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Emotional and effortful control abilities in 42-month-old very preterm and full-term children

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ABSTRACT

Background: Very preterm (VP) infants are at greater risk for cognitive difficulties that may persist during school-age, adolescence and adulthood. Behavioral assessments report either effortful control (part of executive functions) or emotional reactivity/regulation impairments.
Aims: The aim of this study is to examine whether emotional recognition, reactivity, and regulation, as well as effortful control abilities are impaired in very preterm children at 42 months of age, compared with their full-term peers, and to what extent emotional and effortful control difficulties are linked.
Study design: Children born very preterm (VP; < 29 weeks gestational age, $n = 41$) and full-term (FT) aged-matched children ($n = 47$) participated in a series of specific neuropsychological tests assessing their level of emotional understanding, reactivity and regulation, as well as their attentional and effortful control abilities.
Results: VP children exhibited higher scores of frustration and fear, and were less accurate in naming facial expressions of emotions than their aged-matched peers. However, VP children and FT children equally performed when asked to choose emotional facial expression in social context, and when we assessed their selective attention skills. VP performed significantly lower than full terms on two tasks of inhibition when correcting for verbal skills. Moreover, significant correlations between cognitive capacities (effortful control) and emotional abilities were evidenced.
Conclusions: Compared to their FT peers, 42 month-olds who were born very preterm are at higher risk of exhibiting specific emotional and effortful control difficulties. The results suggest that these difficulties are linked. Ongoing behavioral and emotional impairments starting at an early age in preterms highlight the need for early interventions based on a better understanding of the relationship between emotional and cognitive difficulties.

1. Introduction

Children born prematurely are at greater risk for cognitive and behavioral difficulties [1,2] which may persist during school-age, adolescence and adulthood [3,4]. Follow-up studies show that very preterm (VP) and very low birth weight (VLBW) infants are likely to exhibit poor motor, cognitive, behavioral [5,6] and socio-emotional development [7,8], all of which may entail negative consequences for their future social well-being and academic achievements [9]. Emotional and effortful control (EC) impairments are frequently reported in preterm infants. In typical children and adults, emotion and cognition appear interconnected [10]. Emotions influence cognition [11] and cognitive processes contribute to emotion regulation [12]. So far, few studies explored the emotion–cognition interplay in preterm children. These studies showed a link between emotion regulation and executive functions in children [13,14], with parent reports of child temperament correlating with individual differences in executive functions, and more specifically with EC [15]. For instance, children high in EC are less likely to express negative emotionality [16].

During the first year of life, VP children show some difficulties in regulating emotional arousal responses and in allocating and sustaining their attention [17]. Compared to full-term (FT) born peers, 12-

Abbreviations: VP, very preterm; VLBW, very low birth weight; FT, full-term.

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month-old VP infants expressed higher anger reactivity and lower fear reactivity, and showed a distinct attentional pattern with a higher initial attention level that significantly decreased throughout the experimental task [18]. Also, 24-month-old children born VP had difficulties in maintaining inhibitory control and exhibited a distinct attentional pattern compared to FT children [19]. Furthermore, parents reported VP children as having lower sustained attention and a higher level of negative affect than FT children. At an older age, sustained attention and inhibitory control have been also highlighted as potential areas of difficulty for these children [20]. Despite a clear relationship between preterm birth and later cognitive and socio-emotional risks [21], the early precursors of these difficulties and their developmental trajectory between 2 and 5 years-old in VP children remain unclear.

The present study aimed to compare the emotional and EC development in VP children at 42 months of age and in FT children of the same age. We hypothesized that VP children will perform significantly lower in tasks measuring EC and emotional abilities, as compared to FT children. Moreover, we expected that EC abilities and emotional abilities will be correlated in both populations.

2. Methods

2.1. Participants

Forty-one preterm children (23 girls, 18 boys) born before 29 weeks of gestation ($M = 26.7$; SD = 1.13), who have participated in previous assessments at 12 and 24 months of age [18,19], were examined at 42 months of age ($M = 43$ months and 22 days; SD = 2 months and 18 days) at the Division of Child Development and Growth at the University Hospital of XXX and the Child Development Unit at the University Hospital of XXX to undergo general cognitive and motor evaluation and neuropsychological assessment. Children with major brain lesions in the neonatal period (hemorrhage grade III–IV according to Papile [22]), or with mental delay (IQ < 70) were excluded. Table 1 presents the characteristics of the preterm sample. A control group (27 girls, 20 boys) of 47 FT born (>37 weeks of gestation) infants matched on chronological age ($M = 42$ months and 26 days; SD = 2 months and 18 days; $t(86) = -1.74$, $p = .08$) was also assessed. Written informed consent was obtained from the parents of each child. The study was approved by the Research and Ethics Committees of the University Hospitals, XXX and XXX. Socioeconomic status was determined according to the Largo et al.'s 12-point scale [23].

Table 1
Characteristics of very preterm children: mean (standard deviation) or count (percentage).

Characteristics	Very preterm children
Gestational age (weeks)	26.7 (1.13)
Birth weight (g)	935.76 (221.5)
SGA	4 (9.75%)
IVH grades III and IV	0
PVL	3 (7.31%)
NEC	0
PDA	5 (12.19%)
Days of ventilation	4.47 (11.53)
WPPSI III total IQ	95.43 (15.97)
WPPSI III verbal IQ	99.29 (16.3)
WPPSI III performance IQ	92.33 (18.88)
SES (Largo)	4.95 (2.15)

Note. SGA, small for gestational age (<10th percentile for birth weight as a function of GA and gender); IVH, intraventricular hemorrhage (Grade III: intraventricular with distension, Grade IV: hemorrhagic parenchymal infarction, according to Papile, Burstein, Burstein, & Koffler, 1978); PVL, periventricular leukomalacia (based on magnetic resonance imaging); NEC: necrotising enterocolitis needing surgical treatment; PDA: surgical treatment of patent ductus arteriosus; Days of ventilation ($M = 4.475$; SD = 11.53; span = 0–63), with 18 children not ventilated at all and only 5 children having spent more than 10 days with ventilation; WPPSI III, Wechsler Preschool and Primary Scale of Intelligence—Third Edition (Weschler, 2002); Largo, 6-point scale for both paternal occupation and maternal education determining the socioeconomic status; with the lowest combined SES score is 2 (signifying the highest SES), the highest 12 (Largo et al. 1989).

2.2. Outcome measures

Multiple specific tasks or standardized tests assessed different aspects of children's behavior, as described below.

2.2.1. Emotional abilities

2.2.1.1. Emotional reactivity and regulation. Two tasks were selected from the Laboratory Temperament Assessment Battery (Lab-TAB) [24] and assessed the children's reaction to fear- and anger-frustration-eliciting situations. The tasks are videotaped for later coding by two independent raters.

Mask (LabTAB): Experimenter leaves the room for 30 s, wears a scary mask and a jacket, then he walks back into the room and seats facing the child for 30 s. The child's reactions are videotaped. Intensity of fear facial expression and intensity of vocal distress were rated on a 3 point scale by interval of 5 s.

Attractive sweet in box (LabTAB): Experimenter puts an attractive cookie in a 16 × 16 cm transparent box locked with a padlock. Experimenter shows the child how to open the box with the key and locks it again. The child receives keys which do not open the box. Parent and experimenter leave the room, after encouraging the child to try to open the box to eat the cookie during their absence. Child is left for 3 min facing the camera. The intensities of facial anger expression, of bodily anger, of frustration, of sadness facial expression and of gaze aversion were rated on a 3 point scale. Protest vocalizations scored one point. These variables were scored by 10 s intervals.

2.2.1.2. Affect recognition. The subtest from the Neuropsychological Test Battery for Children—Second edition (NEPSY II) [25] assesses the ability to understand and to recognize the appropriate affect given various social contexts. In addition, we created a free labeling of emotions task using the Radboud Faces database [26].

Free labeling: The child is asked to tell "how this daddy or mommy feels" for pictures from the "Radboud Faces Database", 6 male and 6 female adult faces, presented in a random order and displaying happy, sad, angry, fearful, surprised or neutral emotions. No response option is provided. The percentage of correct responses was calculated.

Theory of Mind (TOM, NEPSY II): The child is asked to select a photograph from four options that depicts the appropriate facial expression of one of the characters in a picture depicting a social context. Percentage of correct response was calculated.

2.2.2. Effortful control

2.2.2.1. Hot and cool inhibition. The subtests were selected from the NEPSY [27] and the Effortful Control Battery (ECB) [28]. Cool inhibition is involved in problem resolution skills, decontextualized of any emotional load whereas *hot* inhibition involves an affective or motivational issue [29,30].

Tongue task (ECB) measures motivational (*hot*) inhibition. The child is asked to put a sweet on his tongue keeping his mouth open without chewing or swallowing of the sweet. The score reflects the average latency to produce one of the forbidden behaviors. This is done three times with a waiting time between trials of 20 till 40 s.

Statue (NEPSY) assesses motor persistence and *cool* inhibition. The child is asked to maintain a body position with eyes closed during a 75-second period and to inhibit the impulse to respond to sound distractors. Each motor or vocal infraction makes the score decreased.

2.2.2.2. Selective visual attention. Selective Visual Attention (NEPSY): this task assesses the speed and precision to maintain selective attention on visual stimuli. The participant has to cross out target drawings on a paper page mixed up with multiple distractors during a maximum 180-second period. Selective attention was measured by assessing the number of hits and false alarms as a function of the time to detect the maximum of targets.

2.2.3. Control variable: language

Two verbal tasks evaluated language abilities to control the role of language in emotional and EC performances.

Body part naming (NEPSY): This subtest assesses confrontation naming and name recognition, basic components of expressive and receptive language. For naming items, the child was asked to name ("What is this called?") or to designate ("Show me the ear.") the parts of the body on a figure or on his/her own body. Scores differ regarding whether the answer was given on the picture or with help of the children's own body.

Comprehension of instructions (NEPSY): this subtest is designed to assess the ability to receive, process, and execute oral instructions of increasing syntactic complexity. For each item, the child points to appropriate stimuli in response to oral instructions.

2.3. Procedure

Neuropsychological assessments were conducted by experienced psychologists. The experimental session was planned as follows: body part naming and comprehension of instructions, TOM, selective attention, statue, free labeling, attractive sweet, mask and tongue tasks. In addition, The Wechsler Intelligence Scale for Children—Third Edition (WISC-III) [31] was administered to all preterm children in order to estimate the general intellectual ability. One page general information collected facts about depression, SES, breastfeeding, day-care, ethnicity, language and smoking.

2.4. Statistical analysis

Analyses of variance (ANOVAs) with Group (FT vs. VP) as a between-subjects factor were conducted on the different scores (standardized scores or frequencies of correct responses) obtained in all tasks or tests. Regarding control verbal tasks, VP performed significantly lower than FT children, in the body parts naming task (VP: $M = 7.62$, SD = 2.24; FT: $M = 9.49$, SD = 3.01), $F_{(1,80)} = 10.06$, $p < .01$, as well as in the comprehension task (VP: $M = 10.66$, SD = 2.12; FT: $M = 11.64$, SD = 2.26), $F_{(1,86)} = 14.38$, $p < .001$. All analyses were thus run again to control for the effects of between-group differences in verbal performances using analyses of covariance (ANCOVAs) with a composite score of our verbal tasks. Finally, Spearman's correlations were carried between the seven emotional and cognitive abilities assessed in all children in the present experiment.

3. Results

3.1. Emotional and effortful control performances

Table 2 presents the emotional and EC performances of VP and FT children.

3.0.1.1. Emotional abilities

3.0.1.1.1. Emotional reactivity and regulation. VP children exhibited significantly higher scores of frustration (*Attractive sweet in a box* task) ($M = 70.91$, SD = 22.51), $F_{(1,62)} = 11.93$, $p < .001$, than FT children ($M = 52.90$, SD = 21.51), and they also expressed significantly more fear (*Mask* task) ($M = 4.47$, SD = 2.73) than FT children ($M = 3.19$, SD = 2.41), $F_{(1,55)} = 16.84$, $p < .001$.

Table 2
Emotional and effortful control performances in 42 month-old very preterm and full-term children.

	Very preterm	Full-term	Unadjusted		Adjusted model[a]	
Tasks	*M* (SD)	*M* (SD)	*F*	*p*	*F*	*p*
Emotional reactivity and regulation						
Mask	4.47 (2.73)	3.19 (2.41)	16.84	<.001	12.11	<.001
Attractive sweet	70.91 (22.51)	59.90 (22.51)	11.93	<.001	5.99	<.05
Affect recognition						
Free labeling	37.5 (25.35)	48.85 (15.33)	8.69	<.01	4.55	<.05
Theory of mind contextual	44.31 (19.93)	51.09 (22.04)	1.42	.24	.01	.90
Effortful control						
Tongue task	66.59 (24.85)	71.85 (24.52)	3.17	*.08*	4.20	<.05
Statue	10.79 (2.66)	12.92 (2.59)	6.97	<.05	4.96	<.05
Visual attention	11.31 (3.55)	11.64 (1.89)	.031	.86	.05	.83

[a] Adjusted for composite score of verbal tasks.

3.0.1.1.2. Affect recognition. VP ($M = 37.5\%$, SD = 25.35) were less accurate in naming facial expressions of emotions than FT children ($M = 48.85\%$, SD = 15.33), $F_{(1,69)} = 8.69$, $p < .01$ (*free labeling* task). On the other hand, VP children ($M = 44.31$; SD = 19.93) were not significantly different than FT children ($M = 51.09$; SD = 22.04), $F = 1.42$, $p = .24$, when asked to choose the emotional facial expression that best matched the context in which the character was presented (*TOM* task). Correlation between these two tasks was significant ($r = .25$, $p < .05$).

3.0.1.2. Effortful control

3.0.1.2.1. Inhibition. VP children ($M = 66.59$, SD = 24.85) performed the delay task marginally lower than FT children ($M = 71.85$, SD = 24.52), when the task consisted in maintaining a candy on the tongue, $F_{(1,72)} = 3.17$, $p = .08$. The VP performance was ($M = 10.79\%$, SD = 2.66) significantly lower than these of the FT children ($M = 12.92\%$, SD = 2.59) on the statue task, $F_{(1,62)} = 6.97$, $p < .05$. However, VP performed significantly lower than FT on these two inhibition tasks when correcting for verbal skills (all $p < .05$).

3.0.1.2.2. Selective attention. Results showed that VP children ($M = 11.31$, SD = 3.55) and FT children ($M = 11.64$, SD = 1.89) performed equally the selective attention task, $F < 1$.

3.0.2. Correlational analysis

Table 3 shows the correlation matrix between seven outcome measures. It revealed interesting correlations between the inhibition and the regulation tasks. The *attractive sweet* task performance and the *mask* task performance were correlated ($r = .28$, $p < .05$), while two subtests measuring inhibition were not ($r = .14$, $p = .29$). Furthermore, the performance on *the mask* task was correlated with these on the *tongue* task (*hot* inhibition) ($r = -.31$, $p < .05$), and the performance on the *attractive sweet* task was correlated ($r = -.46$, $p < .001$) with these on the *statue* task (*cool* inhibition). Finally, the two tasks assessing affect recognition were correlated with each other ($r = .25$, $p < .05$), and both were correlated with the *attractive sweet* (regulation) task ($r = -.26$, $p < .05$ and $r = -.29$, $p < .05$, respectively). The visual attention performances were not correlated with any task.

4. Discussion

The study of emotional reactivity and regulation in fear- (*mask* task) and frustration-eliciting (*attractive sweet* task) situations revealed that VP children were more intense, i.e. had more negative affect behaviors,

Table 3
Spearman's correlation matrix between seven emotional and effortful control measures.

	1	2	3	4	5	6	7
1—Mask							
2—Attractive sweet	.28*						
3—Free labeling	−.16	−.26*					
4—Theory of mind	−.04	−.29*	.25*				
5—Tongue task	−.31*	−.24	.51**	−.002			
6—Statue	.10	−.46**	.14	.14	.14		
7—Visual attention	−. 23	.11	.10	.06	.10	−.15	

Note: ***$p < .001$; **$p < .01$; *$p < .05$.

than FT children. These results are consistent with previous findings showing more intense reactions in VP [32]. Previous results on this cohort (with Lab-TAB) revealed that, at 12 months, VP infants exhibited higher reactivity in anger-eliciting situations and a reduced reactivity toward fear-eliciting situations [18], whereas no behavioral differences were reported at 24 months between VP and FT [19]. Studies on this cohort at different time-points thus reported different outcomes across development. This discontinuity in emotional difficulties may result from the child's natural transition through emotional development [33]. However, it may also result from the different experimental paradigms (and of their specific sensibilities to assess emotional difficulties) used at 12-, 24- and 42-months.

Regarding *affect recognition*, VP performed lower than FT children in the *free label of emotions* task. These findings are consistent with the preterms' difficulties in decoding facial expressions of emotions (FEE) [34]. Surprisingly, VP failed to correctly label FEE but succeeded in attributing correct FEE related to social contexts, although the former should be easier as it develops earlier than the latter [35]. Contextual information displayed in the *TOM* tasks might have helped to understand the emotional scenes [36]. These results could have practical implications, such as offering training programs for emotional skills, for instance. However, our results suggest the presence of various emotional difficulties in preterms, which could be partly connected with cognitive dysfunctions, such as EC difficulties.

Regarding EC abilities assessed through the children's skills to inhibit dominant behavioral responses and to maintain attention, VP showed more inhibition difficulties compared to FT children, while VP did not differ from FT children in the selective attention task. It has been shown that 12-month-old VP infants expressed a distinct attentional pattern with a higher initial attention level that significantly decreased throughout the experimental task [18]. In addition, difficulties in maintaining inhibitory control and in inhibiting distraction as well as unchanged level of attention through the task have been reported in 24-month children born VP (corroborating parents reports describing VP children as having lower sustained attention) [19]. Interestingly, our results are consistent with those reported earlier in the same cohort regarding inhibition difficulties, while attention impairment was not anymore observed at 42 months. However, a sustained attention task, assessing effortful control of attention, might have been more appropriate than a selective attention task to show the differences expected between VP and FT children. The poorer EC performance in addition to the poorer emotion task performance exhibited by the VP group compared with their FT peers is consistent with earlier studies suggesting simultaneous difficulties in the regulation of attention and emotion in children born preterm [37,38].

Regarding the emotion–cognition interplay, VP children exhibited emotional and inhibitory difficulties at 42 months of age, compared with their FT peers. Correlational analysis revealed some interrelations between cognitive and emotional skills. The *mask* (fear-eliciting) task was correlated with the *tongue* task (*hot* inhibition), whereas the *attractive sweet* (frustration-eliciting) task was correlated with the *statue* task (*cool* inhibition). Both correlations revealed that poorer inhibition skills are linked with more intense emotional reactivity and lower regulation skills. Furthermore, the two subtests measuring inhibition (*tongue* and *statue* tasks) were not correlated, coherently with the fact that these tasks evaluate separate, i.e. *hot* and *cool,* inhibition skills. However, the two tasks assessing emotional reactivity and regulation skills (*attractive sweet* and *mask* tasks) were correlated, both appraising reactivity and regulation to emotionally negative situations. This suggested that fear-eliciting tasks may require more *hot* inhibition skills, while *cool* inhibition would be more needed in the *attractive sweet test*. This claim is sustained by studies reporting that *Cool* inhibition is needed in problem representation and planning, i.e. a large part of the *attractive sweet* task, whereas *hot* inhibition is necessary in executive and evaluative processes, as mainly requested in the *mask* task [38,39]. Nevertheless, the key finding is that EC difficulties are interrelated with intense emotional reactivity and low regulation skills. This is consistent with the temperament theory which describes EC as the regulatory aspect of temperament that serves to modulate reactivity [15], and with the link between impaired ability to self-regulate and the emergence of behavioral problems [40,41].

Finally, there were also some interesting correlations between the affects recognition task and the regulation task. The *free labeling* task and the *tongue* task were correlated, and the *free labeling task* and *TOM* task were both correlated with the *attractive sweet* task. Affect recognition and hot aspect of EC abilities are thus interconnected. This is consistent with the idea that emotions should be firstly identified and perceived as disturbing in order to trigger emotional regulation [42]. Affect recognition difficulties in VP children might extend to their own emotions.

5. Potential limitations

Limitations to the generalizability of our findings should be acknowledged, due to the size of our sample from a previous cohort. In addition, the selective attention and the *Tom* tasks failed to show differences between VP and FT children. It is possible that these tasks were not sensitive. Thus, to further probe for the presence of attentional difficulties in VP, it would be important to assess sustained attention, assessing EC of attention.

6. Conclusion

The present study brings new insights for understanding VP children's cognitive and emotional difficulties. Firstly, these difficulties persist until the age of 42 months, although emotional skills showed a discontinuous developmental trajectory. Potential emotional difficulties in VP children should thus be evaluated at a specific period according to the development of emotional competence. This also supports planning age appropriate interventions. Secondly, the significant correlations between emotional skills and EC abilities confirmed the link between the ability to self-regulate and the behavioral responses displayed by children in emotional situations. This provided better understanding of the emotion–cognition interplay. Our results also highlight the need to include tasks focusing on the identification of emotions in the self, as well as meaning (potentially helpful) conditions in future studies. Overall, a better understanding of relative strengths and difficulties in preterms will be hugely beneficial for the design of remediation programs.

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Conflict of interest

The authors have no conflicts of interest to disclose.

Clinical trial registration

None.

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