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Temperament and attention in the self-regulation of 7-year-old children

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Abstract

The present work assessed the implications of the posterior orienting and the anterior executive attentional networks on self-regulation abilities in children through studying the relations of 7-year-old children's temperament characteristics to different forms of attentional control. Children were classified in terms of their temperament traits measured through the Children's Behavior Questionnaire. Children carried out two Stroop tasks, with and without distracting stimuli, and flanker and Stroop interference effects were calculated as measures of the orienting and the executive attentional networks, respectively. Results indicated that children scoring high in Anger, Discomfort, Sadness (only girls) and Approach-Anticipation (only girls) showed a stronger flanker interference effect, exhibiting greater difficulty to filter out the non relevant information than children scoring low did. On the other hand, children scoring high in Activity Level and Impulsivity (only girls), and low in Inhibitory Control, showed a stronger Stroop interference effect, indicating less ability to suppress prepotent behaviors under instructions. Also, patterns of interactions between some pairs of scales revealed that negative emotionality and self-regulatory aspects of temperament predicted both Stroop and flanker interference performance.

Keywords: Temperament; Attention; Self-regulation; Childhood

1. Introduction

Temperament has been conceptualized as individual differences in Reactivity and Self-regulation, which are constitutionally based and influenced through time by heredity, maturation and experience (Rothbart & Derryberry, 1981). *Reactivity* refers to responsiveness of emotional,

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activation, and arousal systems; *Self-regulation* includes processes such as approach, avoidance, and attention that serve to modulate the reactivity of the individual (Rothbart, 1989a). From this perspective, young infants are seen as highly reactive. With increasing development, their reactive processes will progressively fall under self-regulative control. This ability to regulate one's behavior in response to the cognitive, emotional and social demands of specific situations constitutes a major developmental task (Ruff & Rothbart, 1996).

According to several theoretical approaches to the development of self-regulation (Block & Block, 1980; Kopp, 1982; Rothbart, 1989b), children increase their abilities as they grow older, moving from rudimentary, rigid controls, to a flexible mechanism of adaptation that enables them to exert conscious, intentional, or effortful control to regulate their own motivational functions. This change seems to be facilitated by biological maturation and experience, and by sensitive care by parents, who give their children the opportunity to learn effective forms of control.

In understanding the mechanisms underlying the development of self-regulation, attentional networks have been given a major role. Posner and Petersen (1990) described three different and relatively independent attentional networks: the posterior, the anterior and the vigilance networks, whose maturation is proposed to be associated with the development of self-regulation skills in children. In addition, individual differences in self-regulation are expected to contribute to the variance in performing attentional tasks (Gerardi, Rothbart, Posner & Kepler, 1996). The present work will study the relevance of the first two attentional networks.

The *posterior attentional network* is involved in the orientation of attention from one location to another, and in adjusting the scale or breadth of attention. Thanks to modern neuroimaging techniques, such as positron emission tomography (PET), and through an extensive study of different patient populations, we now know that the posterior parietal lobe, the superior colliculus of the midbrain and the pulvinar nucleus of the thalamus are relevant parts of the neural circuitry constituting the orienting attentional network. Johnson, Posner and Rothbart (1991) have proposed that the development of connections between the superior colliculus and the posterior parietal cortex is responsible for the increased ability shown by 4-month-olds to disengage attention from habituated stimuli. This improvement, along with the emergence of sustained attention, enables children to concentrate their cognitive activity on other stimuli, facilitating the regulation of negative emotionality and decreasing the amount of crying and distress. Moving the focus of attention from the source of distress to other stimuli has been proven to be an efficient technique in reducing the level of arousal in situations of emotional activation in babies (Gianino & Tronick, 1988; Harman, Rothbart & Posner, 1997; Mangelsdorf, Shapiro & Marzolf, 1995). In adult studies, anxiety has also been related to longer latencies in disengaging attention from threatening stimuli (Derryberry & Tucker, 1993), suggesting that the posterior attentional network can be affected by negative emotionality.

On the other hand, the *anterior attentional network* is involved in situations that require the operation of executive control. These situations are related to planning, decision making, error correction, performing not well-learned responses, or overcoming habitual (or automatic) responses (Posner & DiGirolamo, 1998). PET studies and neuropsychological research involving mainly frontal lobe patients have revealed that the cingulate cortex and portions of the prefrontal cortex form part of this executive network of the attention system (Posner, 1995; Posner & Raichle, 1994). Vogt, Finch and Olson (1992) have proposed that the anterior cingulate cortex, due to its close connections with the motor cortex, may offer a site for the interaction between cognitive and motivational processes, especially those affecting motor output. Gerardi (1997) provided empirical evidence for this hypothesis. In her study, 36–38 months of age children were administered a Stroop-like task (identity-location conflict), and spatially compatible and incompatible conditions were run. Temperament characteristics were measured through parents' report, and Inhibitory Control, Shyness and Perceptual Sensitivity correlated negatively with the size of interference effect (reaction time), while Impulsivity correlated positively. Accuracy in compatible and incompatible trials correlated negatively with Anger.

Other studies have reported similar findings, suggesting that the tendency to low distress and impulsivity, and high adaptability and inhibitory control are associated with better attentional functioning (Caspi & Silva, 1995; Gerardi et al., 1996; Riese, 1987; Shoda, Mischel & Peake, 1990), leading us to understand attention as a multicomponent phenomenon that exerts control functions on both cognitive operations and emotional responses (Posner & Rothbart, 1998). Furthermore, since orienting and executive attentional networks are seen as different and relatively independent functions (Posner & Petersen, 1990), each network may be involved in different aspects of self-regulation. Thus, in the light of the literature above, the orienting attentional network can be expected to be related to the regulation of negative affect, such as the expression of anger or distress (Johnson et al., 1991), while the executive attentional network may be related to aspects of behavioral regulation, such as inhibitory control or impulsivity, as suggested by Vogt et al. (1992). Furthermore, given the control that the anterior network exerts over the posterior network (Posner & Raichle, 1994), the involvement of some portions of the anterior network in negative affectivity can also be expected. Empirical support for this contention comes from recent research relating some portions of the anterior cingulate cortex with performance in the emotional Stroop task (Whalen et al., 1998).

The present work sought to find evidence for implications of orienting and executive attentional networks on self-regulation abilities in children by studying the relation of 7-year-old children's temperament characteristics to different forms of attentional control. In line with theories about self-regulation (Kopp, 1982; Rothbart, 1989b) that place the major developmental changes in infancy and preschool years, the period of childhood can offer us the possibility to study stable individual differences in self-regulation tendencies without other confounding effects such as the different developmental rates. Moreover, the drastic increase in emotional arousal associated with puberty and adolescence has not appeared yet.

One more reason to study this period comes from the attentional task selected in the present work: the Stroop task. We chose this task because it has been considered as a paradigmatic measure of selective attention since Stroop (1935) showed that in order to respond to the task-relevant stimulus dimension (the ink color), participants had to simultaneously ignore the task-irrelevant but prepotent stimulus dimension (the word). When naming the color of incongruent words (e.g., the word RED in a blue color), participants have difficulty ignoring the intrusive effects of the words, producing worse performance (longer reaction times, and/or more errors) than in a neutral condition in which participants name the color of meaningless stimuli (e.g., a string of colored Xs). The Stroop interference effect is obtained by comparing performance in the incongruent condition with respect to the neutral condition. This effect reflects the operation of high-level attention required whenever habitual responses (e.g., reading) must be suppressed to allow less habitual responses (e.g., color naming) to be performed. Recent neuroimaging studies have revealed that the Stroop effect is associated with activation in brain areas including the cingulate cortex (Pardo, Pardo, Janer & Raichle, 1990) or prefrontal cortex (e.g., the left inferior frontal gyrus, Taylor, Kornblum, Lauber, Minoshima & Koepper, 1997), that are thought to reflect the operation of executive attention. It can only be investigated from age 6–7 years, coinciding with the necessary reading skills that make semantic processing an automatic process, and with maturation of the frontal and prefrontal cortices involved in the executive control of information processing.

A second version of the Stroop task in which the Stroop stimulus (color word or colored Xs) was flanked by distractor words was also used. Previous studies have shown that responses to targets are hindered when targets are presented flanked by distracting information, an effect that has been called Eriksen-type or flanker interference (Eriksen & Eriksen, 1974; Eriksen, 1995). As mentioned above, selecting the task-relevant and ignoring the task-irrelevant dimension of Stroop stimuli may reflect the operation of executive attention that is measured by means of the Stroop interference effects, whereas selecting a target among distractors may reflect a filtering operation attributed to the orienting network of the attention system and measured by means of flanker interference effects. Further support for the involvement of the posterior network in the present flanker task comes from a PET study by LaBerge and Buchsbaum (1990). The authors observed increased activity in the pulvinar nucleus of the thalamus in a condition that presented the target letter surrounded by distractors (a similar condition to the present target + distractor task). Thus, we think that the pulvinar is involved when attention has to be narrowed to the target location, which might help to limit distraction by the flankers. In addition, although the anterior and posterior networks are contemplated as mainly independent, they are thought to be hierarchically organized in such a way that the anterior network would command the posterior network functioning (Posner, 1988). It means that certain involvement of the anterior network is expected in the flanker task. Also, Stroop and flanker interference effects are expected to be related.

In summary, 7-year-old children classified in terms of their temperament traits, carried out the two Stroop task versions. Stroop and flanker interference effects were expected to be associated differently in relation to temperament characteristics.

2. Method

2.1. Participants

In the present study 134 children (71 boys and 63 girls) from the Spanish schools Francisco de Goya (Almería), Lope de Vega (Almería), and San Buenaventura (Murcia) participated. All children were aged 7 years and were enroled in the second grade of primary school. No one had participated in a related study, nor reported problems in identifying colors. At the time of the tests, all had normal or corrected-to-normal vision. None had evidenced reading or learning problems.

2.2. Instruments

2.2.1. Measurement of children's temperament

A version of the Children's Behavior Questionnaire (CBQ; Rothbart, Ahadi, Hershey & Fisher, 2000) translated into Spanish was used to measure the children's temperament. This questionnaire provides caregivers' responses to 195 items describing their children's behavior in a variety of everyday life situations. Each item reflects a statement about children's feelings and behavior and responses related on a Likert-type seven-point scale ranging from 'totally false' to 'totally true'. Scale scores include the following dimensions:

- *Activity Level*: level of gross motor activity including rate and extent of locomotion.
- *Anger/Frustration*: amount of negative affect related to interruption of ongoing tasks or goal blocking.
- *Approach Anticipation*: amount of excitement and positive anticipation for expected pleasurable activities.
- *Attentional Focusing*: tendency to maintain attentional focus upon task-related channels.
- *Discomfort*: amount of negative affect related to sensory qualities of stimulation, including intensity, rate or complexity of light, movement, sound, texture.
- *Falling Reactivity and Soothability*: rate of recovery from peak distress, excitement, or general arousal.
- *Fear*: amount of negative affect, including unease, worry or nervousness related to anticipated pain or distress and/or potentially threatening situations.
- *High Intensity Pleasure*: amount of pleasure or enjoyment related to situations involving high stimulus intensity, rate, complexity, novelty and incongruity.
- *Impulsivity*: speed of response initiation.
- *Inhibitory Control*: the capacity to plan and to suppress inappropriate approach responses under instructions or in novel or uncertain situations.
- *Low Intensity Pleasure*: amount of pleasure or enjoyment related to situations involving low stimulus intensity, rate, complexity, novelty and incongruity.
- *Perceptual Sensitivity*: detection of slight, low intensity stimuli from external environment.
- *Sadness*: negative affect and lowered mood and energy related to exposure to suffering, disappointment and object loss.
- *Shyness*: slow or inhibited approach in situations involving novelty or uncertainty.
- *Smiling and Laughter*: positive affect in response to changes in stimulus intensity, rate, complexity, and incongruity.

2.2.2. Attentional measures

Two computerized versions of the Stroop task were used. The targets were the words ROJO (red), AZUL (blue), and VERDE (green) and a string of four Xs, displayed in red, blue, or green color. The color words served in the incongruent condition [e.g., the word ROJO (red) in blue color], and the string of Xs as the neutral condition. The congruent condition [e.g., the word ROJO (red) in red color] was not included in this study because the congruent trials might bias children to read the word instead of the color in those trials that presented words as targets, with the possibility of a higher rate of errors.

In the *target-alone* task, target displays contained only the target and participants were required to name the target color. In the *target+distractor* task, target displays contained the target flanked by the distractor word NEGRO (black) in white color, appearing above and below the target. Children were told to name the color of the target and to ignore the flankers.

2.3. Procedure

For the Stroop tasks, stimuli were presented on a color monitor (VGA) of an IBM compatible computer and responses were recorded per trial by means of a voice-key interfaced to the parallel port of the computer. Stimuli were presented in the middle of the video screen after a plus sign lasting 500 ms that served as the fixation point. The target display remained on the screen until the participant responded. Participants were asked to name the color of the target, the experimenter entered a code for later coding of performance accuracy. After 2000 ms, a new trial began with the presentation of the fixation point. In each single-trial task, participants carried out one block of 72 trials. The first 12 trials were practice trials and data from these trials were not included in the data analysis. The remaining 60 trials were experimental trials and there were 30 trials for the neutral XXXX condition (10 trials per color), and 30 trials for the incongruent condition (10 trials per color). Participants performed the target-alone task first and then the target + distractor task.

The CBQ was explained to mothers in a meeting to which all the parents were invited to attend. Those who did not attend the meeting received the questionnaire in a later interview. All the mothers filled out CBQ at home within a two-weeks interval after their children accomplished the attentional assessment.

2.4. Data analysis

A preliminary analysis was conducted to assess the general Stroop interference effect. It was essential that seven-year-old children show this effect to determine which temperament dimensions are related to the different kinds of attentional control measures. A 2×2×2 mixed ANOVA with sex (boys vs girls) as the between-subjects factor, and task (target alone vs target with distractors) and condition (neutral vs incongruent) as the within-subjects factors, were conducted irrespective of scoring on the CBQ.

We also conducted correlational analyses to assess relationships between the Stroop interference and flanker interference effects. Difference-score measures of Stroop interference (incongruent−neutral) were computed on data from the two tasks and these scores were used to compute correlations among Stroop effects from the different tasks.

Children were split into two groups according to the median value in each temperament dimension. Participants scoring below or above the median were categorized as *low* or *high* on each temperament dimension, respectively. In addition, children were also classified in terms of their scores on pairs of temperament scales. Although it was not a main objective in this study, gender differences were also addressed, since previous literature has shown differences in boys' and girls' temperament and in the implications these differences have in several aspects of social and cognitive functioning (Kohnstamm, 1989).

Two measures of interference were obtained from the task versions: Stroop and flanker interference effects. Stroop interference was calculated for both reaction time and error percentage by averaging the Stroop effect in each task (target alone and target with distractors). We used the following equations:

Stroop (target alone) = incongruent (target alone)−neutral (target alone)
Stroop (distractors) = incongruent (distractors)−neutral (distractors)
Stroop Interference = [Stroop (target alone) + Stroop (distractors)]/2

By subtracting the neutral from the incongruent conditions we measured the extent to which the incongruent word interfered with naming the color.

Flanker interference was obtained by averaging reaction times and errors in both tasks using the following equations:

Average (target alone) = [incongruent (target alone) + neutral (target alone)]/2
Average (distractors) = [incongruent (distractors) + neutral (distractors)]/2
Flanker Interference = average (distractors)−average (target alone)

By subtracting the target alone task from the target + distractor task we measured the extent to which distractors interfered with responses to the target.

Mixed 2×2 ANOVAS with sex (boys vs girls) and temperament scores (low vs high) as the between-subjects factors were conducted for each temperament dimension on each one of the two interference measures: Stroop interference and flanker interference. We also looked at specific interactions between pairs of temperament scales in predicting performance in the attentional tasks.

3. Results

3.1. General Stroop effects

Table 1 shows the mean of median reaction times and percentage of errors for the two versions of the Stroop task.

Results of reaction times showed main effects of task and condition [$F(1,132) = 57.3$, $P < 0.0001$; and $F(1,132) = 310.8$, $P < 0.0001$, respectively]. Reaction times were shorter in the target alone task than in the target with distractors task (1043 vs 1128 ms) and shorter in the neutral than in the incongruent condition (996 vs 1174 ms). These effects were also significant in the error analyses. The percentage of errors was lower in the target alone task than in the target with distractors task (4.7 vs 5.7%) and lower in the neutral than in the incongruent condition (3.3 vs 7.1%) [$F(1,132) = 6.47$, $P < 0.025$; and $F(1,132) = 88.7$, $P < 0.0001$, respectively]. No sex effects

Table 1
Mean of median reaction times and percentage of errors for the stroop tasks as a function of sex and condition[a]

	Boys		Girls	
Task and condition	RT	PE	RT	PE
Target alone task				
Neutral	948	3.0	953	3.2
Incongruent	1141	6.2	1129	6.4
Target with distractors task				
Neutral	1048	3.6	1036	3.6
Incongruent	1213	8.1	1214	7.5

[a] RT = reaction time; PE = percentage of errors.

proved significant, either with reaction times or errors. Thus, we observed both Stroop and flanker interference effects. Importantly, the effects did not interact with each other.

3.2. Correlations between Stroop measures and between Stroop and flanker interference

Pearson product-moment correlational analyses between the Stroop interference obtained through the target alone task, and the Stroop interference measured through the target with distractor task proved significant for both reaction times and errors ($r = 0.38$, $P < 0.0001$; and $r = 0.20$, $P < 0.025$, respectively).

Stroop and flanker interference effects correlated with each other both for reaction times ($r = 0.37$, $P < 0.0001$) and for errors, though this last finding was only marginally significant ($r = 0.15$, $P < 0.08$).

3.3. Relations between temperament dimensions and Stroop and flanker interference effects

Table 2 shows the results of the Stroop and the Flanker interference effects. Data are presented for boys and girls who scored low or high in each temperament dimension.

3.3.1. Stroop interference data

Temperament dimensions found associated significantly with Stroop interference effects are graphed in Fig. 1. Reaction time data analyses showed that the main effects of score in the Activity Level and the Inhibitory Control temperament dimensions were statistically significant [$F(1,130) = 4.4$, $P < 0.05$; and $F(1,130) = 6.23$, $P < 0.025$, respectively]. Participants scoring high in Activity Level and low in Inhibitory Control showed greater levels of Stroop interference effects. There was also a main effect of score on the Impulsivity dimension [$F(1,130) = 6.12$, $P < 0.025$]. Participants with high scores showed a greater Stroop interference effect than participants with low scores in Impulsivity. However, this finding was modulated by the significant Sex×Score interaction [$F(1,130) = 4.47$, $P < 0.05$], indicating that the difference in Stroop interference between high and low scores was true for girls [$F(1,61) = 11.10$, $P < 0.01$], but not for boys ($F < 1$). Error data analyses did not show any significant pattern of results.

An additional pattern of results was obtained when children were classified in terms of their scores in pairs of temperament scales. Attentional Focusing and Soothability interacted significantly when the Stroop interference effect was the dependent variable [$F(1,130) = 5.67$, $P < 0.025$]. Children scoring low in both scales showed the strongest Stroop effect, and children scoring high in Attentional Focusing and low in Soothability showed the smallest effect. Inhibitory Control and Anger also interacted with each other in predicting the Stroop effect [$F(1,130) = 5.11$, $P < 0.05$]. Children scoring low in Inhibitory Control and high in Anger showed the strongest interference effect. Finally, we also found a significant Activity Level×Shyness interaction [$F(1,130) = 4.75$, $P < 0.05$]. Children scoring low in Activity Level and high in Shyness showed the smallest Stroop effect.

3.3.2. Flanker interference data

Temperament dimensions found related significantly to flanker interference effects are graphed in Fig. 2. Reaction time data analyses showed main effects of score for the Anger and the Discomfort

Table 2
Stroop and Flanker interference as a function of sex and scores in temperament dimensions[a]

	Interference measures							
	Stroop interference				Flanker interference			
	Low		High		Low		High	
Temperament dimensions and sex	RT	PE	RT	PE	RT	PE	RT	PE
Activity level								
Boys	137	4.0	208	3.8	69	1.7	98	0.9
Girls	171	4.1	185	3.0	89	0.7	77	0.8
Anger								
Boys	184	3.8	175	3.9	77	1.3	95	1.2
Girls	174	3.5	181	3.7	51	1.8	128	−0.7
Approach								
Boys	162	4.1	197	3.6	92	0.4	80	2.2
Girls	165	3.9	192	3.1	47	0.9	131	0.6
Attentional focusing								
Boys	197	3.6	164	4.1	80	1.1	92	1.4
Girls	183	3.6	170	3.6	80	0.3	87	1.3
Discomfort								
Boys	176	3.5	183	4.2	57	0.9	119	1.6
Girls	160	3.3	191	3.8	69	0.6	95	0.9
Soothability								
Boys	195	3.3	166	4.3	84	0.6	88	1.7
Girls	177	4.0	177	3.2	67	0.0	99	1.5
Fear								
Boys	171	3.8	188	4.0	69	1.1	104	1.4
Girls	183	4.4	171	2.8	93	1.0	74	0.5
High intensity pleasure								
Boys	171	2.5	186	5.1	75	0.6	97	1.8
Girls	177	3.6	177	3.5	92	0.6	74	0.9
Impulsivity								
Boys	175	3.6	183	4.2	70	1.5	102	1.0
Girls	134	4.4	224	2.6	62	0.8	106	0.7
Inhibitory control								
Boys	214	4.1	149	3.7	106	1.8	70	0.8
Girls	193	3.9	158	3.2	97	0.8	67	0.7
Low intensity pleasure								
Boys	186	4.5	174	3.4	79	0.0	91	2.1
Girls	163	3.1	195	4.3	87	0.1	79	1.7
Perceptual sensitivity								
Boys	193	3.2	166	4.5	81	0.5	91	1.9
Girls	177	4.1	177	2.9	72	0.8	98	0.7

(continued on next page)

Table 2 (*continued*)

	Interference measures							
	Stroop interference				Flanker interference			
	Low		High		Low		High	
Temperament dimensions and sex	RT	PE	RT	PE	RT	PE	RT	PE
Sadness								
Boys	170	4.7	188	3.0	95	1.5	78	1.0
Girls	171	3.8	184	3.3	47	1.5	125	−0.1
Shyness								
Boys	176	3.9	182	3.8	114	1.0	60	1.4
Girls	205	3.8	146	3.3	96	1.6	69	−0.1
Smiling and laughter								
Boys	177	3.8	188	4.5	82	0.9	112	3.0
Girls	172	3.8	201	2.7	76	0.6	118	1.5

[a] Low = score below the median. High = score above the median. RT = reaction time. PE = percentage of errors.

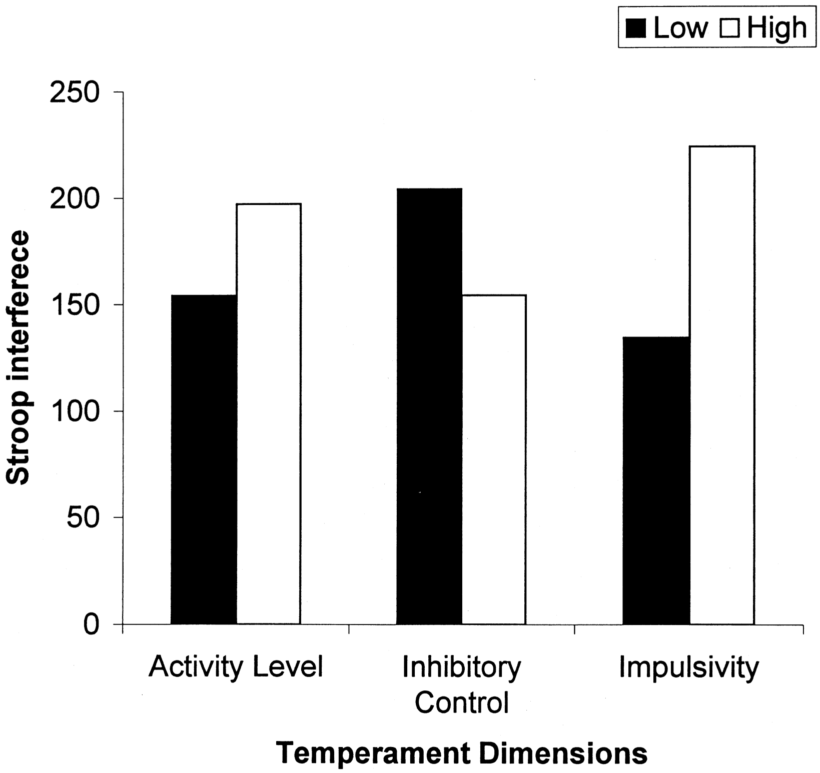

Fig. 1. Stroop interference effects as a function of temperament dimensions.

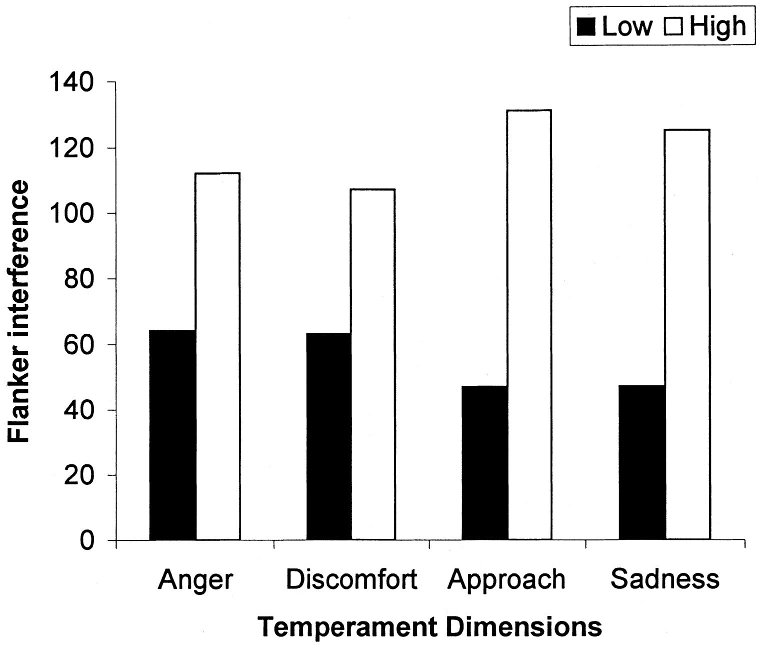

Fig. 2. Flanker interference effects as a function of temperament dimensions.

dimensions [$F(1,130)=4.54$, $P<0.05$, and $F(1,130)=3.96$, $P<0.05$, respectively]. Participants with high scores showed greater flanker effects than participants with low scores in the above dimensions. There were also significant Sex×Score interactions for the Approach Anticipation and the Sadness dimensions [$F(1,130)=4.73$, and $F(1,130)=4.64$, both $P<0.05$, respectively]. In both cases, the differences between high and low scores were found for girls [$F(1,61)=7.12$, $P<0.01$, and $F(1,61)=6.02$, $P<0.025$, respectively]. Differences for boys were not significant for both dimensions ($F<1$). Error data analyses did not show any significant pattern of results.

Some combinations between pairs of temperament scales resulted also significantly to predict this kind of attentional control. Thus, Inhibitory Control interacted significantly with Anger and Shyness [$F(1,130)=7.44$, $P<0.01$; and $F(1,130)=6.62$, $P<0.025$, respectively]. These interactions revealed that children scoring high in Anger and low in IC showed the largest flanker interference effect. On the contrary, children scoring high in both Shyness and Inhibitory Control demonstrated an extremely low flanker effect. Shyness also predicted performance in the attentional task but only when Activity Level was low, and higher scores on Shyness were related to a lower flanker interference, and the opposite was also true. Finally, Activity Level interacted with Sadness, and children scoring high on both Activity Level and Sadness showed a larger flanker effect.

4. Discussion

The present work sought to find evidence for implications of the posterior orienting and the anterior executive attentional networks on self-regulation abilities in children through studying the relation of 7-year-old children's temperament characteristics to different forms of attentional control. More specifically, children classified in terms of their temperament traits carried out two Stroop tasks, and flanker and Stroop interference effects were calculated as measures of the orienting and the executive attentional networks, respectively. The orienting network would be involved in operations necessary to filter out irrelevant information when participants are required to respond to targets in the presence of distractors (LaBerge & Buchsbaum, 1990; Posner & Raichle, 1994).The executive network would be involved in operations necessary to resolve the conflict produced by task-irrelevant but prepotent properties of target stimuli (word meaning) when participants are required to name less well-learned but task-relevant properties of them (i.e., the color) (Posner & Raichle, 1994).

A preliminary analysis showed that boys and girls show interference from color words when performing the different versions of the Stroop tasks. These results confirm previous studies that found Stroop effects with children aged 7 years (Bonino & Ciairano, 1997; Schiller, 1966). Importantly, the Stroop effect was similar for the two versions of the task, the target alone task and the target with distractors task. That is, the Stroop interference effect did not seem to be affected by the presence of distractors compared with when target stimuli were presented alone.

Stroop and flanker interference effects were correlated positively with each other, suggesting that both types of attentional networks form part of a common attentional system (Fuentes, Vivas & Humphreys, 1999; Posner, 1988; Posner, Inhoff, Friedrich & Cohen, 1987; Posner & Raichle, 1994). Nevertheless, the results showed that these two effects did not interact. This suggests that the attentional networks involved in the Stroop and flanker interference, that is, executive and orienting attentional networks respectively, involve different and relatively independent attentional processes, as suggested by Posner and Petersen (1990).

More support for this interpretation comes just from our results related to temperament characteristics, in that each network has been found related to several CBQ dimensions that can be associated with different underlying motivational systems. Thus, as hypothesized, the orienting attentional network was correlated chiefly with negative affect. In our study, a higher tendency to Anger, Discomfort, Sadness (only girls) and Approach-anticipation (only girls) was related to a stronger flanker interference. Children described by their mothers as more prone to anger and discomfort responses took longer to respond to targets when distractors were present, showing more difficulty in filtering the non relevant information in the task than children with low scores in anger and discomfort. The relationship between the orienting attentional network and the negative affect has been already reported in the work of Harman, Rothbart and Posner (1997), where infants in mild distress were soothed by moving their attention to other neutral stimuli. In adult studies, anxiety has been related to performance in orienting attentional tasks (Derryberry & Reed, 1994). Sadness and Approach-anticipation were also associated with flanker interference for girls. Although the dimension of approach anticipation implies a positive emotion, this dimension, along with Sadness, Anger, Discomfort, Fear and Soothability (loading negatively) loaded together in a cluster called Neuroticism in factor analyses of the CBQ (Rothbart et al., 2000). This factor reflects the expression of negative emotionality and is consistent with the superfactor of Negative Affectivity or Neuroticism identified in structural examinations of adult personality (Eysenck & Eysenck, 1985; Tellegen, 1985).

On the other hand, the executive attentional network recruited by our classic Stroop task, was associated with aspects of behavior regulation. Children described by their mothers with low

Inhibitory Control showed a stronger Stroop interference effect. In order to respond accurately at the Stroop task, the individual needs to inhibit a prepotent behavior (to read the word) and permit a less dominant one (to name the color). Consequently, children with higher Inhibitory Control, that is, with a greater ability to suppress inappropriate approach responses under instructions, are expected to perform better in the executive attentional task. Attentional Focusing was also related to performance in the Stroop task, but just in combination with Soothability. Children difficult to soothe, showing also lesser attentional focusing abilities, exhibited a greater Stroop effect. Attentional Focusing, Soothability and Inhibitory Control, altogether, have a positive loading in a factor called Effortful Control found on CBQ (Rothbart et al., 2000), which has been postulated to be linked to executive attention (Derryberry & Rothbart, 1997).

Impulsivity is also expected to influence performance in the attentional task, because a strong tendency to initiate responses may lead children to a greater conflict in the Stroop task. In our study, we found that high impulsivity was associated with a stronger Stroop interference effect, although this was true only for girls. Similar associations were found by Gerardi (1997) in relating Inhibitory Control and Impulsivity measured through CBQ to individual differences in performing a Stroop-like task in preschool years. In addition, we found that children with a high Activity Level showed a greater Stroop interference effect, suggesting that high motor arousal may interfere with the performance of the executive attentional task. This dimension, along with Impulsivity and Inhibitory Control (loading negatively), covers the aspects of motor arousal and approach tendencies included in the Surgency or Extraversion factor found in CBQ (Rothbart et al., 2000). This factor has conceptual similarities to the Behavioral Activation System (Gray, 1991), and the activation of approach behaviors in the presence of reward signals.

A more complex and richer picture about temperament-attention relations emerged when we looked at some combinations between pairs of temperament scales. Interactions between negative affect and self-regulatory systems were found associated with both executive and orienting attentional networks. Thus, the Inhibitory Control-Anger combination predicted Stroop interference performance. Children scoring low in Inhibitory Control and high in Anger showed a stronger Stroop interference. This finding is in consonance with previous literature reporting the relation of negative affect to the anterior attentional network (Gerardi, 1997; Whalen et al., 1998), and is to be expected from some theoretical frameworks (Derryberry & Rothbart, 1997; Vogt et al., 1992), as commented above. Interestingly, children with high levels of Anger, exhibiting also high Inhibitory Control, did not show a lesser attentional control. These results suggest that the influence of anger tendencies on executive attention is being modulated by the own individual self-regulatory skills. Finally, Shyness interacted with Activity Level in predicting Stroop interference effect. Children scoring high on Shyness and low on Activity Level showed the lowest Stroop interference. It is not surprising that high levels of shyness, conceptualized as "slow or inhibited approach in situations involving novelty or uncertainty", are related to a better attentional control, because it is a component of the so-called "passive inhibition" (Kagan, 1989), which seems to facilitate the development of self-regulation skills (Kochanska, DeVet, Goldman, Murray & Putnam, 1994).

Concerning flanker interference, the interaction Inhibitory Control-Anger appeared significant again. As before, children scoring high on Anger and low on Inhibitory Control showed the strongest flanker interference. This time, the influence of behavioral regulation abilities was modulated by the levels of negative affect, since Inhibitory Control did not predict differences in performance in the flanker effect when anger tendencies were low. Given the control that the anterior network exerts over the posterior network (Posner & Raichle, 1994), it is not surprising that self-regulatory aspects of temperament, associated mainly with executive attention, influence the orienting attentional network. The interactions found between Shyness and Inhibitory Control, and Shyness and Activity Level in predicting flanker interference, can be explained in that sense.

In conclusion, this work further explores the relations between attentional and motivational systems, finding differential associations for orienting and executive attentional networks, to the expression of negative emotionality and to behavioral regulation, respectively. Interactions between negative emotionality and self-regulatory aspects of temperament in predicting both Stroop and flanker interference showed the complexity of temperament-attention relations and can be explained by the connections between the anterior and the posterior attentional networks. It is also worth noting that some temperament characteristics were associated with attentional control only for girls. These findings can be understood in line with previous studies in which authors have shown that temperament characteristics interact differently in boys and girls, so that different consequences for their cognitive, social, and emotional development can be derived (Colder & Stice, 1998; Fabes, Shepard, Guthrie & Martin, 1997; Kochanska, Murray, Jacques, Koenig & Vandegeest, 1996).

Our findings support a conception of attention as a multicomponent phenomenon that can exert control functions on both cognitive operations and emotional responses (Posner & Rothbart, 1998), but also defends a broad concept of temperament, where regulatory as well as emotional aspects have a major role (Rothbart & Bates, 1998). A further understanding of temperament-attention relationships will come from advances in cognitive neuroscience linking psychological mental processes to brain functioning (Posner & Raichle, 1994). In the present study, gender differences clearly reveal the necessity of integrating biological, socialization, and developmental factors in undertaking this endeavor.

Focused on 7-year-old children, this work also extends previous research in relating temperament characteristics to individual differences in attentional control in childhood. Since the results shown here are in consonance with previous studies on other periods of the life span, they can be helpful in the task of achieving a coherent corpus of knowledge relating cognitive and motivational mechanisms.

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