

Title: ADHD and ODD symptoms in toddlers: common and specific associations with temperament dimensions.

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## **Abstract**

The aim of this work was to study the relationship between temperament and signs of psychopathology in typically developing toddlers. More specifically, ADHD and ODD symptoms were separately analyzed in connection with fine-grained temperament dimensions. The sample was composed of 65 toddlers (33 boys, 32 girls) aged between 18 to 35 months ( $M = 25,54$ ;  $SD = 5,07$ ). Mothers reported toddlers' temperamental characteristics and ADHD/ODD symptoms using the Spanish version of The Early Childhood Behavior Questionnaire and the Child Behavior Checklist respectively. Bivariate correlations showed a similar pattern of associations of temperament in connection with ADHD and ODD symptoms. Higher levels of negative emotionality (fear, frustration, sadness, motor activation) and approach tendencies (activity level, high-intensity pleasure) were associated with more ADHD and ODD symptoms, whereas lower levels of inhibitory control were related to more ADHD and ODD manifestations. Bivariate correlations also informed of unique associations: lower levels of soothability were only associated with higher ODD symptoms, whereas lower attentional focusing and low-intensity pleasure were related with higher ADHD symptoms. Additionally, regression models included different temperament dimensions in explaining the variance of ADHD and ODD symptoms in toddlers. ADHD was predominantly associated with attentional focusing and motor activation whereas ODD was most closely related to frustration. Results found in this study in a community sample of toddlers are in consonance with previous research carried out at other developmental stages; studying early correlates of psychopathological manifestations enable us to identify children at-risk who could benefit from prevention and early intervention programs.

**Keywords:** ADHD, ODD, temperament, toddlers

## 1. Introduction

Children's behavior problems are considered a major risk for future maladaptation and mental health problems (Liu, 2004). Therefore, examining early predictors and the first signs of behavior problems is crucial for identifying the pathways through which these manifestations appear and establish, and for designing prevention and/or intervention programs.

Temperament traits have been demonstrated as useful early markers in investigating the roots of developmental psychopathology (Martel, Gremillion, & Roberts, 2012). Temperament has been defined as constitutionally based individual differences in reactivity and self-regulation, in the domains of affect, activity, and attention (Rothbart & Derryberry, 1981; Rothbart & Bates, 1998). For the measurement of temperament in children, observational procedures -including naturalistic and structured laboratory observations-, are available, but parents' reports constitute the strategy most widely used because they are inexpensive to develop, administer, and analyze; make use of parents' extensive observations of their children in varied contexts; and allow the study of multiple variables (Rothbart & Bates, 2006).

Following a fine-grained approach, the questionnaires developed under Rothbart's (1989; 2011) framework enable multiple components of temperament to be considered simultaneously. At the same time, efforts for identifying underlying broad constructs have revealed three higher-order structures in infancy and early childhood named Negative Emotionality, Surgency, and Effortful Control (Gartstein & Rothbart, 2003; Putnam, Gartstein, & Rothbart, 2006; Rothbart, Ahadi, Hershey, & Fisher, 2001), with conceptual resemblance to those generated in personality research (e.g., Cloninger, Przybeck, Svrakic, & Wetzel, 1994; McCrae & Costa, 1999).

Negative Emotionality includes dimensions based in individuals' susceptibility to negative affect, with factor analytic studies showing primary loadings of anger, fear, discomfort or sadness scales, as well as a lack of soothability. It is conceptually similar to, and has been shown to correlate with the Big-five factor of Neuroticism (Rothbart, Ahadi, & Evans, 2000). Despite the common core shared by the fine-grained dimensions, the components are not expected to act in the same direction in connection with externalizing problems. For an instance, the model by Frick & Morris, (2004) predicts that high levels of anger in response to real or perceived provocations would lead to disruptive behaviors, such as aggression, whereas low levels of fear when confronted with novel or dangerous stimuli, and low sensitivity to punishment, would be linked to conduct disorders.

Surgency reflects individual differences in approach systems, and combines a disposition towards positive emotions (including a preference for high intensity stimuli) with rapid approach to potential rewards and high activity level. This factor has been related to Extraversion (Rothbart et al., 2000). It also bears similarity to the Behavioral Activation System (Gray, 1990), a neurologically-based system activated by stimuli signaling reward and non-punishment, as well as Cloninger's dimension of novelty seeking, as it reflects behavioral activation in response to novelty, reward, or avoidance of punishment (Cloninger et al., 1994). High activation of the approach systems has been suggested to underlie externalizing problems, as individuals with strong sensitivity to rewards may react strongly when rewards are blocked (Fowles, 2001).

Effortful control reflects individual differences in executive functioning and covers voluntary and willful self-regulation abilities such as attentional focus and inhibitory control; as well as tendencies for perception of low-intensity stimuli and enjoyment of low arousal activities. This factor has been linked with the Conscientiousness domain of personality (Ahadi & Rothbart, 1994). Given its role of regulating dispositional reactivity, low levels of effortful control are expected to be involved in the manifestation of externalizing behaviors (Rothbart & Bates, 2006).

Growing evidence suggests that disruptive behaviors have their roots in early childhood (Hyde, Shaw, & Hariri, 2013; Shaw & Gross, 2008; Waller & Hyde, 2017), but correlates can be found even earlier. In our previous work (González-Salinas, Sánchez-Pérez, Fuentes, Montiroso, & Heinonen, 2019) with data from 14 different countries, it was reported that toddlers' higher dispositions for Negative Emotionality and Surgency were associated with more externalizing symptoms, whereas better Effortful Control was related to lower levels of externalizing. In this earlier work we adopted a "broad" strategy of measurement, wherein temperament was considered at the level of undifferentiated higher-order constructs, and toddlers' symptoms of psychopathology were grouped under the broadband label of "externalizing problems". However, by adopting a fine-grained approach we can better capture the implications of specific individual dispositions for different developmental disorders. In the present study, we aimed to identify connections between temperament and psychopathology symptoms in toddlers, with temperament measured at the level of fine-grained dimensions. Two externalizing disorders are considered, namely Attentional Deficit Hyperactivity Disorder (ADHD) and Oppositional Defiant Disorder (ODD).

ADHD is defined as a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development, present prior to 12 years of age (American Psychiatric Association, 2013). Previous studies showed that high levels of fine-grained temperament traits associated with negative emotional reactivity, including anger (Einziger et al., 2018) and sadness (González-Salinas et al., 2012), were predictive of ADHD in children (Foley, McClowry, & Castellanos, 2008; Martel, Gremillion, Roberts, Zastrow, & Tackett, 2014). Highly activated approach systems, reflected in high Surgency (Martel et al., 2014), activity level (Einziger et al., 2018; Foley et al., 2008), impulsivity (Donfrancesco et al., 2015; Foley et al., 2008), approach-sociability (Forbes, Rapee, Camberis, & McMahan, 2017), and novelty seeking (Donfrancesco et al., 2015; Purper-Ouakil et al., 2010), were also associated with ADHD symptoms. Low levels of effortful self-regulation, including Conscientiousness (Herzhoff, Smack, Reardon, Martel, & Tackett, 2017), Effortful Control (Martel et al., 2014), and fine-grained aspects, such as attentional/behavioral control/persistence (Bussing et al., 2003; Foley et al., 2008; Forbes et al., 2017), also pose risk with respect to ADHD.

ODD is described as a persistent pattern of anger and irritability, along with oppositional, defiant and hostile behavior towards adults and authority figures (American Psychiatric Association, 2013). Similarly to ADHD, ODD was associated with high negative reactivity, including high scores in Negative Affect (Lavigne, Gouze, Hopkins, Bryant, & LeBailly, 2012) and Neuroticism (Herzhoff & Tackett, 2016), irritability, anger, quickness to feel frustrated (Hoffenaar & Hoeksma, 2002; Stringaris, Maughan, & Goodman, 2010; Erdogan, Benga, & Marină, 2017), and also sadness (Erdogan et al., 2017). Furthermore, high activation of the approach systems

manifested in high Surgency and impulsivity (Erdogan et al., 2017), as well as novelty seeking (Bai & Lee, 2017; Kim et al., 2010; Melegari et al., 2015), were linked with ODD symptoms. ODD was also associated with lower levels of Effortful Control (Lavigne et al., 2012; Erdogan et al., 2017) and Conscientiousness (Herzhoff et al., 2017), as well as low attentional shifting and inhibitory control (Erdogan et al., 2017).

The similarity of temperament associations for ADHD and ODD is quite apparent. Are there specific temperament profiles that characterize distinct risk for ADHD and ODD? Although scarce, a few studies have addressed this question. Karalunas, Gustafsson, Fair, Musser, and Nigg (2019) found that school-age children diagnosed with ADHD were more likely to present comorbid ODD if they exhibited high levels of Negative Emotionality. Additionally, Bai and Lee (2017) identified daring behaviors, or tendencies to enjoy risky or novel experiences, as unique predictors of ODD symptoms two years later, independently of baseline ADHD diagnostic status. Kim et al. (2010) found that children diagnosed with ODD, in comparison to a group demonstrating ADHD, scored higher in persistence, self-directness, and cooperativeness, and lower in harm avoidance. In a study by Melegari et al. (2015), preschoolers assigned to an ODD group were characterized as higher in persistence and harm avoidance compared to children with ADHD. Also in the preschool period, Martel et al., (2012) found that, whereas Negative Emotionality and Surgency were positively associated with both ODD and ADHD symptoms, Effortful Control was negatively associated with ADHD symptoms only. These studies addressing both common and specific relations of temperament in connection with ADHD and ODD have tended to rely on broad temperament attributes. Explorations of this issue at the fine-grained level are lacking.

In summary, ODD and ADHD have shown a common pattern of associations, with temperament characterized by high levels of negative emotionality and approach tendencies, and low levels of effortful self-regulation. The search for specific relations is scarce, but suggests negative emotionality and approach tendencies as discriminative of ODD whereas low effortful control, especially persistence, uniquely associated with ADHD. Although tentative, these results suggest that discrete personality or temperament traits could be useful in disentangling disorder heterogeneity (Tackett, Daoud, De Bolle, & Burt, 2013). Our study is aimed at identifying the common and specific relations of fine-grained temperament dimensions in connection with first signs of ADHD and ODD in a sample of typically developing toddlers, consistent with research suggesting that disorders such as ADHD and ODD may be better captured by continuous dimensions than a categorical diagnosis (Martel et al., 2012).

In consonance with theory and previous research, fine-grained components of negative emotionality (e.g., frustration, sadness, low soothability) and surgency (e.g., activity level, high intensity pleasure) will be positively associated with ADHD and ODD symptoms, whereas elements of effortful control (e.g., attentional focusing, inhibitory control) will be negative related to both disorders' symptoms. However, in the search for the best model explaining ADHD symptoms, the attentional focusing component of effortful control will appear as most relevant, whereas the ODD model will include expressions of negative emotionality, especially anger frustration, and approach tendencies, such as high intensity pleasure.

## **2. Method**

## 2.1. Participants

The participants are part of a broader study aimed at studying child characteristics and parental behaviors (see Gartstein & Putnam, 2019, for details). Families of typically developing toddlers living in the Region of Murcia (SE; Spain) were contacted through day-care centers and the Psychology Faculty Facebook page of the University of Murcia. Initially, families of 78 toddlers agreed to participate, but we did not include data from 16 children due to the following issues: the same family contributed information for more than one child (6), the parents did not return any of the distributed questionnaires (3), or children were receiving special educational services (4). Data collected for 65 (33 boys) toddlers were included in this study. Children's ages ranged from 18 to 35 months ( $M = 25,54$ ;  $SD = 5,07$ ).

In terms of parents' education, 9.4% of the mothers were educated at the elementary school level, 19.5% at the high school level, and 59.6% at the university level. For fathers, the analogous percentages were: 17.3%, 23.1% and 59.6% respectively. Mean RDSI<sup>1</sup> was 58.2 (range from 10 to 97), with a predominance of medium-high SES among the families.

## 2.2. Measures

2.2.1. A Spanish version of The Early Childhood Behavior Questionnaire (ECBQ; Putnam et al., 2006) was completed by mothers. This parent-report instrument was designed to assess temperament between 18 and 36 months of age and has proved robust psychometric properties across cultures (Gartstein & Putnam, 2018) as well as predictive (Putnam, Rothbart, & Gartstein, 2008), and construct validity (Gartstein, Putnam, & Rothbart, 2012). It consists of 201 items rated on a 1-7 Likert-type scale, ranging from *never* (0) to *always* (7), to reflect the frequency of the child demonstrating specific behaviors in commonly-occurring situations. The items comprised 18 scales: Discomfort, Fear, Sadness, Frustration, Motor Activation, Perceptual Sensitivity, Shyness, Soothability, Activity Level, High-intensity Pleasure, Sociability, Positive Anticipation, Inhibitory Control, Attention Focusing and Shifting, Low-intensity Pleasure, and Cuddliness. Cronbach's alphas for the scales in our sample ranged between .64 and .92. See Table 1 for more detailed information.

Table 1. ECBQ scales, definitions, number of items and Cronbach's alpha for the sample of this study.

Scale	Definition	Number of items	Cronbach's alpha
Discomfort	Amount of negative affect related to sensory qualities of stimulation, including intensity, rate or complexity of light, sound, texture.	10	.80
Fear	Negative affect, including unease, worry, or nervousness related to anticipated pain or distress and/or potentially threatening situations; startle to sudden events.	11	.77

<sup>1</sup> RDSI: Revised Duncan Sociometric Index (Stevens & Featherman, 1981).

Frustration	Negative affect related to interruption of ongoing tasks or goal blocking.	12	.74
Sadness	Tearfulness or lowered mood related to exposure to personal suffering, disappointment, object loss, loss of approval, or response to other's suffering.	12	.78
Motor Activation	Repetitive small-motor movements; fidgeting.	11	.73
Perceptual Sensitivity	Detection of slight, low intensity stimuli from the external environment.	12	.87
Shyness	Slow or inhibited approach and/or discomfort in social situations involving novelty or uncertainty.	12	.81
Soothability	Rate of recovery from peak distress, excitement, or general arousal.	9	.78
Activity Level/Energy	Level (rate and intensity) of gross motor activity, including rate and extent of locomotion.	8 <sup>2</sup>	.65
High-intensity Pleasure	Pleasure or enjoyment related to situations involving high stimulus intensity, rate, complexity, novelty and incongruity.	12	.86
Impulsivity	Speed of response initiation.	10	.64
Positive Anticipation	Excitement about expected pleasurable activities.	11	.82
Sociability	Seeking and taking pleasure in interactions with others.	8	.88
Attentional Focusing	Sustained duration of orienting on an object of attention; resisting distraction.	12	.81
Attentional Shifting	The ability to transfer attentional focus from one activity/task to another.	12	.64
Inhibitory Control	The capacity to stop, moderate, or refrain from a behavior under instruction.	12	.90
Low-intensity Pleasure	Pleasure or enjoyment related to situations involving low stimulus intensity, rate, complexity, novelty and incongruity.	11	.77
Cuddliness	Child's expression of enjoyment in and molding of the body to being held by a caregiver.	12	.92

2.2.2. Mothers responded to the Spanish version of the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2000) for ages 18 months to 5 years. It contains 100 items that assess behavior problems. Reliability and validity of this instrument are well established (Achenbach & Rescorla, 2000). Mothers endorsed whether the sentences described her child's behavior quite often (2), sometimes (1), or whether it did not

<sup>2</sup> The original number of items (n=12) brought out an unsatisfactory index of internal consistency ( $\alpha = .56$ ). After examining item-test correlation, items (n= 4) with a poor correlation with the scale ( $r < .20$ ) were removed.

describe her child's behavior (0). For the purpose of this study, we selected the DSM-oriented scales for ADHD ( $\alpha = .70$ ) and ODD ( $\alpha = .62$ ) as dependent variables.

### 2.3. Procedure

The study was approved by the Ethics Committee of the University of Murcia. Parents contacted through the day-care centers were given personal letters informing about the objectives and procedures of the study, including an informed consent form. For parents who agreed to participate, an envelope containing a socio-demographic questionnaire, the ECBQ, and the CBCL, was given by the toddlers' teachers. Once the mothers filled out the questionnaires, they returned them to the day-care center, where a member of our staff picked them up. A second envelope containing additional questionnaires (not used in the current paper) regarding parenting philosophy and practice was sent later during the academic year. For parents contacted through the internet, letters were sent and returned by post-mail. In all cases, parents could contact a research assistant by phone with any inquiry.

### 2.4. Data analyses

The data analytic strategy consisted of several sequential steps. First, independent t-tests were conducted to examine potential sex differences for the two dependent variables. Second, bivariate correlations between toddlers' ADHD and ODD scores and temperament traits were computed. Once significant associations between CBCL variables and specific temperament scores were obtained, multiple regression analyses were undertaken to examine the independent effects of the significant temperament traits on ADHD and ODD scores.

## 3. Results

### 3.1. *t*-test analyses

Independent t-test analyses did not reveal significant sex differences for the ADHD or ODD scores;  $t(63) = 0.46$ ,  $p = .646$  and  $t(63) = 0.44$ ,  $p = 0.663$ , respectively. Therefore, child sex was not included as a covariate in further analyses.

### 3.2. Zero-order correlations

Zero-order correlation analyses were conducted to elucidate significant associations between ADHD and ODD variables and the fine-grained temperament traits. Results showed that both ADHD and ODD symptoms were associated with higher levels of fear, frustration, sadness, motor activation, activity level, high-intensity pleasure, and lower levels of inhibitory control. On the other hand, lower soothability was significantly associated with ODD, but not ADHD; whereas lower levels of attentional focusing and low-intensity pleasure were associated with ADHD but not ODD (see table 2).

Table 2. Correlations between ECBQ and CBCL scales.

Temperament Scale	Externalizing disorder scale	
	ADHD	ODD
Discomfort	.17	.07
Fear	.32**	.28*



Frustration	.30*	.41**
Sadness	.26*	.29*
Motor Activation	.41**	.29*
Perceptual Sensitivity	-.07	-.14
Shyness	.17	.07
Soothability	-.14	-.29*
Activity Level	.41**	.39**
High-intensity Pleasure	.26*	.28*
Impulsivity	.23	.06
Positive Anticipation	.11	.01
Sociability	-.11	-.21
Attentional Focusing	-.45***	-.06
Attentional Shifting	-.15	-.18
Inhibitory Control	-.42***	-.33**
Low-intensity Pleasure	-.34**	-.24
Cuddliness	-.12	-.21

Note. \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$

### 3.3. Multiple regression analyses

In order to study the independent contributions of toddlers' temperament traits to ADHD and ODD scales, two stepwise multiple regression analyses were conducted including as predictors those temperament dimensions that were previously significantly correlated with ADHD/ODD scores.

The first multiple regression analysis was performed to examine specific associations between toddlers' temperament characteristics and ADHD symptoms. The results of the model,  $F(2,61) = 11.70$ ,  $p < .001$ ,  $R^2_{adj} = .25$ , revealed that attentional focusing and motor activation were significant concurrent predictors (see table 3).

The second model was computed to analyze specific relations between toddlers' temperament variables and their ODD scores. In this case, results,  $F(1,62) = 12.14$ ,  $p = .001$ ,  $R^2_{adj} = .15$ , showed that only toddlers' frustration was a significant predictor of ODD scores (see table 3).

Table 3. Results of the multiple regression analyses to predict ADHD and ODD scores with toddlers' temperament traits.

<b>DV: ADHD symptoms</b>			
	$\Delta R^2_{adj}$	$\hat{\beta}$	$p$
<b>Model 1</b>	.18		<.001
Attentional Focusing		-.44	<.001
<b>Model 2</b>	.07		<.001
Attentional Focusing		-.34	.004
Motor Activation		.31	.010
Fear		.19	.085
Low Intensity Pleasure		-.18	.127
Inhibitory Control		-.17	.178

Sadness		.14	.222
Activity Level		.16	.254
Frustration		.10	.423
High intensity pleasure		.07	.567
<b>DV: ODD symptoms</b>			
	$\Delta R^2_{adj}$	$\beta$	<i>p</i>
<b>Model 1</b>	.15		.001
Frustration		.41	.001
Activity Level		.24	.061
High Intensity Pleasure		.20	.089
Motor Activation		.16	.204
Fear		.16	.210
Soothability		-.15	.259
Inhibitory Control		-.11	.460
Sadness		.07	.641

Note:  $\beta$  = standardized coefficients

#### 4. Discussion

The aim of this work was to study the relationship between temperament and signs of psychopathology in typically developing toddlers. More specifically, ADHD and ODD symptoms were separately analyzed in connection with temperament dimensions as reported by mothers. Correlational analyses brought out commonality of associations for ADHD and ODD symptoms in relation to the majority of temperament scales. However, step-wise regression models brought out specific associations: ADHD was predominantly associated with attentional focusing and motor activation, whereas ODD was most closely related to frustration.

##### 4.1. Correlational results

Higher levels of ADHD and ODD symptoms were associated with higher scores on several subcomponents of Negative Emotionality and Surgency, and lower scores on aspects of Effortful Control. These findings largely replicate, in terms of the direction and magnitude of connections between fine-grained measures of temperament and externalizing problems, those found previously by Gartstein, Putnam, and Rothbart (2012) in a community sample of children from the U.S., studied longitudinally from infancy to preschool years. The present findings are also consistent with results reported by Martel, Gremillion, & Roberts (2012), wherein preschoolers diagnosed of developmental behavioral disorders (including ADHD and ODD symptoms) were characterized by higher negative affect and surgency, and lower effortful control, compared with preschoolers without disorders.

Scales addressing expression of Negative Emotionality, including anger/frustration, fear, sadness, and motor activation, were found to be positively related to ADHD and ODD symptoms. High levels of proneness to anger, quickness to become frustrated and irritability contribute to manifestations of externalizing disorders and are considered signs of emotional dysregulation (Barkley, 2013; Ezpeleta, Granero, de la Osa, Penelo, & Domènech, 2012; Karalunas et al., 2014). Contrary to expectations (e.g. Frick and Morris, 2004), fear was positively associated with ADHD and ODD symptoms. Although high levels of fear and sadness are typically associated with internalizing

rather than externalizing problems, a considerable proportion of children diagnosed of ODD and ADHD show concomitant symptoms of anxiety and depression (Boylan, Vaillancourt, Boyle, & Szatmari, 2007; Elia, Ambrosini, & Berrettini, 2008). Finally, motor activation refers to the presence of repetitive small movements, such as fidgeting, and has been previously associated with externalizing disorders in toddlers and preschoolers (Gartstein et al., 2012).

In contrast with these commonalities in associations of Negative Emotionality dimensions with ADHD and ODD, soothability was significantly related only to ODD. This finding replicates previous research; for instance, in results reported by Ezpeleta et al. (2012), an irritable losing temper component of ODD was associated with low soothability in preschoolers. Collectively, these results can be understood in the context of children with ODD symptoms also demonstrating difficulties with emotional regulation (Schoorl, Van Rijn, De Wied, Van Goozen, & Swaab, 2016). Concerning ADHD, a relative lack of association between soothability and ADHD has been shown in other studies. For instance, prior research did not identify a significant difference in soothability between infants with familial risk for ADHD and controls (Auerbach et al., 2008), or a contribution of soothability to prediction of ADHD symptoms (Sullivan et al., 2015).

For the scales that constitute the construct of Surgency, positive correlations were found between activity level, high intensity pleasure, and ADHD/ODD symptoms. Activity level refers to the rate and intensity of gross motor activity and locomotion, and high levels of activity have been associated with ADHD in the preschool period (Bussing et al., 2003; Foley et al., 2008; McIntosh & Cole-Love, 1996). Concerning ODD, Stringaris, Maughan, and Goodman (2010) found that preschool children with high levels of activity (altogether with high negative emotionality) were more likely to develop ODD at school-age compared to those low in these traits. High intensity pleasure covers enjoyment related to situations involving high stimulus intensity, rate, complexity, novelty and incongruity. This preference for high arousal positive stimulation and novelty seeking is central in the construct of Gray's model (1981) Behavioral Activation System (BAS) and involves sensitivity to reward. A highly activated BAS would be involved in externalizing disorders (Colder & O'connor, 2004). In this line, our results are consistent with previous studies supporting that children diagnosed with ODD (Kim et al., 2010) and ADHD (Donfrancesco et al., 2015; Pelaz, Pérez, Herráez, Granada, & Ruiz, 2014) show higher novelty seeking compared to typically developing children.

Turning to Effortful Control scales, attentional focusing, inhibitory control and low-intensity pleasure correlated negatively with ADHD symptoms. Attentional focusing and inhibitory control provide the foundation of Effortful Control (Rothbart, 2011) and reflect individual differences in executive control at the cognitive and behavioral level respectively. Similarly to ours, Auerbach et al. (2008) reported that infants at risk for ADHD were rated as having significantly lower levels of inhibitory control than the comparison group. Moreover, Einziger et al. (2018) showed that Effortful Control during the preschool years was negatively associated with ADHD symptoms in adolescence in a non-clinical male sample. Furthermore, Martel, Gremillion, Roberts, Zastrow, & Tackett (2014) reported that poor Effortful Control in the preschool years was related to hyperactivity/impulsivity symptoms one year later. Low-intensity pleasure covers enjoyment of situations involving low arousal, and low levels of this dimension were previously associated with externalizing symptoms (Garstein et al.,

2012) and with ADHD (González-Salinas et al., 2012). ADHD symptoms could be generated by insufficient inhibitory control relative to the strength of activation (Ruff & Rothbart, 1996), preventing children from engaging in low-arousal pleasurable activities. In the case of ODD, inhibitory control was negatively associated to it, in consonance with previous studies (e.g., Ezpeleta et al., 2012; Erdogan et al., 2017). More generally, Lavigne, Gouze, Hopkins, Bryant, and LeBailly (2012) found a strong association between Effortful Control and ODD symptoms in 4-years-old community children. As suggested by Bates, Pettit, Dodge, and Ridge (1998), low effortful abilities in conjunction with strong approach tendencies could explain young children's resistance to control, as their weak inhibitory competencies likely prevent them from controlling actions when required by adults, resulting in difficulties learning rules and raising the risk for behavior disorders.

Collectively, our bivariate correlation results indicate that toddlers with more ADHD and ODD symptoms show higher approach tendencies, experience more negative emotions, and exhibit poorer self-regulation abilities. As suggested by Barkley (2013), deficits associated with emotion regulation can explain in part the considerable comorbidity between ADHD and ODD.

#### **4.2. Stepwise regression results**

Stepwise regression model results obtained for ADHD included two temperament dimensions: attentional focusing and motor activation. Attentional focusing is defined as the ability for sustained attention on an object or activity, resisting distraction. Attentional deficits constitute one of the key aspects for ADHD diagnosis (American Psychiatric Association, 2013). Moreover, this inattention interferes with the effortful actions required to downregulate the emotional state of the child to enable age-appropriate and socially acceptable behavior (Barkley & Murphy, 2010), which likely explains further consequences in childhood for adjustment in the academic and social context (Sánchez Pérez & González Salinas, 2013).

Motor activation is referred to the presence of repetitive motor movements, such as tics or restlessness associated with problems in dopamine release and reuptake, and has been identified in the ADHD clinical population (Mahone, Bridges, Prahme, & Singer, 2004). The latter has been interpreted as repetitive movements facilitating an optimal arousal state by regulating the physiological and psychological state of alertness and permitting an optimal use of cognitive resources (Mahone et al., 2004).

The stepwise regression model with ODD as the dependent variable indicated that frustration alone contributed to explaining variance in toddlers' symptoms. Previous research had consistently found the association of anger proneness in young children and the expression of ODD symptoms in community samples (Erdogan et al., 2017; Ezpeleta et al., 2012). An over-reactivity in response to interruption of ongoing tasks or goal blocking is identified as a symptom of ODD (American Psychiatric Association, 2013), and has been explained by poor executive control, failing to modulate the expression of emotion, consequential in terms of an adverse impact on behavior problems (Eisenberg et al., 2005; Rothbart, Ellis, Rueda, & Posner, 2003). Unexpectedly, although correlated, individual differences in the approach systems as reflected by the dimensions of activity level and high-intensity pleasure, did not contribute additional variance in the explanation of ODD symptoms. This is probably due to an effect of multicollinearity of the predictors; evidence supports the view that

anger relates to an appetitive or approach motivational system, given that individuals with high approach tendencies tend to exhibit strong anger reactions (Carver & Harmon-Jones, 2009).

### **4.3. Limitations**

A number of limitations should be noted in this study. First, our sample included only a small number of participants, primarily from the middle/upper-middle socioeconomic level. Second, the concurrent data collected for the purposes of this study do not allow us to draw any conclusions regarding longitudinal predictions of later externalizing symptoms based on toddlers' temperamental traits. Third, we cannot rule out the possibility that our findings connecting temperament to externalizing symptoms have been impacted to some extent by conceptual overlap among measures for these constructs. Some researchers have cautioned that relations between temperament and maladjustment may be caused by overlap in item content (Sanson, Prior, & Kyrios, 1990); however, later empirical findings indicated that links between temperament and behavior problems remain even after "decontamination" of measures (Lemery & Essex, 2002; Lengua, West, & Sandler, 1998; Oldehinkel, Hartman, De Winter, Veenstra, & Ormel, 2004). Fourth, the data gathered were derived from questionnaires completed by mothers, which may arise some concerns about shared rater variance. In this regard, Kagan (1994) argued that research on children's characteristics including personality, present potential sources of bias in caregiver-report questionnaires. These concerns are at least partially addressed in the ECBQ through use of items that ask only about recently occurring events and inquiring about concrete child behaviors rather than asking parents to make abstract or comparative judgments (Rothbart, 2011; Rothbart & Goldsmith, 1985). Moreover, ECBQ external validation is supported by studies showing that ECBQ scales are related to physiological indicators, such as resting heart rate and respiratory sinus arrhythmia (Li, Deater-Deckard, Calkins, & Bell, 2017) and observational measures (e.g., parental practices; Laurin & Joussemet, 2017).

### **4.4. Future research**

An important direction for future research involves the employment of empirical evidence showing the associations between toddlers' temperament and externalizing symptoms to early identify children at risk of developing ADHD or ODD. Furthermore, this knowledge would facilitate the development of preventive programs to be implemented prior to the escalation of symptoms, and to design a more modular treatment approach based on the toddlers' temperament profiles.

### **5. Acknowledgments**

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