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**Short Title:** TEMPERAMENT, PEER SOCIAL PROCESSES AND ANTISOCIAL BEHAVIOR & SUBSTANCE USE

**Full Title:** Developmental Pathways Linking Childhood Temperament with Antisocial Behavior and Substance Use in Adolescence: Explanatory Mechanisms in the Peer Environment

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### Abstract

This study investigated three developmental pathways involving the peer environment that may explain how certain temperamental dispositions in childhood may become manifested in later antisocial behavior and substance use. A total of 411 (52% boys) Canadian children were followed annually from ages 6 to 15 years. The study tested whether the temperamental traits approach, negative reactivity and attention (assessed at ages 6-7 years), were associated with overt antisocial behavior, covert antisocial behavior and illicit substance use (assessed at ages 14-15 years), via poor social preference among peers, inflated social self-perception and antisocial behavior of peer-group affiliates (assessed throughout ages 8-13 years). Results indicated that negative reactivity was indirectly associated with overt antisocial behavior and substance use via poor social preference. Specifically, negative reactivity in earlier childhood predicted poor social preference in later childhood and early adolescence. This poor social standing among peers, in turn, predicted more engagement in overt antisocial behavior but less substance use in later adolescence. Over and above the influence of social preference, negative reactivity predicted engagement in all three outcomes via children's antisocial behavior in childhood and early adolescence. Inflated social self-perception and antisocial behavior of peer-group affiliates did not mediate the link between temperament and the outcomes under scrutiny. No sex differences in developmental pathways from temperament to the outcomes were found. To further our understanding of the developmental link between childhood temperament and

later antisocial behavior and substance use, we need to recognize the role of peer environmental factors, specifically peer preference among peers.

Keywords: temperament; peer environment; antisocial behavior; substance use; developmental pathways

The study of childhood temperament has been put forth as a promising avenue for understanding the etiology of behavioral problems within the externalizing spectrum, including overt antisocial behavior, covert antisocial behavior and illicit substance use (for overviews, see De Pauw, 2010; Nigg, 2006; Shiner & Caspi, 2003). A key question in this area of research is *how* temperamental traits may lead to these problematic and undesirable behaviors. In the present study, we studied a sample of 411 Canadian children who were followed annually from age 6 to 15 years, to test whether childhood temperamental traits were associated with children's difficulties with mastering three key developmental tasks that involve the peer environment, namely 1) establishing a positive position in the peer-group, 2) forming a realistic social self-perception, and 3) affiliating with a group of friends that encourages healthy behavioral adjustment (Masten & Coatsworth, 1998; Sroufe, Egeland, Carlson, & Collins, 2009). We tested whether difficulties in mastering these key tasks may explain the link between children's temperament and later engagement in antisocial behavior and illicit substance use.

### **Childhood Temperament and Pathways to Overt Antisocial Behavior, Covert Antisocial Behavior and Illicit Substance Use**

Temperament refers to “early emerging basic dispositions in the domains of activity, affectivity, attention and self-regulation, and these dispositions are the product of complex interactions among genetic, biological and environmental factors across time” (Shiner et al., 2012, p. 437). Individual differences in temperament are organized in a hierarchical way. That is,

certain temperamental traits (i.e., lower-order traits) show covariance which is explained by broader underlying dimensions of temperament (i.e., higher-order dimensions; Shiner et al., 2012). Although there is still debate on which dimensions best describe children's temperamental characteristics, researchers generally agree that the vast majority of temperamental characteristics in childhood is captured by the three higher-order dimensions 'effortful control', 'positive emotionality/surgency', and 'negative emotionality' (Rothbart, 2007; Shiner et al., 2012). Effortful control refers to children's ability to focus their attention and detect errors, plan their course of action, show inhibitory control and derive pleasure from low-intensity activities. This construct includes lower-order traits like task persistence, attentional focus and ability to suppress inappropriate responses. Positive emotionality/surgency reflects children's affinity with engaging with others, their sociability, activity level and pleasure derived from high-intensity activities. This construct includes lower-order traits such as the tendency to approach novel situations and unfamiliar people (also known as behavioral disinhibition), the tendency to be attracted to adventurous activities and the tendency to easily smile and laugh. Lastly, negative emotionality refers to the tendency to experience frustration, fear, discomfort and sadness, as well as being hard to sooth. This construct includes lower-order traits like the tendency to express negative reactivity to sensory stimuli such as pain, light, texture or sounds and the intensity of this negative reaction, the tendency to experience unease, worry or nervousness, the tendency to show lowered mood when exposed to suffering or disappointment and having difficulties with recovering from distress or general arousal (Coplan & Bullock, 2012; Rothbart, 2007; Shiner et al., 2012).

In the present study we investigated differences in the temperamental traits 'attention span', 'approach', and 'negative reactivity', which comprise part of the aforementioned higher-

order dimensions ‘effortful control’, ‘positive emotionality/surgency’ and ‘negative emotionality’, respectively (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006; Goldsmith, Rieser-Danner, & Briggs, 1991; Rothbart, 2007). Differences in these temperamental traits have been related to various distinct - although related - behavioral problems within the externalizing spectrum, including antisocial behavior and substance use (for an overview of studies addressing the comorbid nature of antisocial behavior and substance use, see e.g., Clark, 2005; Krueger, Markon, Patrick, Benning, & Kramer, 2007; McGue, Irons, & Iacono, 2014). Specifically, differences in effortful control, positive emotionality/surgency and negative emotionality have been associated with overt forms of antisocial behavior, like aggression (Becht, Prinzie, Deković, Van den Akker, & Shiner, 2015; Burt & Donnellan, 2008; Wang, Chassin, Eisenberg, & Spinrad, 2015), covert forms of antisocial behavior, like vandalism and theft (Becht et al., 2015; Carrasco, Barker, Tremblay, & Vitaro, 2006) and illicit substance use, like drug use and alcohol use by minors (Burt & Donnellan, 2008; Dick et al., 2013).

Several authors have theorized about the pathways through which temperamental traits may lead to later antisocial problems and substance use (X. Chen & Schmidt, 2015; Nigg, 2006; Shiner & Caspi, 2003). According to the vulnerability model, certain temperamental traits may set in motion a cascade of negative processes, eventually putting children at risk for developing antisocial behavior and illicit substance use (De Bolle, Beyers, De Clercq, & De Fruyt, 2012; Nigg, 2006). According to this viewpoint, the interplay between temperament and the daily environment that children encounter is key. For instance, temperament may influence how children learn from, elicit reactions from, interpret, compare themselves with, select and manipulate their social environment (for overviews, see Hasenfratz, Benish-Weisman, Steinberg, & Knafo-Noam, 2015; Shiner & Caspi, 2003). In the present study we focused on three of these

processes, namely environmental elicitation, social comparison and environmental selection, with regard to one of the most important contexts for behavioral development for school-aged children, that is, the world of peers (Rubin, Bukowski, & Bowker, 2015; Rubin, Bukowski, & Parker, 2006).

The process of *environmental elicitation* indicates that children's temperament may shape the responses of their peers (Shiner & Caspi, 2003), which in turn may influence the development of antisocial behavior and substance use. As said, establishing a positive position within the peer-group is an important developmental task for school-aged children (Hasenfratz et al., 2015; Sroufe et al., 2009). Temperamental traits may influence how children are perceived by their peers, thereby influencing these children's position within the peer-group through the process of environmental elicitation. Indeed, empirical findings indicate that temperamental traits reflective of or related to negative reactivity, low attention and low approach are linked to poor social preference among peers and related constructs (for an overview, see Coplan & Bullock, 2012). Poor social preference (i.e., a sociometric measure that captures how much a child is disliked relative to being liked by peers; Coie, Dodge, & Coppotelli, 1982) has been found to be a robust predictor of subsequent behavioral problems within the externalizing spectrum (Ladd, 2006; Sturaro, Van Lier, Cuijpers, & Koot, 2011), possibly because of the missed opportunities for positive socialization by normative peers or the resentment that follows peer rejection.

The process of *social comparison* indicates that temperament may shape the way children evaluate themselves relative to others (Shiner & Caspi, 2003), thereby potentially influencing the development of problematic behaviors. Indeed, there is some (indirect) evidence supporting the hypothesis that children's temperament may influence whether they exhibit a more congruent or an inflated self-perception. For example, it has been found that higher levels of inattention are

associated with a positive illusory bias of children's social acceptance among peers (Scholtens, Diamantopoulou, Tillman, & Rydell, 2012). In turn, various studies have found that children who have an overly positive self-perception of their social status, meaning that they overestimate their social standing relative to their actual social standing among peers, may be at risk for engaging in overt antisocial behavior (Lynch, Kistner, Stephens, & David-Ferdon, 2016; Orobio de Castro, Brendgen, Van Boxtel, Vitaro, & Schaeppers, 2007; Stephens, Lynch, & Kistner, 2015). Although the processes through which an overly positive self-perception of one's social standing may lead to future antisocial behavior remain to be investigated, one possibility is that children who hold biased perceptions may retaliate against peers who challenge these perceptions by acting in aggressive ways (Lynch et al., 2016).

The process of *environmental selection* suggests that temperament may shape children's choices about their day-to-day environment, including choices about with whom they do and do not (want to) affiliate (Shiner & Caspi, 2003). This, in turn, may influence antisocial behavior development and substance use. For example, children may want to affiliate with peers who are like them, potentially because they have similar (negative) temperamental characteristics. Indeed, in a study of adolescents, Steca and colleagues (2007) found that adolescents with an undercontrolled temperament (which included temperamental traits reflective of – in part – high negative reactivity, low attention and high approach) as well as children with an overcontrolled temperament (characterized by – in part – low approach, low attention and high negative reactivity) both had more friends who engaged in antisocial behavior and substance use, compared to resilient, well-adjusted children (which included temperamental traits reflective of low negative reactivity, high attention and high approach). Thus in this study, negative reactivity and low attention were associated with affiliation with deviant peers. More recently, low

attention has also been associated with antisocial peer-group affiliation in adolescence, as well as in young adulthood (Kendler, Myers, & Dick, 2015; Li, Newman, Li, & Zhang, 2016). For the temperamental trait approach the results are more inconsistent. That is, both high and low levels of this trait have been associated with affiliation with antisocial peers (Kendler et al., 2015; Li et al., 2016; Steca et al., 2007). Multiple studies have indicated that affiliation with antisocial peers is a salient risk factor for engaging in antisocial behavior and using illicit substances (Forgatch, Patterson, Degarmo, & Beldavs, 2009; Keijsers et al., 2012). This link is potentially explained by modeling of deviant behaviors, coercive interactions such as interacting in an aggressive way, and deviancy training such as talking about, rehearsing and receiving positive social evaluation of deviant acts (Dishion, Kim, & Tein, 2015; Salazar et al., 2015).

Furthermore, previous studies have shown that indicators of environmental elicitation, social comparison and environmental selection may relate differently to various distinct, although related, forms of externalizing behaviors. For instance, poor social preference and related constructs have been associated with overt antisocial behavior such as aggression, but seem less strongly associated with covert antisocial behavior such as vandalism and theft (Barnow, Lucht, & Freyberger, 2005; McEachern & Snyder, 2012). Inflated social self-perception has been linked to overt antisocial behavior in particular (Lynch et al., 2016; Orobio de Castro et al., 2007; Stephens et al., 2015), while affiliation with an antisocial peer-group may be more strongly linked to covert antisocial behavior, than to overt antisocial behavior (Barnow et al., 2005; Dick et al., 2013; Slattery & Meyers, 2014).

Studies reporting on predictors of illicit substance use have been more inconsistent. These studies generally agree that affiliation with antisocial peers is related to substance use (Dick et al., 2013; Dishion, Capaldi, & Yoerger, 1999). However, regarding poor social

preference, some studies indicated that poor preference and related constructs increase risk for substance use (Dishion et al., 1999; Kelly et al., 2015), while others reported that being well-liked instead of being disliked increases this risk (Allen, Porter, McFarland, Marsh, & McElhaney, 2005; Tucker et al., 2011; Van Ryzin, DeLay, & Dishion, 2016), and still others found no association between social preference and substance use (Kaplow, Curran, & Dodge, 2002). To the best of our knowledge, no developmental links have as of yet been reported between an inflated social self-perception and substance use. In this case, it may be possible that an overly positive social self-perception is not directly linked to substance use. However, given that previous studies have found that an inflated self-perception positively influenced children's actual social preference (e.g., see Brendgen, Vitaro, Turgeon, Poulin, & Wanner, 2004), the link between inflated social self-perception and substance use could be indirect, that is, mediated by social preference.

In sum, evidence from prior studies suggests that the developmental link between childhood temperament and later engagement in problematic behaviors may be explained by environmental elicitation, social comparison and environmental selection processes. Although informative, these studies were hampered by various limitations. First, our literature search provided no examples of studies that investigated the hypothesized developmental pathways in their entirety. That is, the results of prior studies provide evidence in support of segments of the developmental pathways, but to our knowledge no previous studies have investigated the full pathways testing whether links between temperament and antisocial behavior or substance use indeed run via the hypothesized peer processes.

Second, although many of the more recent studies do, some previous studies (e.g., Kendler et al., 2015; Li et al., 2016; Stephens et al., 2015; Sterry et al., 2010) have not accounted

for children's existing antisocial behavior. This is of importance because empirical evidence suggests that peer-environmental factors may no longer add to the prediction of antisocial behavior or substance use when concurrent behavioral problems are accounted for (Lynch et al., 2016; Woodward & Fergusson, 1999). Thus, temperament could be linked to antisocial behavior or substance use through individual characteristics of the child (i.e., concurrent antisocial behavior) with little or no contribution of social experiences with peers. This actually could be seen as an alternative fourth pathway: the *externalizing psychopathology pathway*. This pathway suggests that certain adverse temperamental traits in childhood may be linked to behavioral problems in adolescence because of a shared underlying factor, in this case: externalizing psychopathology (Krueger et al., 2007). According to this viewpoint, also known as the spectrum or 'shared factor' model, certain temperamental traits may be regarded as 'mild' or 'normative' manifestations of behaviors of a more problematic nature and - even more extreme - behavioral disorders, rather than temperament being distinct from psychopathology (Nigg, 2006). Hence, in order to ascertain that the hypothesized intermediate peer-factors may truly add to the development of antisocial behaviors or substance use, that is, above and beyond behavioral problems, these behavioral problems should be taken into account.

Third, the processes of environmental elicitation, social comparison and environmental selection have been described as independent developmental pathways that may operate in parallel (e.g., Shiner & Caspi, 2003). However, at the empirical level, studies have found evidence for an interplay between these social processes. For example, previous studies have indicated that poor social preference and related constructs were correlated with affiliation with antisocial peers (D. Chen, Drabick, & Burgers, 2015; Ettekal & Ladd, 2015). Likewise, disparities between self-ratings and peer-ratings of peer acceptance have previously been found

to be associated with actual peer acceptance (Brendgen et al., 2004; MacDonald & Cohen, 1995; Stephens et al., 2015). In addition, the environmental elicitation, social comparison and environmental selection processes may influence each other over time. For instance, children who are rejected by their normative peers may later on in their development affiliate with friends who engage in antisocial behavior (for an overview, see D. Chen et al., 2015). Our literature search provided no examples of previous studies that investigated the unique contribution of environmental elicitation, social comparison and environmental selection to the development of antisocial behavior or substance use, when all three processes are investigated together. In the present study we took potential overlap into account in order to determine the respective contribution of each individual process and their possible interplay.

Fourth, previous research often neglected to include multiple aspects of behavioral problems within the externalizing spectrum. This may be a serious omission, given that the use of a broad and heterogeneous constructs like ‘externalizing behavior’ or ‘behavioral problems’ may obscure more specific associations between particular risk factors and different kinds of problems (Burt, 2012; Moffitt, 1993), as we have outlined above.

Lastly, when studying explanatory mechanisms that link temperament with the development of antisocial behavior and illicit substance use, potential sex-differences in developmental pathways should be investigated. For example, several studies found that children’s sex may be a moderator in the association between temperament and peer relationships. That is, this association was found to be stronger for boys than for girls (Coplan, Prakash, O’Neil, & Armer, 2004; Sterry et al., 2010). In addition, sex-differences have been found in the associations between peer-factors and the outcomes under scrutiny. For example, results from cross-sectional studies imply that the association between poor social preference and

behavioral problems within the externalizing spectrum is stronger for boys (Moffitt, Caspi, Rutter, & Silva, 2001). Furthermore, the correlation between affiliation with antisocial peers and these outcomes also seems stronger for boys (Van Lier, Vitaro, Wanner, Vuijk, & Crijnen, 2005). However, not all studies found such sex-differences for poor social preference (Coie, Terry, Lenox, Lochman, & Hyman, 1995; Dodge et al., 2003; Van Lier et al., 2005) and affiliation with deviant peers (Moffitt et al., 2001; Simons, Johnson, Beaman, Conger, & Whitbeck, 1996). Regarding the link between an inflated social self-perception and antisocial behavior and substance use, previous studies have generally found no sex-differences (Brendgen et al., 2004; Hughes, Cavell, & Prasad-Gaur, 2001). Nevertheless, closer attention to potential sex-differences would further enhance our understanding of developmental pathways that link temperament to later problematic behaviors.

### **The Present Study**

In the present study, we tested three developmental pathways that may link childhood temperamental traits to overt antisocial behavior, covert antisocial behavior and illicit substance use, using a sample of 411 children from the general population followed from age 6 until age 15. We added to existing knowledge in three ways. First, we investigated the developmental pathways that potentially link temperament to these problematic behaviors via three peer environmental factors that may contribute in a negative way to the behavioral development of elementary school children and adolescents, namely: difficulties in establishing a positive position in the peer-group, difficulties in developing a congruent and realistic social self-perception and difficulties in affiliating with a group of friends that encourages healthy behavioral adjustment. These developmental pathways were studied while accounting for children's concurrent antisocial behavioral problems. Second, we not only tested for parallel

links between temperament, intermediate processes and our outcomes under scrutiny (i.e., the environmental elicitation, social comparison and environmental selection processes as individual pathways that don't influence each other), but also investigated sequential and transactional pathways between these intermediate processes that account for the influence of one process on another process (e.g., environmental elicitation may subsequently predict environmental selection). Third, we took into account three different although related subtypes of problematic behavior, namely overt antisocial behavior, covert antisocial behavior and illicit substance use.

Based on previous studies we formulated three hypotheses. First, we expected that childhood temperament would be associated with later antisocial behavior and substance use, via poor social preference, overly positive social self-perception and affiliation with antisocial peers (hypothesis 1). More specifically, we predicted that higher levels of negative reactivity, lower levels of attention and lower levels of approach would be prospectively associated with poor social preference among peers (Coplan & Bullock, 2012; Ilmarinen, Vainikainen, Verkasalo, & Lönnqvist, 2015; Sterry et al., 2010). In addition, we predicted that these temperamental traits would be related to subsequent affiliation with peers who engage in antisocial behavior (Kendler et al., 2015; Li et al., 2016; Sterry et al., 2010). Lastly, we predicted that low levels of attention would be associated with an inflated social self-perception (Scholtens et al., 2012). We expected that the intermediate peer-processes, in turn, would be prospectively associated with antisocial behavior or substance use (see, e.g., D. Chen et al., 2015; Lynch et al., 2016).

Second, we explored parallel, sequential and transactional effects between the intermediate processes (hypothesis 2). More specifically, poor social preference could predict subsequent overly positive self-perceptions and affiliation with antisocial peers (see e.g., D. Chen et al., 2015; Stephens et al., 2015). However, poor social preference and affiliation with

antisocial peers could also operate independently (i.e., in parallel; D. Chen et al., 2015; Ettekal & Ladd, 2015). Reversed patterns are also possible. For example, overly positive self-perceptions could positively influence social preference among peers (Brendgen et al., 2004). In sum, parallel, sequential and transactional links between the three intermediate processes were deemed possible.

Third, we expected differential links between the intermediate processes and the outcomes (hypothesis 3). More specifically, we predicted that poor social preference would be more associated with overt than with covert antisocial behavior (Barnow et al., 2005; McEachern & Snyder, 2012). In addition, we predicted that overly positive social self-perception would be specifically related to overt antisocial behavior (Lynch et al., 2016; Stephens et al., 2015). Lastly, we expected that affiliation with antisocial peers would be associated more with covert antisocial behavior and substance use than with overt antisocial behavior (Dick et al., 2013; Slattery & Meyers, 2014).

## **Method**

### **Participants and procedure**

Participants were 411 children ( $n = 214$  boys, 52%) from five mainstream elementary schools in Quebec, Canada. Whole classrooms were included (note that the classroom composition in Canada changes from one year to the next). This study was approved by the University of Montreal ethics board (protocol # 410-95-1129; Study title: Behavior problems, peer relations and psychosocial adjustment), as well as by each participating school. Informed written consent was obtained from parents of all participants, whereas informed verbal assent was obtained from all participating children. Four previous studies have been published on (parts of) the same dataset that was used for the current study (i.e., Pedersen, Vitaro, Barker &

Borge, 2007; Vitaro, Pedersen & Brendgen, 2007; Witvliet, Brendgen, van Lier, Koot & Vitaro, 2010; Witvliet, van Lier, Brendgen, & Vitaro; 2010). Although none of these studies focused on the association between childhood temperament, peer social processes and antisocial behavior and substance use, there is some overlap between the key variables used in the current study and the four previously published studies (for more detailed information, see the footnote<sup>1</sup>).

Participants were on average 6.30 years ( $SD = 0.47$ ) at the initiation of this study (i.e., at the end of kindergarten) and were followed annually over ten years, until age 15 (i.e., at the end of grade 10). The majority of the children (> 90%) had a French-Canadian background.

Participants' average socioeconomic status ( $M = 42.81$ ,  $SD = 9.43$ ) was representative of the socioeconomic status of the general Canadian population ( $M = 42.74$ ,  $SD = 13.28$ ; Blishen, Carroll, & Moore, 1987).

Each spring (in April or May), participants spent two hours of classroom time, divided by a 20-min break, answering questionnaires. After the children were informed about the purpose of the study, they were told that all of their answers would be confidential and that they did not have to answer any of the questions if they did not want to. The children were encouraged to keep their answers confidential and not to talk with classmates about their answers. Trained research-assistants administered and collected the questionnaires. Teachers were asked to leave

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<sup>1</sup>Pedersen et al (2007) studied 551 children surveyed yearly from ages 6 to 13 to examine the longitudinal associations among early behavior (i.e., anxiety/social withdrawal and disruptive behavior) at ages 6-7 years, middle-childhood peer social preference and friendedness at ages 8 through 11 years, and early-adolescent depressive symptoms, loneliness, and delinquency at ages 12 and 13 years. Vitaro et al (2007) studied whether peer rejection and affiliation with deviant friends throughout childhood (ages 7 through 13 years) could mediate the link between early disruptiveness and engagement of violence and substance use at ages 15 and 15 years in a sample of 375 children. Witvliet, Brendgen et al (2010) studied whether isolation from cliques predicted an increase in depressive symptoms and whether this association was mediated by loneliness and perceived social acceptance in 310 children followed from age 11–14 years. Witvliet, van Lier et al (2010) studied the role of clique membership and clique isolation in children's psychosocial adjustment in 300 first grade pupils who were followed over a 1-year period.

the classroom during the assessment time to emphasize that participants' answers would not be revealed to their teachers. Teachers also completed questionnaires during this period.

Only children whose data was present on each of the study variables for at least one annual assessment wave within two out of four age periods were included in the present study. The four age periods were 1) ages 6 and 7 years; 2) ages 8 to 10 years; 3) ages 11 to 13 years; and 4) ages 14 and 15 (see Figure 1). These age periods were chosen for two main reasons. Conceptually, we chose these age periods because our constructs under scrutiny are of particular importance during these specific developmental stages. That is, in middle childhood and adolescence peer-relationships become particularly important for children's development (Sroufe et al., 2009), with certain aspects of the peer-world having the strongest influence in the earlier childhood years (e.g., social preference) and other aspects having the strongest influence in later childhood and early adolescent years (e.g., affiliation with antisocial peers; Vitaro, Pedersen, & Brendgen, 2007). Furthermore, engagement in overt antisocial behavior, covert antisocial behavior and the use of illicit substances tends to significantly increase in the middle adolescent years (e.g., see DeLisi, 2015; Liu, 2015; Loeber et al., 2012), which makes this the ideal period to assess these types of behavioral problems. Methodologically, we chose to average our data across two or three assessments for reasons of parsimony and to increase the reliability of the developmental model.

The 411 participants were part of an initial sample of 469 children who represented 92.5% of all French-speaking kindergarten children of a small community in northwestern Quebec, Canada (population 30,000). Each year, children that entered a participating classroom were included in the sample, which resulted in a total sample of 680 children after 10 years of follow-up. Of the final sample ( $N = 411$ ), 287 children (70%) had information on all study

variables for at least three age periods. Attrition during the study-period was due to a lack of parental permission, moving out of the school district, or absence on the day of data collection.

Children who were included in the present study had higher levels of attention compared to excluded children at age 7 ( $F(1, 381) = 4.45, p < .05, \eta^2 = .01$ ). At ages 8 to 10 years, included children were on average more preferred ( $F(1, 582) = 19.29, p < .001, \eta^2 = .03$ ) and had lower levels of antisocial behavior themselves ( $F(1, 495) = 14.99, p < .001, \eta^2 = .03$ ). At ages 11 to 13 years, included children were on average again more preferred than excluded children ( $F(1, 521) = 6.78, p < .01, \eta^2 = .01$ ). Note that the effect sizes of these differences were always small. None of the other variables differed between included and excluded children.

## Measures

**Temperament.** Childhood temperament was measured by the Dimensions of Temperament Survey (DOTS; Lerner, Marion, Avron, & R., 1982), rated by mothers when children were 6 and 7 years old. The DOTS is a 34-item, factor-analytically developed questionnaire that measures five temperamental traits of which three were used. Attention (11 items, e.g., “child was able to persist at a task”, “child was not distracted when involved in a task”), approach (6 items, e.g., “child moved towards new situations”, “child moved towards unfamiliar persons”) and negative reactivity (6 items, e.g., “child reacted intensely to pain”, “sunlight bothered child’s eyes”). Items could be answered with yes (1) or no (0). Items scores were averaged over ages 6 and 7 years, which were subsequently used as indicators of their latent factors (attention, negative reactivity and approach; see Figure 1). Confirmatory factor analysis (CFA) indicated that a correlated three-factor model fitted the data sufficiently (CFI = .89, RMSEA = .06). Correlations for similar dimensions measured at ages 6 and age 7 varied between  $r = .49$  and  $r = .65$ , all  $ps < .01$ . Internal consistency coefficients (Cronbach’s alpha) for the three traits varied

between .61 and .80 for the assessments, which is comparable to levels found in previous studies (Lerner et al., 1982). Moderate convergent and discriminant validity of the DOTS subscales with other measures of temperament have been reported (Goldsmith et al., 1991; Hubert, Wachs, Peters-Martin, & Gandour, 1982).

The DOTS rhythmicity (7 items that refer to sleep and eating habits, e.g., “child woke up from naps at different time than yesterday”, “child ate same amount of food as yesterday”) and activity (3 items that refer to activity during bed-time, e.g., “today my child moved a lot in bed”) scales were omitted because they did not map on the three higher-order dimensions effortful control, positive emotionality/surgency and negative emotionality and are often not included in current empirical and conceptual trait taxonomies of temperament (e.g., see De Pauw & Mervielde, 2010).

**Poor social preference** was used as an indicator of environmental elicitation. It was assessed annually throughout ages 8 to 13 by asking children to nominate three children in their class whom they liked least and three children whom they liked most (Coie et al., 1982). Separately for each year, the total number of received positive nominations was calculated for each participant and z-standardized within the classroom to create a total liked-most score. The total number of received negative nominations was calculated for each participant and z-standardized within the classroom to create a total liked-least score. The liked-most score was then subtracted from the liked-least score, resulting in a score where high values indicate a poor social preference score (Coie et al., 1982). Poor social preference scores were averaged for ages 8 to 10 ( $r_s$  between ages all  $\geq .51$ ,  $p < .001$ ) and ages 11 to 13 years ( $r_s$  between ages all  $\geq .51$ ,  $p < .001$ ).

**Inflated social self-perception** was used as an indicator of social comparison. It was operationalized by calculating discrepancy scores between children's actual social preference among peers and their self-perceived social competence. Self-perceived social competence was measured over ages 9 to 13 years using the Social Competence subscale (6 items, e.g. "it's hard to make friends") of the Self-Perception Profile for Children (Harter, 1982). Items were scored from 1 to 4, with higher scores reflecting more positive self-perception. Cronbach's alpha's ranged from .67 to .80 throughout the assessments.

Inflated social self-perception was then operationalized by computing a standardized residual score by regressing children's self-perceived social competence on their peer-perceived social preference score. Standardized residuals above zero represent a more positive evaluation of social competence from a child's own perspective than would be expected based on his or her peer-perceived social preference. Residual scores below zero were recoded into zero to create a variable that ranged from no overestimation to high overestimation. Scores for overestimation were averaged across ages 9 and 10 years ( $r = .47, p < .001$ ) and across ages 11 to 13 years ( $r_s \geq .44, p < .001$ ).

**Antisocial behavior of peer-group affiliates** was used as an indicator of environmental selection of friends who engage in antisocial behavior and was measured annually over ages 9 to 12 years. Each year, children were asked to nominate up to four friends in their classroom. Membership in a clique was established using the program *Kliquefinder* (Frank, 1995, 1996). Cliques are groups of friends, determined on the basis of friendship nominations within the classroom. *Kliquefinder* identifies cohesive cliques based on these friendship nominations. Clique-membership was conceptualized as having a minimum of two (un)reciprocated friendship nominations with other members of the clique. Children with reciprocated friendships are

children who have nominated each other as a friend. Unreciprocated friends are peers who a certain child has nominated as a friend, but these peers have not nominated this particular child back as a friend. Clique-sizes varied between 3 and 12 members at age 9, between 3 and 10 members at age 10, between 3 and 11 members at age 11, and between 3 and 9 members at age 12. More detailed information on how clique-membership was obtained and on the characteristics of clique-members is provided elsewhere (Witvliet, Brendgen, van Lier, Koot & Vitaro, 2010; Witvliet, van Lier, Brendgen, Koot & Vitaro, 2010).

For members of a clique, the level of antisocial behavior within that clique was determined by summing peer-nominated antisocial behavior scores (e.g., “starts fights”) retrieved from the Pupil Evaluation Inventory (PEI; Pekarik, Prinz, Liebert, Weintraub, & Neale, 1976) of all members of a clique, minus the score of the target child. This way, the target child’s own level of antisocial behavior is not confounded with the clique’s level of antisocial behavior. Given that children who were not part of a clique at a given year (i.e., isolates) by definition did not affiliate with an antisocial peer-group, they received a score of zero for that particular year. Scores were averaged for ages 9 and 10 ( $r = .13, p < .05$ ) and for ages 11 and 12 years ( $r = .13, p < .05$ ). Note that the magnitude of these correlations is moderately high given that classroom compositions in Canada change from one year to the next.

**Overt antisocial behavior, covert antisocial behavior and illicit substance use** at ages 14 and 15 years was assessed using the Self-Reported Delinquency Questionnaire (SRDQ; Le Blanc & Frechette, 1989). Items of the violence subscale (6 items, e.g., “engaged in a fistfight”) were used as indicators of overt antisocial behavior. Items of the theft (10 items, e.g., “stole from a store”) and vandalism (6 items, e.g., “purposely destroyed school equipment”) subscales were used as indicators of covert antisocial behavior. Items from the subscale drug-alcohol (3 items,

e.g., “used alcohol”) were used to indicate illicit substance use. Participants reported annually how frequently they had engaged in each act (1 = never, 2 = rarely, 3 = sometimes, or 4 = often) in the past 12 months. Because of very few responses in the extreme ends of the response scales of overt and covert antisocial behavior, we recoded mean item scores of these scales into binary item scores (0 = never, 1 = rarely to often). Items scores were averaged over age 14 and 15 years.

In our study sample, 45.6% of participants had not engaged in overt antisocial behavior at all at age 14 and 15; 26.2% of participants had engaged in at least some form of overt antisocial behavior at one point in time (either at age 14 or at age 15 years), and 28.3% of participants had engaged in at least some form of overt antisocial behavior at both measurement times (i.e., both at age 14 and age 15 years). These percentages were 26.6%, 18.6% and 54.9%, respectively, for covert antisocial behavior. Illicit substances were used by the grand majority of our sample (> 90%). Of these adolescents, 49.4% reported they used illicit substances rarely, 31.5% reported they used illicit substances sometimes and 12.3% reported they used illicit substances often, when they were 14 or 15 years old.

Item scores were used as indicators of their latent factors (overt antisocial behavior, covert antisocial behavior and substance use; see Figure 1). A three-factor model fitted the data well (CFI = .95; RMSEA = .04). Correlations for similar dimensions measured at age 14 and age 15 varied between  $r = .46$  and  $r = .73$ , all  $ps < .01$ . Internal consistency coefficients (Cronbach’s alpha) for the three traits in the current sample varied between .68 and .87 for the assessments. Satisfactory internal consistency, test–retest reliability, as well as convergent, discriminant and predictive validity of the SRDQ have been reported (LeBlanc & McDuff, 1991).

### **Control variables**

**Children's own antisocial behavior** was measured annually throughout ages 9 to 13 years through peer-nominations using the Pupil Evaluation Inventory (PEI; Pekarik et al., 1976). Children nominated classmates whom they believed fitted descriptions for behaving in an antisocial manner (8 items, e.g., "starts fights"). Scores were z-standardized within each classroom (see also Vitaro, Tremblay, Kerr, Pagani, & Bukowski, 1997), and averaged for ages 9 and 10 ( $r = .76, p < .01$ ) and ages 11 to 13 years ( $r_s \geq .65, p < .01$ ). Cronbach's alphas ranged from .91 to .93 across the data points. Evidence for reliability, construct and predictive validity of the PEI has been reported (Pekarik et al., 1976).

**Socioeconomic status (SES)** was obtained through mother-reported parental occupation(s) using the Blishen and colleagues' (1987) occupational prestige scale. Scores are based on the average income and average education level associated with occupations in Canada. Scores were first averaged across the two parents and then across the first 8 years of data collection ( $r_s$  ranged between .62 and .79). Information on SES was not available when children were 14 and 15 years of age. The SES variable is a continuous scale, which in our sample ranged from 21.37 to 86.41. On average, participants had a mean SES score of 42.81 ( $SD = 9.43$ ).

### **Statistical Analyses**

Analyses were performed in Mplus version 7.31 (Muthén & Muthén, 1998-2015). Because some of our measures were binary, we used the robust weighted least squares mean and variance adjusted (WLSMV) estimator to fit our models, which is the recommended estimator for analyzing skewed (partially) categorical data. Missing data was handled according to the default options of Mplus when using the WLSMV estimator (Muthén & Muthén, 1998-2015). Model fit was determined via the Comparative Fit Index (CFI;  $\geq .95$  indicates good fit; between .95 and .90 indicates acceptable fit; Hu & Bentler, 1999) and the Root Mean Squared Error of

Approximation (RMSEA;  $\leq .05$  indicates close approximate fit; between .05 and .08 indicates reasonable error of approximation;  $\geq 1.00$  indicates poor fit; Browne & Cudeck, 1993). Nested model comparisons were assessed using robust chi-square difference testing using the DIFFTEST function available in Mplus (Muthén & Muthén, 1998-2015). We used 50,000 bootstrap resamples with replacement and bias-corrected 95% confidence intervals (95% CI; Preacher & Hayes, 2004) to estimate the significance of indirect effects. (In)equality of the indirect pathways was estimated using the DIFFTEST option in Mplus (Muthén & Muthén, 1998-2015). Estimates were controlled for children's own antisocial behavior between ages 8 and 13 years. Furthermore, all estimates were controlled for household SES.

Figure 1 provides an illustration of the tested model. Latent early childhood temperamental traits (indicators were measured at ages 6 and 7 years) were used to predict middle childhood peer factors (ages 8 to 10 years), which, in turn, predicted their consecutive scores at ages 11 to age 13 years. In addition to these autoregressive (i.e., parallel) paths, cross-lagged (i.e., sequential/transactional) paths were estimated. The peer factors at ages 11 to 13 years were used to predict adolescents' outcomes.

In order to find the most parsimonious model that represented the data adequately, an iteration process was utilized in which the full models were trimmed of paths with significance levels of two-sided  $p > .10$ . We used this most parsimonious model to examine the significance of indirect pathways linking temperament to later problems behaviors via the three intermediate processes (hypothesis 1); to test whether the intermediate processes influenced each other over time (hypothesis 2); and to test for differential links between the intermediate processes and overt antisocial behavior, covert antisocial behavior and illicit substance use (hypothesis 3). Sex-differences were explored using multiple-group nested model testing (boys versus girls) using

the Wald chi-square test of parameter constraints (Muthén & Muthén, 1998-2015). To this end, a model in which all developmental paths and cross-sectional residual error correlations between boys and girls were freely estimated, was compared to a model in which developmental paths and residual error correlations were constrained to be equal for boys and girls. Note that before measures between boys and girls can be meaningfully compared, the constructs under scrutiny should be measurement invariant (i.e., similarly measured in boys and girls; Knight & Zerr, 2010). Therefore, we first tested whether our latent constructs (i.e., temperament and problem behavior) were invariant across sex. Results for measurement invariance testing are available in online supplementary material.

## **Results**

### **Descriptive Statistics**

Table 1 gives the means and standard deviations for poor social preference, inflated social self-perception and affiliation with an antisocial peer-group, for boys and girls. Furthermore, Table 1 presents the results of analyses of variance (ANOVAs) comparing mean differences between boys and girls. ANOVAs indicated that boys' peer-groups had higher mean levels of antisocial behavior compared to girls' peer-groups throughout ages 8 to 10 years as well as throughout ages 11 to 13 years. In addition, throughout ages 11 to 13 years boys had poorer social preference scores than girls. None of the other variables differed significantly between boys and girls.

Analyses of structural invariance (see online supplementary material) of the latent temperament and problem behavior constructs indicated that boys and girls had similar latent means and variances for the childhood temperamental traits. Furthermore, there were no sex differences in latent variances of the three types of behavioral problems under scrutiny.

However, compared to girls, boys had higher latent means of overt antisocial behavior (0.85 standard deviations higher than girls) and covert antisocial behavior (0.29 standard deviations higher than girls).

Correlations between study variables in Table 2 indicate within- and cross-time correlations of temperament, intermediate processes and outcomes. All significant correlations were in the expected directions, except for the negative correlations between poor social preference and level of antisocial behavior of peer-group affiliates. These negative correlations likely resulted from the fact that some of the children with low social preference scores were not part of a clique (i.e., were isolates). We performed analyses of variance (ANOVAs) to test this possibility. Table 3 presents the differences in poor social preference scores between clique-members and isolates. Results indicate that throughout the study period, isolates had indeed significantly lower social preference scores compared to children who were part of a clique. That is, whereas clique-members on average received more like-most nominations relative to like-least nominations, the opposite was true for isolates.

### **Childhood Temperament and Pathways to Antisocial Behaviors and Substance Use**

**Model building.** To test our three hypotheses about indirect pathways linking temperament to antisocial behavior and substance use, via poor social preference, inflated social self-perception and affiliation with peers who engage in antisocial behavior, we fitted a cross-lagged model grouped into four age periods (see Figure 1). This model fitted the data adequately,  $\chi^2(1412) = 1605.60, p < .001, CFI = .95, RMSEA = .02$ . To improve model parsimony and interpretation we tested a simpler model in which all the paths that were not significant at two-sided  $p < .10$  were removed. This trimmed model also fitted the data adequately,  $\chi^2(1461) = 1620.77, p < .01, CFI = .96, RMSEA = .02$  (in fact, according to the fit indices the model fit

became better). Results of indirect pathways for the total sample are presented in Table 4 and estimates for individual paths for the sample in total and sex differences in these paths are illustrated in Figure 2. These results are described below.

**Hypothesis 1: Linking temperament to antisocial behavior and substance use via poor social preference (i.e., *environmental elicitation process*), inflated social self-perception (i.e., *social comparison process*) and antisocial behavior of peer-group affiliates (i.e., *environmental selection process*).** To investigate our first hypothesis, we examined the significance of indirect pathways linking temperamental traits to later antisocial behavior and substance use via poor social preference, inflated social self-perception and antisocial behavior of peer-group affiliates. These three pathways were estimated above and beyond a developmental pathway that reflected children's personal antisocial characteristics (i.e., the externalizing psychopathology pathway).

As can be seen in Table 4, we found evidence for the environmental elicitation process. That is, we found an indirect pathway linking negative reactivity to overt antisocial behavior via poor social preference. Negative reactivity was also linked to substance use via poor social preference. Specifically, higher levels of negative reactivity at ages 6 and 7, were associated with lower social preference scores throughout ages 8 to 13, which in turn were associated with higher levels of overt antisocial behavior and lower levels of illicit substance use when children were 14 and 15 years old.

Negative reactivity was also related to all three types of problem behavior via the externalizing psychopathology pathway. Specifically, higher levels of negative reactivity at ages 6 and 7 were associated with higher levels of antisocial behavior throughout ages 8 to 13, which in turn were associated with higher levels of overt antisocial behavior, covert antisocial behavior

and illicit substance use at ages 14 and 15 years. Furthermore, negative reactivity was linked to overt antisocial behavior via a sequential indirect pathway which is described in the results section of our second hypothesis.

We found no indirect pathways linking the temperamental traits attention and approach to the outcomes via the intermediate processes. Specifically, approach was not related to any of the three intermediate processes, nor to children's own antisocial behavior. Regarding attention, higher levels of attention were prospectively associated with better social preference among peers, but indirect links involving these constructs did not reach statistical significance. Given that we found no indirect links that ran via inflated social self-perception or antisocial behavior of peer-group affiliates, no evidence for the processes of social comparison or environmental selection was found.

To sum up, our results showed that higher levels of negative reactivity in childhood were indirectly related to higher levels of overt antisocial behavior and to lower levels of substance use in adolescence, via the negative influence that negative reactivity has on children's standing among peers. This result is indicative of an environmental elicitation pathway. Furthermore, negative reactivity was also related to antisocial behavior (both overt and covert) and substance use via children's personal antisocial profile, which is indicative of an externalizing psychopathology pathway. In the present study, we found no evidence that social comparison or environmental selection processes explained the link between childhood temperament and adolescent problem behaviors.

**Hypothesis 2: Parallel, sequential and transactional links between poor social preference, inflated social self-perception and level of antisocial behavior of peer-group affiliates.** Given that we only found evidence for the environmental elicitation process, our

findings do not support the hypothesis that the other peer-processes (i.e., social comparison and environmental selection) could explain the prospective association between temperament and the outcomes under scrutiny in parallel to the environmental elicitation process. In addition, we found no evidence that temperament is linked to overt antisocial behavior, covert antisocial behavior or substance use via sequential or transactional associations between the intermediate peer-processes. However and as shown in Table 4, we found that negative reactivity was associated with overt antisocial behavior in adolescence, via children's own antisocial behavior at ages 8 to 10 years first and poor social preference at ages 11 to 13 years next. Specifically, higher levels of negative reactivity at ages 6 and 7 years were associated with higher levels of antisocial behavior at ages 8 to 10 years, which in turn predicted lower social preference scores at ages 11 to 13 years. Poor social preference was subsequently associated with more engagement in overt antisocial behavior. This indicates that negative reactivity at ages 6 to 7 years is not only directly related to poor preference at ages 8 to 10 years, but also to poor preference at ages 11 to 13 years via the child's own antisocial profile at ages 8 to 10 years.

Furthermore, and as can be seen in Figure 2, higher levels of boys' own antisocial behavior predicted an increase in their inflated social self-perception. That is, boys who showed more antisocial behavior themselves at ages 8 to 10 years showed more inflated social self-perception at ages 11 to 13 years, relative to their self-perception levels at ages 8 to 10 years. However, the indirect path linking negative reactivity to covert antisocial behavior via the boys' own antisocial behavior first and inflated social self-perception next, did not reach statistical significance.

Thus, given that we only found evidence for the environmental elicitation pathway, our hypothesis that the three intermediate peer-processes may operate in parallel, sequential or

transactional ways, was not supported by our data. However, we did find evidence for a sequential pathway that involved children's own antisocial behavior. That is, higher levels of negative reactivity in earlier childhood predicted antisocial behavior in later childhood. Higher levels of antisocial behavior in later childhood, in turn, predicted poor social preference in early adolescence. Next, poor preference in early adolescence predicted higher levels of overt antisocial behavior in later adolescence. Hence, the environmental elicitation pathway and the externalizing psychopathology pathway operated not only in parallel, but the latter also influenced the former, hence representing another sequence of personal and environmental influences on the development of overt antisocial behavior.

**Hypothesis 3: Differential links for overt antisocial behavior, covert antisocial behavior and substance use.** As Table 4 shows, we found initial evidence for our third hypothesis on differential indirect effects. Specifically, poor social preference was related to both illicit substance use and overt antisocial behavior. However, whereas lower levels of social preference were positively associated with subsequent overt antisocial behavior, these were negatively associated with subsequent substance use.

We performed an follow-up analysis to test whether the indirect paths linking social preference to overt antisocial behavior and substance use, respectively, were statistically different from each other. To this end, we tested the (in)equality of the total indirect effect between negative reactivity, poor social preference and substance use and between negative reactivity, poor social preference and overt antisocial behavior. The Wald chi-square test of parameter constraints was significant ( $\Delta\chi^2(1) = 4.11, p < .05$ ). This indicates that the developmental pathway from negative reactivity to poor social preference to overt antisocial

behavior is different from the developmental pathway from negative reactivity to poor social preference to substance use.

In short, we found differential developmental pathways that linked negative reactivity to overt antisocial behavior and substance use., via its negative influence on social preference. Specifically, poor preference among peers predicted higher levels of antisocial behavior in adolescence, while it at the same time predicted lower levels of substance use.

**Sex differences.** Cross-sex measurement invariance was fully established for the childhood temperament latent factors as well as for the adolescence antisocial behavior and substance use latent factors (see online supplementary material). This indicates that temperament as well as antisocial behavior and substance use were similarly measured in boys and girls. Constraining the estimates in our developmental model to be equal for boys and girls resulted in a significant drop in fit when this model was compared to a freely estimated model,  $\Delta\chi^2(39) = 95.38, p < .001$ . Follow-up analyses indicated various sex differences in residual error correlations, in various links between the covariate household SES and the constructs under scrutiny and in five path estimates. Differences for the five path estimates are illustrated in Figure 2. These indicate that the association between affiliation with antisocial peers and subsequent covert antisocial behavior was significant and positive for both boys and girls, but somewhat stronger for girls compared to boys. In addition, affiliation with antisocial peers was positively associated with subsequent engagement in illicit substance use for girls, but not significant for boys. Furthermore, the association between inflated social self-perception and subsequent covert antisocial behavior was significant and negative for boys, but not significant for girls. Moreover, children's own antisocial development at ages 8 to 10 years was positively associated with inflated social self-perception at ages 11 to 13 years for boys, but not significant

for girls. Lastly, children's own antisocial behavior at ages 11 to 13 years was positive associated with subsequent illicit substance use and this association was stronger for boys than for girls.

When the coefficients for the five individual paths (as well as significantly different residual error correlations and links between household SES and constructs) were allowed to vary between boys and girls (i.e., when these coefficients were freely estimated), this no longer resulted in a significant drop in fit compared to the totally unconstrained model  $\Delta\chi^2(22) = 30.53$ ,  $p = .11$ . Despite the sex-differences that were found in individual path estimates, testing for sex differences in the indirect pathways showed that these indirect paths did not differ between boys and girls (all  $ps \geq .30$ ).

In sum, indirect paths that linked temperament to later antisocial behavior and substance use did not differ in magnitude between boys and girls. However, compared to boys, girls showed stronger associations between affiliation with antisocial peers and subsequent covert antisocial behavior and illicit substance use. In contrast, boys showed stronger associations between inflated social self-perception and covert antisocial behavior and between their own antisocial characteristics and subsequent illicit substance use than girls. Lastly, boys showed stronger associations between their own antisocial behavior and subsequent over-estimated self-perception than girls.

## **Discussion**

### **Developmental Pathways Linking Temperament with Overt Antisocial Behavior, Covert Antisocial Behavior and Substance Use**

The purpose of the current study was to investigate why childhood temperament may be linked with antisocial behaviors and substance use in adolescence. Three developmental pathways involving peer-related experiences were tested: a) an environmental elicitation

pathway, which indicates that certain temperamental traits may elicit negative evaluations from peers, in our study indexed by poor social preference, b) a social comparison pathway, indicating that certain temperamental traits may influence how children compare themselves with others, in our study indexed by an inflated social self-perception, and c) an environmental selection pathway, which indicates that certain temperamental traits may influence with which peer-environment children choose to surround themselves, in our study indexed by affiliation with a peer-group that engages in antisocial behavior. We expected that these processes, in turn, may influence the development of antisocial behavior and substance use, above and beyond a more direct pathway that involves the child's own antisocial characteristics (i.e., the externalizing psychopathology pathway) and above and beyond socioeconomic factors (X. Chen & Schmidt, 2015; Nigg, 2006; Shiner & Caspi, 2003).

We found evidence for the hypothesized environmental elicitation pathway. That is, we found that children (boys as well as girls) who had lower thresholds for reacting in a negative way to sensory stimuli and who reacted more intensely, which represents one of the (multiple) lower-order traits related to the higher-order trait 'negative emotionality', evoked more poor social preference among peers than children who had lower levels of negative reactivity. This finding is in line with previous cross-sectional studies (De Bolle & Tackett, 2013; Jensen-Campbell & Malcolm, 2007) as well as with a longitudinal study focused on children aged 10 to 13 years (Bollmer, Harris, & Milich, 2006). The latter study indicated that high neuroticism (a higher-order personality construct that overlaps with negative emotionality; Rothbart, Ahadi, & Evans, 2000) was related to a variety of social difficulties, including low peer acceptance and being a victim of bullying (Bollmer et al., 2006). In our study, poor social preference was, in turn, positively associated with subsequent overt antisocial behavior but negatively with illicit

substance use. Previous studies have indicated that poor social preference may set into motion a cascade of social difficulties, such as difficulties with forming friendships and becoming a victim of bullying (Van Lier & Koot, 2010). This indicates that several peer-processes could account for the mediating role of poor social preference. In addition to the influence of peers, negative reactivity as well as other temperamental traits may be linked to later antisocial behavior and substance use via (environmental elicitation) processes beyond peer-experiences. For example, some studies have found that certain temperamental characteristics of children, such as negative reactivity, may influence their parents' behaviors and parent-child interactions in a negative way, which then may influence the development of problematic behaviors in these children (Bates & Pettit, 2015).

Furthermore, we found evidence for the externalizing psychopathology pathway. Specifically, negative reactivity in childhood was associated with overt antisocial behavior, covert antisocial behavior as well as substance use in later adolescence, via the child's engagement in antisocial behavior in middle childhood and early adolescence. Specifically, children who scored higher on negative reactivity in earlier childhood also scored higher on subsequent antisocial behavior in later childhood and early adolescence, which in turn was associated with engagement in all three types of behavioral outcomes that were investigated in the present study. This may indicate that higher levels of negative reactivity may – to some extent – be an early manifestation of a broad spectrum of behavioral problems and that an underlying common shared etiological factor of externalizing psychopathology may explain the link between negative reactivity and antisocial behavior and substance use (see, e.g., Krueger et al., 2007; Nigg, 2006). For example, one such underlying etiological factor may be experiencing difficulties in emotion- and behavior-related self-regulation. That is children with high levels of

negative reactivity as well as children with high levels of externalizing behaviors tend to respond to distressing or difficult situations with emotional and behavioral dysregulation (Eisenberg, Spinrad, & Eggum, 2010; Kim & Cicchetti, 2010; Veilleux, Skinner, Reese, & Shaver, 2014). Hence, our results support both the ‘vulnerability’ and the ‘spectrum’ theory of the trait- psychopathology link, indicating that these two theories –both of which aim to explain the developmental association between temperament and later psychopathology - are not mutually exclusive. This possibility warrants further research attention.

Above and beyond the environmental elicitation pathway and the externalizing psychopathology pathway, we found no evidence for the hypothesized social comparison and environmental selection pathways. That is, in the present study, we found no evidence for developmental paths linking temperament to later antisocial behavior or substance use via inflated social self-perception or via affiliation with an antisocial peer-group, when these pathways were studied together developmental paths in addition to the environmental elicitation and the externalizing psychopathology pathway. These findings contradict theoretical considerations as well as cross-sectional empirical findings that are suggestive of such developmental links (e.g., Shiner & Caspi, 2003; Steca et al., 2007; Wu, Bischof, Anderson, Jakobsen, & Kingstone, 2014). Results from the present study may suggest that such associations may vanish when studied in a longitudinal, well-controlled design. This finding is in line with a previous study that reached a similar conclusion (White & Kistner, 2011). However, it is important to recognize that all three peer-processes investigated in the current study were associated with later antisocial behavior or substance use. Thus, although inflated social self-perception and antisocial behavior of peer-group affiliates did not explain the developmental link between the childhood temperamental traits included in the present study and engagement in

problematic behaviors in adolescence, these peer processes should not be disregarded when studying the development of antisocial behavior and substance use. In addition, it is also important to note that inflated social self-perception and antisocial behavior of peer-group affiliates may be important processes linking other temperament traits beyond those investigated in the current study with antisocial behavior and substance use. For example, traits related high sensation seeking or narcissism may be linked with antisocial behavior or substance use through these processes (John & Robins, 1994; Yanovitzky, 2005).

Furthermore, in alignment with other studies and our own hypothesis, we found that lower levels of attention predicted poor social preference among peers (Coplan & Bullock, 2012), although the pathway connecting this temperamental trait to any of the outcomes under scrutiny did not reach statistical significance. Moreover, we did not find that lower levels of attention or approach predicted subsequent affiliation with antisocial peer-groups or inflated social self-perception, as was hypothesized by us and as others have found (Kendler et al., 2015; Li et al., 2016; Scholtens et al., 2012). Nor did we find that lower levels of approach were affiliated with lower levels of social preference among peers (Ilmarinen et al., 2015). The fact that, with the exception of Scholtens and colleagues (2012), none of the studies cited above controlled for children's antisocial behavior when examining developmental paths between temperament and peer-factors, may be a plausible explanation for our findings. Our study indicates that controlling for children's personal antisocial profile is of importance, because we found strong evidence for a developmental pathway linking temperament to antisocial outcomes via these antisocial characteristics (i.e., the externalizing psychopathology pathway). Hence, this may suggest that certain peer factors may no longer predict the indirect link of attention and approach with later behavioral outcomes, when emerging, concurrent and ongoing antisocial

behaviors are taken into account. Furthermore, studies that found links of temperamental dimensions involving the lower-order traits approach and attention with peer-factors, often included a more complete representation of the higher-order dimensions of temperament (e.g., 'extraversion', see Ilmarinen et al., 2015; or 'effortfull control', see Ilmarinen et al., 2015; Li et al., 2016), than was utilized in the present study. This potentially indicates that our temperamental measures may be too narrowly defined to capture links between these temperamental traits and peer-factors. Moreover, Scholtens and colleagues (2012) found that inattention was related to parent-reported levels of social acceptance, but not to child-reported levels of social acceptance, indicating that the use of different informants result may in different findings. These possibilities warrant further research attention.

In sum, in the current study we found evidence for the environmental elicitation pathway and the externalizing psychopathology pathway. That is, negative reactivity was linked to higher levels of overt antisocial behavior and less use of illicit substances, via its negative effect on social preference. In addition, negative reactivity was also linked to all three outcomes via the children's personal antisocial characteristics. We found no evidence for the social comparison or the environmental selection pathway in the present study.

### **No Evidence for Sequential Developmental Paths Involving Peer-Processes**

Second, we explored whether the intermediate peer-processes influenced each other over time, resulting in sequential or transactional indirect links that predict the association between temperament and the outcomes under scrutiny. In contrast to others who have found that poorly preferred children affiliated with peers who engage in antisocial behavior (for an overview, see D. Chen et al., 2015), we found no evidence for such a sequential link. This finding may be explained by the fact that studies that found such a developmental link used a different design

and different constructs than was utilized in the present study. For example, Vitaro and colleagues (2007) found that peer rejection predicted affiliation with antisocial peers, although a more recent study failed to replicate this finding (Ettetal & Ladd, 2015). Peer rejection and poor social preference are distinct constructs, albeit related (Bukowski, Sippola, Hoza, & Newcomb, 2000; Coie et al., 1982). That is, poor social preference refers to the extent to which children are disliked by their peers, relative to being liked. It includes both an advantageous (i.e., being liked among many and disliked by few) and a disadvantageous (i.e., being disliked by many and liked by few) end of children's social standing among peers. Peer rejection, in contrast, reflects only the negative end of the social preference spectrum. In this regard it is of interest to note that a previous study found that both higher poor social preference scores ('high rejection') as well as lower positive preference scores ('low acceptance') were associated with behavioral problems that included overt antisocial behavior, covert antisocial behavior and substance use (Buil, Koot, Olthof, Nelson, & van Lier, 2015). This indicates that the total spectrum of social preference influences the development of these behavioral problems, rather than only the negative part of the spectrum. In this light, it is also noteworthy that a previous study using similar constructs as were used in the present study, that is, poor social preference and antisocial behavior of clique-affiliates, also found no evidence for a link between these constructs over time (Bagwell, Coie, Terry, & Lochman, 2000). In addition, children who showed more antisocial behavior at ages 8 to 10 years showed lower social preference scores when they were 11 to 13 years old and boys who showed more antisocial behavior at ages 8 to 10 years tended to show more inflated social self-perception. However, none of these sequential paths could explain the link between temperament and antisocial behavior or substance use.

Despite that the intermediate peer-processes did not influence each other, we found that negative reactivity predicted later engagement in overt antisocial behavior, via children's own antisocial behavior first, and poor social preference next. This finding complements the debate on the vulnerability-trait model and the spectrum model of the temperament-psychopathology link, by showing that both models may explain the developmental link from temperament to later psychopathology not only in parallel, but also via complex, interactive ways. This too warrants further research attention.

### **The Importance of Distinguishing Between Overt Antisocial Behavior, Covert Antisocial Behavior and Substance Use**

Third, we hypothesized that the developmental links between temperament, the intermediate peer-processes and the outcomes, would vary depending upon the specific outcome under scrutiny. Results from the present study support this hypothesis. That is, in line with findings from others (e.g. Dodge et al., 2003; Ladd, 2006; Miller-Johnson, Coie, Maumary-Gremaud, & Bierman, 2002; Sturaro et al., 2011), our results suggest that low social preference among peers puts children at risk for engagement in overt antisocial behavior. This link may be explained through the possibility that children who are not highly preferred by peers may lack opportunities or lack sufficient motivation to learn social norms for adaptive behavior. Furthermore, overt antisocial behavior may also be a result of negative social encounters with peers such as acts of retribution resulting from low preference (Rubin et al., 2006). In addition, our results suggest that low social preference at the same time may protect children against engaging in illicit substance use, as has been found in previous studies investigating related constructs (e.g., Allen et al., 2005; Tucker et al., 2011; Van Ryzin et al., 2016). Our results indicate that children who are relatively more disliked than liked by their peers have a higher

chance of being isolated from peer-groups than children who are relatively more liked. Given that youngsters tend to use substances in a social manner, that is, when with peers, being isolated from peer-groups may hamper children's access to substances and may render them less influenced by peer-group norms encouraging substance use (Osgood et al., 2013; Verkooyen, de Vries, & Nielsen, 2007).

In sum, we found evidence for differential developmental pathways dependent upon the which outcome was investigated. That is, negative reactivity predicted, over time, more engagement in overt antisocial behavior and less engagement in illicit substance use and this differential effect was due to the difference in influence that poor social preference has on these two different types of behavioral problems. This finding emphasizes the importance of differentiating between several subtypes of behavioral problems within the externalizing spectrum, rather than investigating a broad spectrum of externalizing behavior as one construct.

#### **No Evidence for Sex-Differences in the Developmental Pathways**

Lastly, no evidence was found for the suggestion that developmental paths between temperament and antisocial behavior or substance use may be different for boys and girls as some other studies have found (Moffitt et al., 2001; Van Lier et al., 2005). However, some differences in individual paths between two constructs were found. For example, and in line with Laird and colleagues (1999), we found that antisocial peer affiliation was related to covert antisocial behavior for both boys and girls, but more strongly for girls. Second, antisocial peer-group affiliation was related to the use of illicit substances for girls, but not for boys. This may be explained by the finding that compared to boys, girls may anticipate more negative consequences for their friendships and expect more peer disapproval when they refuse to participate in deviant behaviors (Pearl, Bryan, & Herzog, 1990). Furthermore, girls seem to care

more about close friendships than boys and may be more afraid of negative peer evaluations than boys (see overview by Rose & Rudolph, 2006), which may make them more vulnerable to negative peer-influences. Third, overestimation of one's social standing among peers was related to less engagement in covert antisocial behavior for boys, but was not related to covert antisocial behavior for girls; boys' antisocial characteristics were more strongly related to illicit substance use than girls' antisocial tendencies; and boys' antisocial characteristics were more strongly related to subsequent overestimation of their social standing among peers. This might indicate that girls are more influenced by interpersonal, peer-relationship factors, particularly affiliation with antisocial peers, while boys may be more influenced by intrapersonal characteristics (i.e., their own antisocial behavior).

### **Limitations and Future Directions**

There are limitations that need to be considered when interpreting the present findings. First, we used the original version of the behavioral-based questionnaire the DOTS (Lerner et al., 1982) to investigate temperamental traits. A substantive strength of this instrument is that it does not include items that overlap with the items used to measure antisocial behavior and substance use, thus avoiding spurious relationships between temperament and the outcomes (De Pauw & Mervielde, 2010; Shiner & Caspi, 2003). However, the DOTS questionnaire also has considerable weaknesses. A substantive limitation of the DOTS is that its constructs do not entirely map onto the lower-order temperament traits as they are currently conceived. In addition, the DOTS does not measure higher-order traits, nor the full range of temperamental traits that are incorporated in the most recent taxonomies of temperament. For example, the DOTS does not measure lower-order traits like deriving pleasure from low- or high intense activities, inhibitory control, sociability, or the full range of negative emotions (e.g. sensitivity to

sensory stimuli is measured, but the tendency to experience anxiety or frustration is not measured). It also needs to be noted that previous studies found that convergent and discriminant validity of the DOTS scales with other measures of temperament was only moderate (Goldsmith et al., 1991; Hubert et al., 1982). Lastly, while not a limitation per se, it needs to be kept in mind that our results may not extend to other indicators of temperament, like psychobiological indicators (Rothbart, 2007). Thus, although our study provides substantive insight in how temperamental traits, via the peer-environment and via children's own antisocial characteristics, may or may not influence future engagement in antisocial behavior and substance use, studies aiming to extend our findings to a broader range of temperamental traits as how they are currently conceived are warranted before any firm conclusions can be made.

Second, influences of peers as assessed in this study were limited to peers within the classroom. However, peers outside the classroom may also affect children's behavior. Although others have shown that influences of peers outside of the school-context are limited for elementary school children (Kupersmidt, Burchinal, & Patterson, 1995), we cannot be certain that peers outside the classroom have not influenced our results.

Third, because we used aggregated data over four age periods. Because classroom composition in Canada changes from one year to the next, we were not able to control for nesting of children within schools and classrooms.

Fourth, we studied a sample of elementary school children who were representative of the Canadian population. However, because of our general population sample, no generalization to clinical and high-risk samples is possible. Future studies may want to investigate whether similar developmental processes are indicative of substance use disorders or clinical diagnoses of antisocial behavior such as conduct disorder and antisocial personality disorder.

Fifth, we did not examine interactions between temperamental characteristics. For example, high levels of positive emotionality/surgency may not be related to environmental elicitation, social comparison, or environmental selection processes when studied in isolation. However, when high levels of positive emotionality are accompanied with high negative reactivity levels, such a relationship may in fact appear (X. Chen & Schmidt, 2015; Eisenberg, Fabes, Guthrie, & Reiser, 2000). Therefore, future studies should also consider temperament profiles, not just individual temperamental traits.

Sixth, we were able to investigate only some of the suggested pathways linking temperament with antisocial behavior and substance use. Other pathways, such as learning processes, have been suggested (Nigg, 2006; Shiner & Caspi, 2003) and should be investigated in future studies. In relation to this latter point, future studies should investigate not only other explanatory environmental factors, but also should also investigate indicators of common, shared etiological factors, such as genetic factors (Clark, 2005). In addition, future studies may want to investigate developmental pathways that focus on environmental factors outside the peer-context such as factors within the home-context.

Seventh, only the environmental elicitation process was supported by the data in the present study. As outlined earlier, this is not to say, that the processes of social comparison and environmental selection play no part in explaining the link between temperament and later problem behaviors. Other temperamental traits not included in the present study may be related to antisocial peer-group affiliation and the development of an inflated social self-perception (John & Robins, 1994; Yanovitzky, 2005). Therefore, it should be kept in mind that the current results only extend to the measured temperamental traits in the present study and that other studies investigating other temperamental traits may reach different results and conclusions.

## **Conclusions and Implications**

To further our understanding of the link between temperament and the development of antisocial behavior and substance use, we need to recognize the role of peer environmental factors. That is, temperamental traits, particularly negative reactivity, may influence whether or not a child establishes a positive position within the peer-group. The difficulties that children may have with mastering this important developmental task may contribute to youths' engagement in overt antisocial behavior while it may decrease risk for illicit substance use. This being said, it is also important to acknowledge the importance of a child-personal developmental pathway of antisocial behavior that is independent of peer experiences and is predicted by high negative reactivity.

Our results have implications for research and practice. First, the impact of troublesome social experiences with peers, especially poor social preference at the peer-group level, should be taken into account in order to understand developmental links between temperament and the emergence of antisocial behavior and substance use. Second, it needs to be recognized that links between temperament and these problem behaviors may differ for the behavioral outcome under scrutiny. Thus, future developmental models that aim to explain the link between temperament and behavioral problems within the externalizing spectrum should include social-environmental factors as potential explanatory factors and should investigate various forms of behavioral problems as separate, although related, outcome measures. Third, teachers and other professionals should be particularly aware of those children who show frequent and intense negative reactions to stimuli and who (subsequently) evoke poor social preference among their peers. Teachers should not ignore the significance of this poor social preference, as our findings underscore the power of poor social preference during elementary school years to explain, at

least in part, how early temperamental difficulties may become manifested in later overt antisocial behavior. Related to this latter point, our results imply that improving children's poor social standing among peers might be a useful treatment target, particularly for highly reactive children.

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**Tables**

Table 1

*Means and Standard Deviations for Intermediate Social Processes for Boys and Girls*

	Boys		Girls		Test	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>F</i>	$\eta^2$
<hr/>						
Ages 8 to 10 years						
<hr/>						
Poor social preference	-0.05	0.81	-0.17	0.74	2.40	.01
Inflated social self-perception	0.40	0.50	0.31	0.45	3.77	.01
Peer-group ASB	1.47	0.73	1.16	0.57	18.84***	.05
<hr/>						
Ages 11 to 13 years						
<hr/>						
Poor social preference	0.06	0.89	-0.13	0.73	5.52*	.01
Inflated social self-perception	0.39	0.49	0.30	0.41	3.66	.01
Peer-group ASB	1.77	0.90	1.49	0.59	9.00**	.03
<hr/>						

*Note.* ASB = antisocial behavior. Test statistic from ANOVA.  $\eta^2$  = eta squared. \*  $p < .05$ . \*\*  $p <$

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

Table 2

*Correlations for Temperamental Traits, Intermediate Social Peer Processes, Antisocial Behavior and Substance Use*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Temperament																	
1 Attention age 6	-																
2 Neg. reactivity age 6	<b>-.21</b>	-															
3 Approach age 6	-.05	.03	-														
4 Attention age 7	<b>.65</b>	<b>-.22</b>	-.05	-													
5 Neg. reactivity age 7	<b>-.19</b>	<b>.59</b>	.03	<b>-.30</b>	-												
6 Approach age 7	-.02	.09	<b>.49</b>	.00	.09	-											
Intermediate social processes 8 to 10 years																	
7 Poor social preference	<b>-.18</b>	<b>.26</b>	.02	<b>-.28</b>	<b>.26</b>	.11	-										
8 Self-perception	.07	.02	-.06	.04	-.06	.00	.04	-									
9 Peer-group ASB	.01	-.05	-.04	-.01	-.10	-.05	<b>-.36</b>	.04	-								
Intermediate social processes 11 to 13 years																	
10 Poor social preference	-.10	<b>.24</b>	.09	<b>-.18</b>	<b>.24</b>	-.01	<b>.57</b>	.02	<b>.12</b>	-							
11 Self-perception	.06	-.03	-.01	-.03	.02	.00	-.03	<b>.40</b>	-.03	.05	-						
12 Peer-group ASB	-.02	-.14	.08	.05	-.03	.09	<b>-.23</b>	-.05	<b>.25</b>	<b>-.32</b>	.02	-					
Externalizing behavior																	
13 Overt ASB age 14	.04	.02	.03	-.10	-.08	.01	.03	-.03	.06	<b>.13</b>	-.03	.12	-				

14	Covert ASB age 14	.12	.00	-.01	.07	-.03	.07	-.04	-.07	.02	-.04	-.04	.12	<b>.30</b>	-			
15	Substance use age 14	.11	.11	-.04	.09	-.03	.02	.00	-.01	-.06	<b>-.12</b>	-.01	.04	<b>.19</b>	<b>.39</b>	-		
16	Overt ASB age 15	-.05	.07	<b>.17</b>	-.04	-.01	.07	<b>.22</b>	.06	.02	<b>.15</b>	.04	.14	<b>.46</b>	<b>.16</b>	.12	-	
17	Covert ASB age 15	.02	.06	.02	.02	.02	.01	.11	-.04	-.02	.01	-.01	.09	<b>.22</b>	<b>.60</b>	<b>.30</b>	<b>.35</b>	-
18	Substance use age 15	.05	.11	.03	.04	.06	.02	.03	.08	-.10	<b>-.14</b>	.09	.13	.11	<b>.39</b>	<b>.73</b>	<b>.22</b>	<b>.41</b>

*Note.* Estimates in bold are  $p < .05$ . Neg. reactivity = negative reactivity; Self-perception = inflated social self-perception; ASB = antisocial behavior.

Table 3

*Differences for Poor Social Preference Scores between Clique-members and Isolates*

	Clique members		Isolates		Test	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>F</i>	$\eta^2$
Age 9	-0.34	0.82	0.44	0.90	58.27*	0.17
Age 10	-0.27	0.92	0.35	0.89	33.35*	0.09
Age 11	-0.20	0.90	0.45	1.00	25.99*	0.08
Age 12	-0.16	0.94	0.29	1.01	14.67*	0.05

*Note.* Negative poor social preference values indicate that children were on average more liked than disliked. Positive poor social preference values indicate that children were on average more disliked than liked. Data on clique-membership was not available for ages 8 and 13 years. \* $p < .001$ .

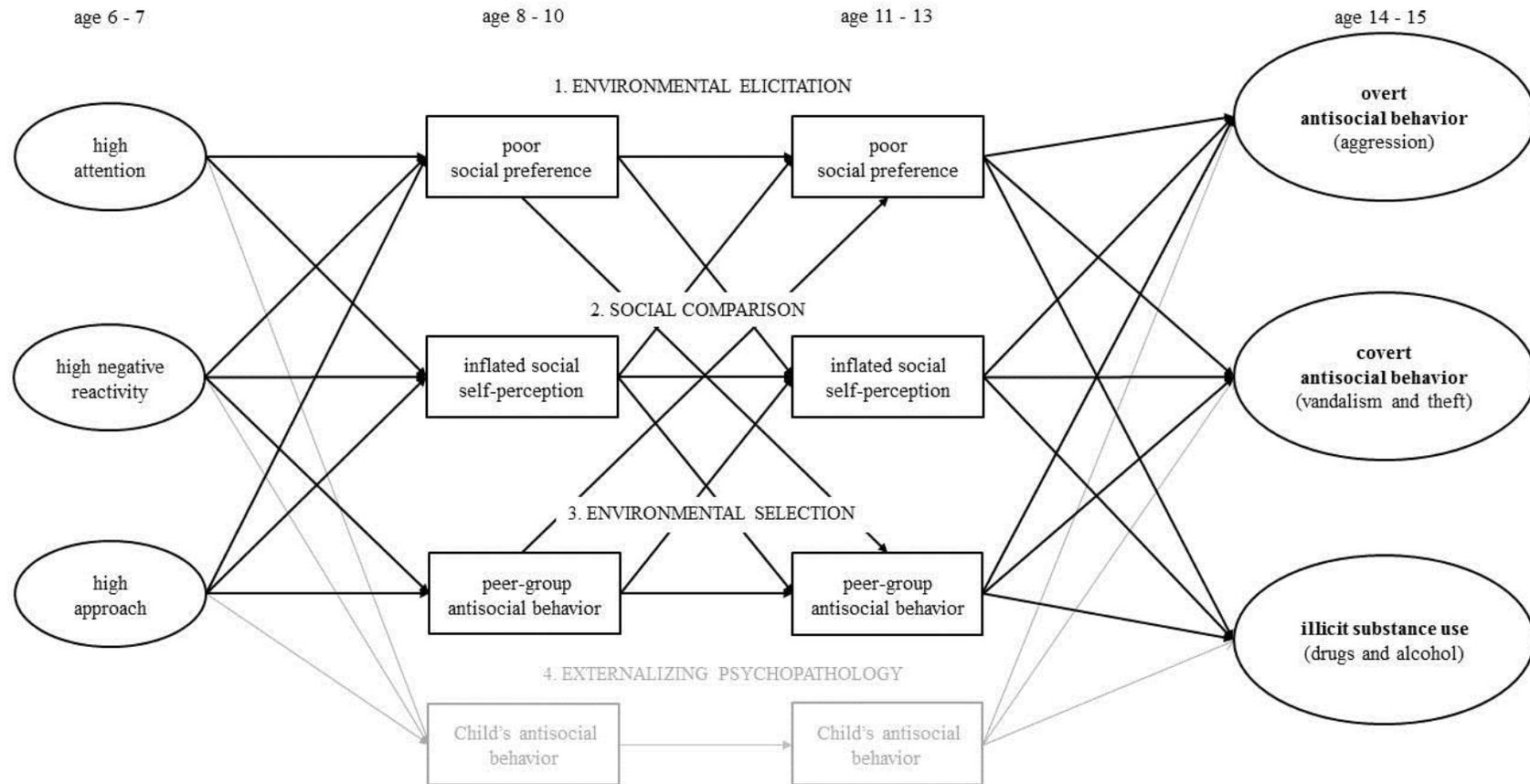
Table 4

*Significant Indirect Effects Linking Childhood Temperament with Antisocial Behavior and Substance Use in Adolescence*

				95% CI			
Ages 6 - 7	Ages 8 - 10	Ages 11 - 13	Ages 14 - 15	$\beta$	B	LL	UL
Indirect links predicting overt antisocial behavior							
neg. reactivity →	+ poor social preference →	+ poor social preference →	+ overt ASB	0.04	0.15	.008	.495
neg. reactivity →	+ own antisocial behavior →	+ poor social preference →	+ overt ASB	0.01	0.04	.001	.170
neg. reactivity →	+ own antisocial behavior →	+ own antisocial behavior →	+ overt ASB	0.05	0.17	.015	.450
Indirect links predicting covert antisocial behavior							
neg. reactivity →	+ own antisocial behavior →	+ own antisocial behavior →	+ covert ASB	0.05	0.17	.015	.450
Indirect links predicting substance use							
neg. reactivity →	+ poor social preference →	+ poor social preference →	- substance use	- 0.02	- 0.05	-.127	-.001
neg. reactivity →	+ own antisocial behavior →	+ own antisocial behavior →	+ substance use	0.05	0.11	.019	.262

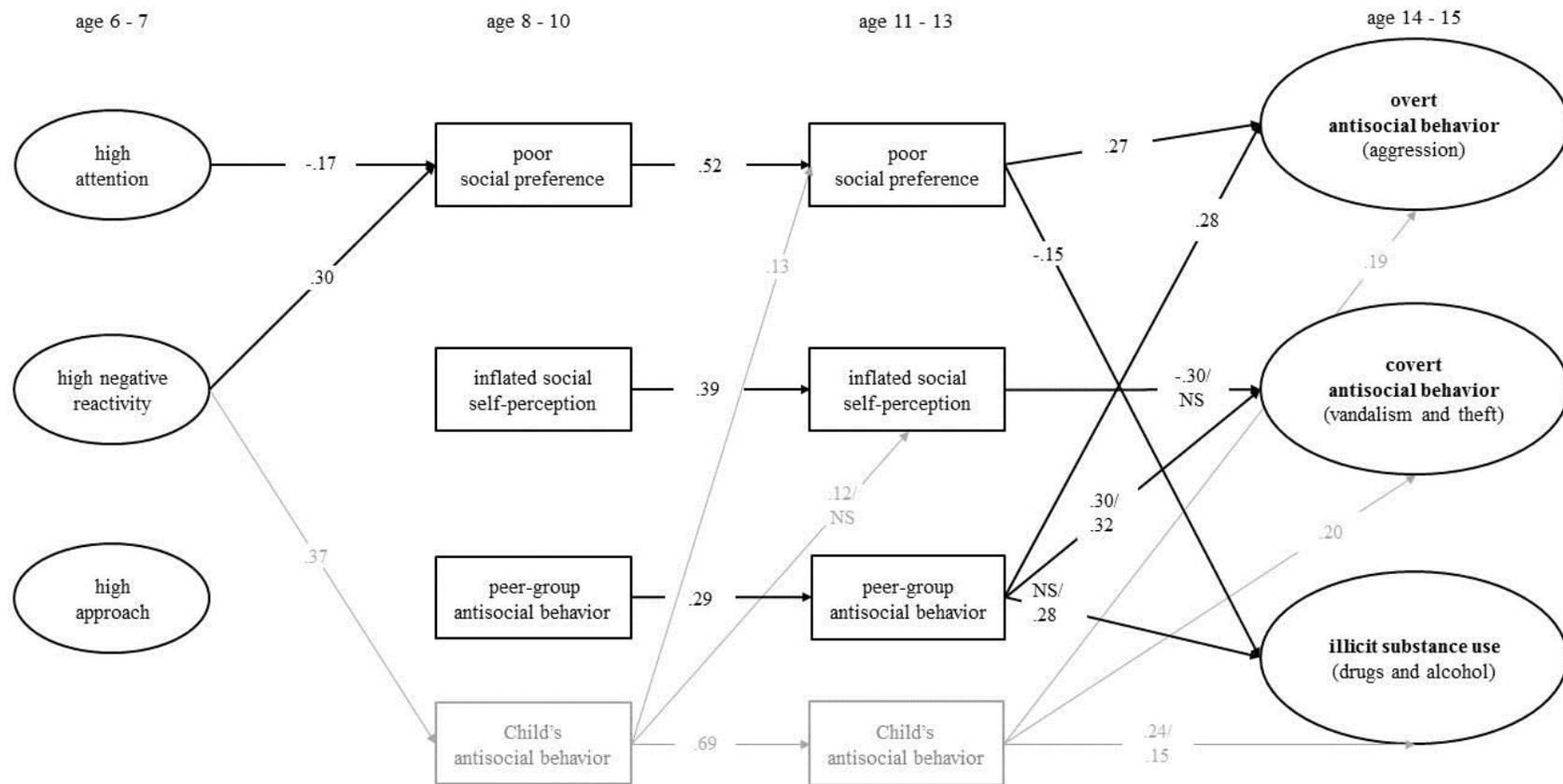
*Note.* [+] = positive association; [-] = negative association; neg. reactivity = negative reactivity; ASB = antisocial behavior; CI = confidence interval; LL = lower limit; UL = upper limit.

## Figures



*Figure 1.* Cross-lagged model illustrating possible links between children's temperament at ages 6 and 7 years, poor social preference, inflated social self-perception, antisocial behavior of peer-group affiliates at ages 8 to 13 years and antisocial behavior and substance use at ages 14 and 15 years. Grey lines represent the 'externalizing psychopathology pathway', which links temperamental traits to the

outcomes via children's own emerging and ongoing antisocial behavior. Note that residual error correlations between constructs were estimated in the model, but are not depicted for reasons of clarity. Furthermore, paths between children's own antisocial behavior and the peer-processes were also estimated in the model, but are not depicted for reasons of clarity.



*Figure 2.* Results for the restricted model (standardized estimates). When two coefficients are presented, the upper coefficient represents estimates for boys and the lower coefficient represents estimates for girls. Grey lines represent the 'externalizing psychopathology pathway', which links temperamental traits to the outcomes via children's own emerging and ongoing antisocial

behavior. Note that residual error correlations between constructs were estimated in the model, but are not depicted for reasons of clarity. All reported coefficients were significant at  $p < .05$ . NS = not significant.

