the Block Design subtest assessed children's ability to copy models using two-colored blocks. Based on children's scaled scores on these two tasks, their full IQ was estimated following the procedure described by Sattler (1992) and which has been performed in previous studies (e.g., Shields, Palermo, Powers, Grewe, & Smith, 2003).

Language ability. Language ability was assessed using the *Peabody Picture Vocabulary Test – Revised* (PPVT-R; L. M. Dunn & Dunn, 1981). After hearing a word, children were asked to choose the corresponding picture from a set of four pictures. The coding consisted of subtracting the total number of errors from the highest item the child attained. As Portuguese norms for this instrument are not yet available, an age-adjusted residual for the raw scores was computed and used in the statistical analyses.

Theory of mind. Theory of mind was assessed using a set of six standardized tasks, four of which were derived from a theory of mind scale for preschoolers (Wellman & Liu, 2004). These four included i) Diverse Beliefs, ii) Knowledge Access, iii) Unexpected Contents False Belief, and iv) Explicit False Belief. The two additional false belief tasks (Hughes et al., 2000) were v) Unexpected Contents II, and vi) Unexpected Location. The order of presentation of the first two tasks was fixed, whilst the order of the remaining tasks was counterbalanced. All the tasks were coded in terms of success (1) or failure (0), and to succeed on each of the tasks, the children had to correctly answer both the control and the key questions. Inter-rater reliability was very good (mean Cohen's kappa = .98, range = .88–1.00). A composite theory of mind score consisting of the sum of the childrens' scores on all six tasks was calculated (range 0–6), and the internal consistency of the final score was very good (Kuder-Richardson = .98).

Inhibitory control. Inhibitory control was assessed using the Head-Toes-Knees-Shoulders task (HTKS; Ponitz et al., 2009). This procedure involved two rules, and children were asked to perform the opposite of the researcher's oral prompts. For example, when the researcher said, "touch your head", the children were required to touch their toes; when the researcher said, "touch your toes", the children should have touched their head. This procedure was divided into two parts. Part I consisted of four practice trials with feedback followed by 10 test trials. For children who responded correctly to five or more test trials, Part II was administered wherein two new prompts were added—"touch your shoulders" and "touch your knees"—to the previous prompts, thus resulting in a total of four rules. Again, the child was instructed to do the opposite of that requested by the researcher. Four practice trials with feedback were administered followed by 10 test trials. Each trial was scored as 0 for an incorrect response, 1 for an incorrect response followed by a spontaneous correction towards the correct response, and 2 for a correct response. Final scores for the task were the sum of the children's performance on Part I (10 items) and on Part II (10 items) (range 0–40). The internal consistency of the final score was very good (Kuder-Richardson = .93).

Set shifting. Set shifting was assessed using a modified version of the *Dimensional Change Card Sort* task (DCCS; Frye et al., 1995; Zelazo, 2006), which was developed by a research group at the University of Minnesota led by Stephanie Carlson. The researcher showed children two boxes with target cards affixed to the front and gave them a series of cards to sort. There were several sorting games organized in the following ascending order of difficulty.

i) *Categorization/Reverse categorization*: In the *categorization* test 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. In the *reverse categorization* test the same cards as in *categorization* are used, but now children had to put the "little kitty" cards in the "big kitty" box and vice-versa.
ii) *Separated color/shape*: in the *separated color* game, the trial cards were "red with a black star" or "blue with a black truck". Children were instructed that all the red things would go to the box that had the "red card with a black truck picture". The researcher would continue explaining that all the blue things would go to the box that had the "blue card with a black star picture". In the *separated shape* test, children used the same cards as before, but now had to sort them by shape.
iii) *Integrated color/shape*: in the *integrated color* game children had to sort cards by color—red or blue. 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 picture" and the other had a "blue star picture". In the *integrated shape* test the same cards were used, but the child was asked to sort by shape.
iv) *Mixed*: the cards used were the same as those used in the *integrated* game. The children were instructed that sometimes they were going to play the shape game and sometimes the color game, depending on whether the researcher said, "Play the shape game" versus "Play the color game" when giving out the card.
v) *Advanced border/reverse border*: in the *advanced border* test, the cards attached to the boxes were the same as those used in the *integrated* games, but the test cards were as follows: white cards with blue truck picture and black border; white cards with blue truck picture; white cards with red star picture and white cards with red star and black border. Children were instructed to play the color game if there was a border and to play the shape game if there was no border. In the *advanced reverse border*, children were instructed to reverse the rule, that is, play the shape game if the card had a black border and play the color game if the card had no border.

Our sample consisted of 4½-year-olds, therefore the DCCS administration started with the *integrated color* test. If children completed five out of six trials correctly, the researcher administered the *integrated shape* test. The tests continued as long as children completed five out of six trials correctly in each dimension for color and shape. If children failed the *integrated color* test (less than five correct answers), the researcher administered the less difficult DCCS sorting tests in a predetermined order. 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. The internal consistency was determined to be very good (Kuder-Richardson = .97).

Analytic plan

Descriptive measures were first presented, followed by associations between children's sex and age, as well between mother's age and education level and the variables of interest—emotion understanding, language, IQ, ToM, inhibitory control, and set shifting. Finally, a hierarchical regression analysis with emotion understanding as the outcome variable was conducted. In the first step, mother's age was included as it was the only demographic variable found to be related with emotion understanding. In the second step, the cognitive variables, IQ and language ability, were entered as predictors, as research has highlighted the associations of these two variables not only with emotion understanding but also with ToM and EFs. In the third step, the socio-cognitive variable (ToM) was included. Finally, inhibitory control and set shifting were added in the fourth and fifth steps, respectively. They were entered separately because previous studies that are suggestive of a relation between EFs and emotion understanding used inhibitory control measures (Denham et al., 2012), thus leaving the association with set shifting open for exploration.

Table 2. Descriptive statistics and intercorrelations ($N = 75$).

	Min	Max	Range	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. Child's age (months)	53	60	7	55.05	1.53	–								
2. Mother's age (years)	26	46	20	36.84	3.60	.14	–							
3. Mother's years of education[1]	2	5	3			.07	.06	–						
4. Emotion understanding	15	32	17	25.89	4.07	.09	.36**	.07	–					
5. IQ	79	139	60	118.40	12.39	.13	.06	.20†	.32**	–				
6. Language ability[2]	46	126	80	91.47	19.61	0	.14	–.12	.47***	.44***	–			
7. Theory of mind	16.67	100	83.33	57.73	25.66	–.01	.19	.08	.23†	.10	.16	–		
8. Inhibitory control	0	38	38	23.81	11.74	.19	.24*	.26*	.35**	.41***	.29*	.12	–	
9. Set shifting	10	71	61	45.15	12.59	.26*	.10	.17	.42***	.29**	.35**	.21†	.28*	–

Note. [1]All correlations with mother's years of education are Spearman correlations. [2]Descriptives presented using PPVT-R's raw scores and correlations using the age-adjusted residual.
$^{\dagger}p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

Table 3. Hierarchical regression analysis summary for mother's age, IQ, language, theory of mind, inhibitory control and set shifting predicting emotion understanding ($N = 75$).

	R^2	(Adjusted R^2)	*F* change	*B*
Step 1:	.13	(.12)	10.91**	
Mother's age				.36**
Step 2:	.33	(.30)	10.58***	
Mother's age				.30**
IQ				.14
Language ability				.37**
Step 3:	.34	(.30)	.98	
Mother's age				.28**
IQ				.14
Language ability				.36**
Theory of Mind				.10
Step 4:	.36	(.31)	1.71	
Mother's age				.26*
IQ				.09
Language ability				.34**
Theory of Mind				.10
Inhibitory control				.14
Step 5:	.40	(.35)	4.96*	
Mother's age				.26*
IQ				.06
Language ability				.29*
Theory of Mind				.06
Inhibitory control				.11
Set shifting				.23*

$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

Results

Descriptive statistics and intercorrelations between demographics and study variables

Descriptive statistics for sample variables and their intercorrelations are presented in Table 2. Positive correlations were found between children's age and set shifting; mother's age and child's emotion understanding and inhibitory control; and mother's education level and child's inhibitory control. A marginally significant association was found between the mother's education and the child's IQ.

Children's emotion understanding was positively correlated with IQ, language ability, inhibitory control, and set shifting. Emotion understanding and ToM were marginally associated.

Predicting emotion understanding

As shown in Table 3, in step 1, mother's age emerged as a significant predictor of emotion understanding. In step 2, IQ and language ability were introduced, but only the latter was found to be a significant predictor. In step 3, ToM did not predict emotion understanding,[1] nor did inhibitory control in step 4. In step 5, set shifting emerged as a significant predictor, over and above the effect of the variables in the previous steps. The inclusion of this last variable resulted in a significant increase in R^2 from .36 to .40. Thus, of all the variables in the regression equation, three significantly predicted emotion understanding: mother's age, child's language ability, and set shifting. Children of older mothers and with better language ability and better capacities to shift mental sets are expected to have better emotion understanding.

Discussion

This empirical study aimed at exploring the relations between 4½-year-olds' executive functions—inhibitory control and set shifting—and their emotion understanding after controlling for IQ, language, and ToM. We believe that our cross-sectional research advances extant literature as we analysed the association between EFs and emotion understanding whilst controlling for important cognitive and socio-cognitive variables. To the best of our knowledge, this is the first study to examine the specific relation between set shifting and emotion understanding, a relationship that was supported by our results. Unexpectedly, however, inhibitory control did not emerge as a relevant predictor in the tested model. Further significant predictors of emotion understanding include mother's age and child's language ability.

The fact that set shifting emerged as a significant predictor of children's emotion understanding is interesting and innovative. The results indicated that, although language seems to be necessary for the development of preschoolers' EFs (Kuhn et al., 2014) and for emotion understanding (Gavazzi & Ornaghi, 2011), part of the variance regarding emotion understanding was exclusively attributed to set shifting. Similarly, bearing in mind that i) EFs and IQ, although distinct constructs (Friedman et al., 2006), entail problem solving; ii) inhibitory control relates considerably with set shifting (Diamond, 2013); and iii) ToM is, according to some, related to the development of emotion understanding (de Rosnay et al., 2004), our results showed that the possible overlap between these variables and set shifting does not fully account for the link between set shifting and emotion understanding.

To progress from a valence-based emotion understanding to a discrete categorical understanding, as is developmentally expected (Widen, 2013), children may need to develop set shifting capacities that allow for complex categorization using embedded rules. This cognitive growth may support their capacity to develop and use emotion scripts, which are also complex categories formed by the combination of different components (e.g., facial displays, situational causes, and behavioral consequences). This view, supported by longitudinal and intervention studies (Benson et al., 2013; Carlson et al., 2013; Moriguchi, 2014) and commonly referred to as the "emergence account" (Benson et al., 2013; Carlson et al., 2013), postulates that EFs are necessary for the emergence of certain socio-cognitive competences. Within this perspective, it is also possible that children who are better able to executively control their behaviors, may develop better relations with others, which, in turn, are fundamental for the development of emotion understanding (Harris, 2008). Alternatively, the "expression account" (Benson et al., 2013; Carlson et al., 2013) suggests that the association between the two variables may be due to methodological issues. The task used to assess emotion understanding requires children to infer emotions based on stories that they must decode and then to adjust their answer from story to story. As these cognitive demands may be associated with their executive function level, this may explain the relation that was found between children's performance on the emotion understanding task and set shifting. However, as DCCS is not a pure measure of set shifting (Anderson & Reidy, 2012) and as set shifting shares common features with inhibitory control and working memory (Diamond, 2013), one cannot discard the roles of other EF components.

In contrast, emotion understanding may foster the development of set shifting. Children who are better equipped to decode their own and others' emotions may be more predisposed to control their behaviors to adjust it to that of their social partners. This functioning may result in more opportunities to practice EFs, which might contribute to increased levels of performance with respect to these abilities.

Surprisingly, inhibitory control did not emerge as a predictor of emotion understanding, which conflicts with previous studies (Blankson et al., 2012; Denham et al., 2012). Indeed, the significant bivariate correlation between inhibitory control and emotion understanding did not stand when other variables were included in the model. However, bearing in mind the overlap between set shifting and inhibitory control, these results do not prove that inhibitory control is not associated with emotion understanding. There is an open debate if during preschool years it is possible to reliably identify the three core processes of EFs: inhibitory control, working memory, and set shifting (Wiebe, 2014). In fact, if these are still in a process of differentiation, our measures may not have allowed for disentangling inhibitory control and set shifting, precluding any definite conclusions regarding the role of each one. From a psychometric standpoint, we may also speculate about the specific components of inhibitory control assessed. Both measures (HTKS and DCCS) assess cognitive inhibition, given that the child has to inhibit a rule previously learned. However, HTKS also assesses behavioral inhibition (i.e., resisting acting impulsively) as the child is required to perform his/her answer through gross motor movements (e.g., "touch your toes"). It is a plausible assumption that the capacity to inhibit a script component and then shift component as outlined above may be more associated with cognitive than behavioral inhibition. Therefore, future research could benefit from enriching their design by including the different components of inhibitory control as Diamond (2013) proposes—resisting temptations, resisting acting impulsively, selective attention and cognitive inhibition—in order to clarify the relations between inhibition and emotion understanding.

In addition to EFs, children's language ability, but not their IQ, emerged as a significant predictor of emotion understanding. Two interpretative hypotheses may be advanced. On the one hand, some of the studies that evidenced a relation with IQ used high-risk samples (Bennett et al., 2005; Pears & Fisher, 2005; Sullivan et al., 2008), whereas ours uses a low-risk sample. In adverse contexts, IQ differences may have an exponential impact on children's capacities to understand emotions when they are stressed by many other difficulties. An alternate hypothesis is that script components that are first mastered throughout development may not be related with IQ, but script components associated with higher representational demands may be so. For example, Albanese et al. (2010) found that nonverbal intelligence did not predict external components of emotion understanding that included, as in our study, attributions regarding external causes of emotion, but it did predict mental (e.g., beliefs) and reflective (e.g., moral emotions) components. Furthermore, Montirosso et al. (2010) found that IQ was not associated with facial expression recognition in 4–18-year-olds.

Our study supports research accounting for the importance of language for emotion understanding. Language may be fundamental for children to engage in social interactions that are crucial for the development of emotion understanding (Gavazzi & Ornaghi, 2011), to represent emotional states, and/or to perform on emotion understanding tests (Ornaghi & Grazzani, 2013; Pons et al., 2003). Language also seems to be a necessary process for the development of EFs in preschool (Kuhn et al., 2014). Accordingly, it could be that the relation between language and emotion understanding found in prior studies was actually explained by a relation between language and EFs. Our research suggests that this is not the case because language explains a specific part of the variance of emotion understanding that is over and above the predictor role of mother's age and set shifting. Furthermore, this investigation highlights that the association of language with emotion understanding cannot be better explained by general (IQ) or specific (EFs) cognitive functioning. Therefore, language with its pragmatic component (i.e., rules for social use) may support children's capacity to understand emotional concepts that are also social in nature.

Contrary to our expectations, ToM did not emerge as a predictor of emotion understanding, which conflicts with the research that attests to the significant relation between both constructs (de Rosnay et al., 2004; Harwood & Farrar, 2006; Hughes & Dunn, 1998; O'Brien et al., 2011). This result may be explained by the task material used to assess emotion understanding—stories with typical and unequivocal situational causes of emotion where there is little (to no) conflict between what the children and the character may feel in the portrayed situation, thus requiring minimal use of mentalizing capacities. Our result is partially consistent with that of O'Brien et al. (2011), who did not find an association between unequivocal emotional reactions and ToM, though they did find an association between emotion labelling and stories evoking equivocal emotional reactions. In addition, Harwood and Farrar (2006) found a correlation between ToM and emotion understanding but highlighted that a higher correlation emerged when children were asked to predict another person's emotion when it differed from their own, rather than when it was congruent with their emotional state. Faced with our and others' results, we argue that ToM understanding may not overlap or be fundamental for the development of certain aspects of emotion understanding (cf. de Rosnay et al., 2004; Harris, 2006), specifically when children have to reason about situational causes of emotion based on desires. Nevertheless, as O'Brien et al. (2011) hypothesized, the nature of this relationship may change as children's reasoning progresses to include conflicting views and beliefs, such that ToM and emotion understanding may become intertwined later in development. This view encompasses our non-significant findings, alongside other investigations that report a relation between ToM and emotion understanding.

Finally, mother's age seems to relate to children's emotion understanding with children of older mothers demonstrating an advantage. This result seems to corroborate previous work that showed an association between an increase in mother's age and improved health and development (e.g., fewer social and emotional difficulties) for children up to 5 years of age (Sutcliffe, Barnes, Belsky, Gardiner, & Melhuish, 2012). However, contrary to existing interpretations (Sutcliffe et al., 2012), in our sample, this link cannot be accounted for by a relation to mother's higher education as neither variables was correlated. Still, one can speculate that these mothers may be more adjusted to their jobs as they have been working longer, making them more effective in balancing work and family demands. Specifically, these mothers may be more prone to interact with their children outside routine caregiving (e.g., meals) and to develop more positive interactions, while also initiating and maintaining discussions about emotions, which is known to foster emotion understanding development (Bennett et al., 2005; Harris, 2008).

A limitation of the present research is its cross-sectional design, which precludes concluding whether set shifting is necessary for emotion understanding, whether the inverse is true, or whether they are just co-occurring developmental phenomena. Furthermore, the emotion understanding assessment measure only covered one component of the emotion script (i.e., external situational causes of emotion). We framed our research in this way as we were interested in capturing individual differences co-occurring with early emotion understanding, and this is one of the first script components to be acquired when children begin to develop categorical understanding of emotions (Widen & Russell, 2010, 2011). However, these conclusions may not generalize to emotion understanding as a whole.

Given the limitations, future research should adopt a longitudinal design that assesses emotion understanding as a multicomponent phenomenon and that includes the assessing of set shifting, along with other EFs, through multiple measures. Such a research design would allow for testing the directionality of influence, that is, from set shifting to emotion understanding or vice-versa. It would also prove useful for determining whether set shifting is indeed the EF more strongly related with emotion understanding or if this is limited to the script component or the assessment measures used in this investigation.

This research provided new insights into the correlates of emotion understanding in 4½-year-olds, highlighting the specific role of set shifting. As emotion understanding is associated with numerous positive social and school-related outcomes (Harris, 2008), and inter-individual differences appear to be stable throughout childhood (Pons & Harris, 2005), this investigation may offer clues into new foci of intervention in early developmental stages.

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Note

1. An alternative model were ToM was included in the second step was also tested in order to investigate the possibility of ToM predicting emotion understanding if entered before IQ/language. Again, ToM emerged as a non-significant predictor.

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