

The interaction between temperament and the family environment in adolescent substance use and externalizing behaviors: Support for diathesis–stress or differential susceptibility?

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Abstract

Both individual and environmental factors predict externalizing behaviors and substance use (EB-SU); however, different patterns of interaction among these factors may have different implications. This review first examines how temperament and the family environment interact in the prediction of adolescent EB-SU. Second, studies are reviewed according to two theoretical models: (1) diathesis–stress, i.e., certain individual characteristics are linked to vulnerability and later problems in adverse environments; (2) differential susceptibility, i.e., these characteristics are linked to susceptibility, predicting problems in adverse environments, but *also* better than average outcomes in good environments. Fourteen studies focusing on the prediction of EB-SU at ages 12–18 were selected through a literature search. Results showed that certain temperament traits (high levels of impulsivity and disinhibition; low levels of effortful control, negative affect, fearfulness and shyness), hereby designated as “adventurous” disposition, were associated with higher levels of EB-SU in adverse family environments. Some studies also showed that children with “adventurous” temperament traits in positive environments had the lowest levels of EB-SU. This suggests that prevention of EB-SU might target family factors such as parenting and focus on children with “adventurous” temperament traits. Further, studies that supported the differential susceptibility model were those assessing temperament and the family environment in childhood and studies that supported the diathesis–stress model assessed these variables in adolescence. It is thus possible that some of these “adventurous” temperament traits, with regard to EB-SU, would be indicators of susceptibility to both enriched and adverse environments in childhood but no

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longer in adolescence, when they would only be indicators of vulnerability to adverse environments.

Keywords

Diathesis–stress; Differential susceptibility; Temperament; Family; Externalizing; Moderation

Adolescent substance use has several adverse short- and long-term consequences, including addiction, poor academic achievement, sleep disturbances, depression, suicidal behavior, injuries, overdoses, car accidents, teenage pregnancy, sexually transmitted diseases and liver disease (Newbury-Birch et al., 2009; Single, Rehm, Robson, & Van Truong, 2000; Stolle, Sack, & Thomasius, 2009). Correlates of substance use in adolescence include both individual and environmental characteristics (Chartier, Hesselbrock, & Hesselbrock, 2010; Patrick & Schulenberg, 2013). While internalizing problems are more strongly associated with substance use in adulthood (Chan, Dennis, & Funk, 2008; Grant et al., 2004; King, Iacono, & McGue, 2004), a history of externalizing behaviors beginning in early childhood is more likely to be observed in adolescents using substances (Chan et al., 2008; Jester et al., 2008; Pingault et al., 2013; Zucker, Heitzeg, & Nigg, 2011). Furthermore, since adolescent substance use and externalizing behaviors share common variance and developmental predictors (Castellanos-Ryan & Conrod, 2011; Castellanos-Ryan et al., 2014; Krueger, Markon, Patrick, Benning, & Kramer, 2007; Vrieze, Perlman, Krueger, & Iacono, 2012), substance use may be considered a form of externalizing behavior. Thus, examining the predictors of adolescent externalizing behaviors can also provide insights into the development of substance use problems.

Two sets of predictors reflecting the child's early predisposition and its environment have shown promise in understanding the development of externalizing behaviors and substance use. Most researchers agree that temperament consists of individual differences in behavior-influencing traits which appear early, are relatively stable across situations and time, and are thought to have some biological foundation (De Pauw & Mervielde, 2010; Goldsmith et al., 1987; Henderson & Wachs, 2007; Rothbart & Bates, 2006; Shiner et al., 2012). Historically, temperament research has allowed to study the potential influence of children's early characteristics to their social development and began after the publication of the New York Longitudinal Study by Thomas, Chess, Birch, Hertzog, and Korn (1963). Until then, most studies focused on the influence of the environment on children's development, including the family environment, such as parenting practices, the quality of the parent–child relationship and marital conflict (Sanson, Hemphill, & Smart, 2004; Schaffer, 1999; Thomas et al., 1963). Still, most studies of temperament and the family environment have focused on the direct associations with children's development (Sanson et al., 2004), and both have been found to be associated with substance use and externalizing behaviors (Barnes, Reifman, Farrell, & Dintcheff, 2000; Kitzmann, Gaylord, Holt, & Kenny, 2003; Teerikangas, Aronen, Martin, & Huttunen, 1998; Willem et al., 2011). Some studies have also examined how they may interact with each other. This is important since the impact of temperament on children's development has long been considered to be dependent on their environment (Thomas & Chess, 1977; Wachs, 2000). However, specific information regarding their

pattern of interaction is lacking. Accordingly, the present study will systematically review studies on the interactions between temperament and the family environment in the prediction of adolescent substance use and externalizing behaviors and examine the pattern of these interactions according to two theoretical models.

To complete this introduction, we will now clarify the concepts of temperament and family environment, examine the associations they each have with substance use and externalizing behaviors, and consider why and how we could study their interaction in the prediction of substance use and externalizing behaviors.

Temperament, substance use and externalizing behaviors

Researchers usually either study specific temperament dimensions or cluster temperamental dimensions into overarching temperament profiles, with few indications that one method would have specific advantages over the other. Although the most common overarching temperament profile for which questionnaires were developed is difficult temperament, researchers have proposed different combinations of temperament dimensions, based on theory or through factor analysis. Overarching temperament profiles observed in this review are defined in Table 1.

Regarding more specific temperament dimensions, the number and nature of these behavior-influencing traits is still debated and there are several theoretical and measurement traditions in the temperament literature, the most common being the theories of Thomas and Chess (1977), Buss and Plomin (1975, 1984) and Rothbart (1981) (see Zentner & Bates, 2008, for a review on temperament theories).

Rothbart (1981) defined temperament as constitutionally based individual differences in two broad categories: reactivity and self-regulation. Reactivity refers to the speed and intensity of responses, which includes dimensions related to motor activation, surgency and negative affectivity. Self-regulation refers to the strategies that modulate reactivity, which includes dimensions related to attentional control and the inhibition of dominant responses. Because this theory is the broadest and most inclusive (Shiner et al., 2012), and we note that most temperamental dimensions proposed by Thomas and Chess (1977) and Buss and Plomin (1975, 1984) can be theoretically classified within the reactivity and self-regulation categories, the Rothbart classification will serve to organize the results presented in this review. Table 1 also provides a list of temperament dimensions observed in the current review, classified within the reactivity or self-regulation categories, along with their definition.

Several studies have documented direct associations between temperament and developmental outcomes (Sanson et al., 2004), including substance use and externalizing behaviors. Some of these studies have examined how overarching temperament profiles are associated with substance use and externalizing behaviors. Windle (1991) measured temperament in adolescence (average age 15.7 years) with a questionnaire evaluating ten dimensions and summarized the scores by computing an overarching profile of the number of difficult temperament dimensions (activity level-general, activity level-sleep, approach-

withdrawal, flexibility, rhythmicity-sleep, rhythmicity-eating, rhythmicity-daily habits, distractibility, persistence). A significant linear trend was found in which the number of difficult temperament dimensions predicted higher cigarette, alcohol and hard drugs use as well as delinquency. In a longitudinal study of adolescents (average age 15.5 at time one) whose temperament (categorized as not difficult, somewhat difficult and difficult) and substance use were assessed twice one year apart, Tubman and Windle (1995) found that cigarette and alcohol use, averaged across the two time points, were higher for adolescents who showed stable difficult temperament across both time points. Finally, Wennberg and Bohman (2002) showed that participants scoring high on the overarching temperament profile extravert/aggressive at age 4 years had a higher frequency of intoxication at age 25 years, whereas those who scored high on the dimension extravert/outgoing at age 4 years had more lifetime alcohol problems at age 25 years.

With regard to reactivity dimensions of temperament, high levels of impulsivity have also been shown to accompany high levels of externalizing behaviors in a study of 11-year-old children (Oldehinkel, Hartman, De Winter, Veenstra, & Ormel, 2004), and high levels of alcohol use in 12- to 18-year-old adolescents (Colder & Chassin, 1997). Similarly, in a cross-sectional study of 14- to 18-year-old participants, Willem et al. (2011) compared a clinical group of adolescents recruited from a specialized inpatient unit for substance use disorders to a control group recruited through schools. They found that the clinical youth had higher levels of impulsivity compared to the school group. Finally, Oldehinkel et al. (2004) found that high levels of frustration were concurrently associated with externalizing behaviors at 11 years.

Some studies have also examined self-regulatory dimensions of temperament. The study by Oldehinkel et al. (2004) also found that low levels of effortful control were concurrently associated with externalizing behaviors at 11 years. Effortful control at 14 years was also concurrently and negatively associated with delinquency and aggression (van der Voort, Linting, Juffer, Bakermans-Kranenburg, & van Ijzendoorn, 2013) and effortful control at 54 months was negatively associated with externalizing behaviors at 15 years (Honomichl & Donnellan, 2012). Also, in a longitudinal study of participants who reported on their age of substance use initiation at 19.5 years, lower duration of orienting at 14.5 years was found to be associated with earlier initiation of cigarette smoking, but was not associated with alcohol and illicit drug initiation (Hartman, Hopfer, Corley, Hewitt, & Stallings, 2013).

Finally, in a cross-sectional study (mean age 11 years), Muris, Meesters, and Blijlevens (2007) examined interactions between reactive and self-regulatory temperament dimensions and found that high levels of frustration were associated with high levels of externalizing behaviors when inhibitory control was low. They also found that the more general temperament dimension of negative affectivity was associated with externalizing behaviors when effortful control was low. Because the previously mentioned study by Oldehinkel et al. (2004) found that high levels of frustration and low levels of effortful control were associated with externalizing behaviors, it is possible that a test for interactions would have yielded an interaction similar to those found in the study by Muris et al. (2007).

In summary, and examining temperament alone, difficult temperament and temperament dimensions including high impulsivity, high negative affectivity, low effortful control and low duration of orienting were found in some studies to be directly associated with externalizing behaviors and substance use.

The family environment, substance use and externalizing behaviors

Among the most studied environmental factors conveying risk for externalizing behaviors and substance use are those related to the family environment. Family factors highlighted as important univariate predictors of externalizing behaviors and substance use include parenting practices (i.e., child rearing strategies; see Table 2 for definitions of parenting variables observed in the present review), quality of the parent–child relationship (i.e., parent and child behaviors, feelings and expectations toward each other) and marital conflict (i.e., disagreements and/or arguments between the father and the mother).

Problematic parenting practices, including high coercive parenting, low parental control and low parental monitoring in childhood (Fergusson & Lynskey, 1997; Hayatbakhsh et al., 2008), preadolescence (Burnette, Oshri, Lax, Richards, & Ragbeer, 2012; Buschgens et al., 2010) and in adolescence (Abar, Jackson, Colby, & Barnett, 2014; Aquilino & Supple, 2001; Barnes & Farrell, 1992; Barnes et al., 2000; Clark, Shamblen, Ringwalt, & Hanley, 2012; DiClemente et al., 2001; Duncan, Duncan, Biglan, & Ary, 1998; Kaynak et al., 2013; Tornay et al., 2013), have been associated with substance use and other externalizing behaviors in adolescence and young adulthood. High levels of parent–child conflict and poor parent–child relationship quality in preadolescence (Burt, McGue, Krueger, & Iacono, 2005) and adolescence (Duncan et al., 1998; Koh & Rueter, 2011; Loke & Mak, 2013; Marsiglia, Kulis, Parsai, Villar, & Garcia, 2009; McKinney & Renk, 2011; Yeh, 2011) have also been shown to contribute to adolescent substance use and externalizing behaviors. Finally, marital conflict and divorce in childhood (Dube et al., 2006; Sourander & Helstela, 2005) and adolescence (Barnett, Rowley, Zimmerman, Vansadia, & Caldwell, 2011; Cui, Donnellan, & Conger, 2007; Fletcher & Sindelar, 2012; Grych, Raynor, & Fosco, 2004; Kristjansson, Sigfusdottir, Allegrante, & Helgason, 2009; Roustit, Chaix, & Chauvin, 2007; Vanassche, Sodermans, Matthijs, & Swicegood, 2014) have also been associated with heightened externalizing behaviors and alcohol use in adolescents.

The interplay between temperament and family environments

Although various studies have examined temperament and the family environment separately as predictors of substance use and externalizing behaviors, models taking into account their joint effects are needed to explain the development of adolescent substance use and externalizing behaviors (Sanson et al., 2004). These include but are not restricted to moderation effects, which will be the focus of the present review. Examining these interactions is important because the impact of temperament on developmental outcomes is often considered to be dependent on the child's environment (Thomas & Chess, 1977; Wachs, 2000) and it has been suggested that temperament is involved in children's responsiveness to environmental stressors (Rothbart, 2004). Furthermore, developmentally, and in interaction with the family environment, temperament could be associated with

substance use and externalizing behaviors in adolescence through its influence on self-control abilities (Wills & Dishion, 2004), which are a complex set of attributes involved in the control of cognition, emotion, and behavior including self-monitoring, planning, future orientation, delay of gratification, and emotional regulation (Barkley, 1997; Mischel, Shoda, & Rodriguez, 1989; Wills & Dishion, 2004; Wills, Sandy, & Yaeger, 2000).

Within this context, a primary goal of this review is to examine how temperament and family factors such as those just reviewed interact in the prediction of adolescent substance use and externalizing behaviors. This could inform prevention and early intervention efforts by helping identify which children could benefit most from targeted interventions, and what aspects of family life could be targeted by these interventions. A second goal is to review studies according to two theoretical models that address how children's individual characteristics can interact with the family environment and convey risk or advantage to the child.

Patterns of person–environment interactions

There are several patterns of person–environment interactions that have different theoretical and methodological implications. The diathesis–stress model (Monroe & Simons, 1991) suggests that vulnerable individuals with certain characteristics exhibit worse outcomes in adverse environments (see Fig. 1a). The differential susceptibility model (Belsky & Pluess, 2009) posits that these individuals also benefit more from enriched environments (see Fig. 1b). A pattern of contrastive effects (see Fig. 1c) suggests that individuals high on an individual characteristic and those low on the same characteristic are both affected by environmental variables, but in opposite directions (Belsky, Bakermans-Kranenburg, & van Ijzendoorn, 2007). Finally, the vantage sensitivity model (Pluess & Belsky, 2013) suggests that individuals with certain characteristics can benefit more from positive environmental influences (see Fig. 1d). Since the diathesis–stress model has guided most research on person–environment interactions and the differential susceptibility model can provide an alternative interpretation for some results interpreted according to the diathesis–stress model (Belsky & Pluess, 2009), the present review will focus on these two models, which are described in more detail below.

The diathesis–stress and differential susceptibility models

Research on interactions between individual characteristics and the environment has been primarily guided by the diathesis–stress model (Gottesman & Shields, 1967; Monroe & Simons, 1991; Zuckerman, 1999). According to this model (see Fig. 1a), some individuals are disproportionately likely to be affected adversely by an environmental stressor due to an individual vulnerability factor (e.g., difficult temperament). This model purports that “vulnerable” and “resilient” individuals develop differently primarily when exposed to adverse environmental conditions. That is, “vulnerable” individuals will experience worse outcomes than “resilient” individuals when exposed to environmental stress or negative environmental factors, whereas they will develop more or less similarly in the absence of adversity.

The differential susceptibility model (Belsky, 2005; Belsky et al., 2007, 2014; Belsky & Pluess, 2009; Ellis, Boyce, Belsky, Bakermans-Kranenburg, & van IJzendoorn, 2011) is more recent and posits that individuals with certain characteristics, such as difficult temperament, are not only adversely affected by environmental stressors but also reap the most benefits from good environmental conditions (see Fig. 1b) because they are more sensitive to environmental influences. That is, the differential susceptibility model does not consider these individuals as “vulnerable”, but as “susceptible” to input from environmental factors, whether positive or negative. Thus, from a developmental-psychopathology perspective, the main implication of the differential susceptibility model is that more susceptible individuals would have an increased tendency to experience good outcomes in positive environments in addition to their increased likelihood of bad outcomes in negative environments (Ellis et al., 2011). As such, susceptibility factors would no longer be conceptualized exclusively as a risk.

Statistical testing of the diathesis–stress and differential susceptibility models

Interactions are usually tested using moderation analyses. These analyses can be conducted using ANOVA techniques when the two predictors are categorical, but multiple regression techniques with continuous predictors are recommended because they are more flexible (Cohen, Cohen, West, & Aiken, 2013). When one or both predictors are continuous, multiple regression techniques (multiple linear regression for continuous outcomes and multiple logistic regression for categorical outcomes) should be used, where the interaction between the individual and environmental factors is tested after taking into account their main effects. The main concern with moderation analysis is that it tends to lack power. The three most common problems leading to lack of power in moderation analysis include small sample size, with effect sizes for interactions that are often small (Aguinis, Beaty, Boik, & Pierce, 2005; Chaplin, 1991), low reliability of the predictor and/or moderator, which dramatically reduces the reliability of the interaction term, and restriction in range, where individuals in the studied population do not have the same probabilities of being selected for the sample (Aguinis, 1995; Aguinis & Stone-Romero, 1997; Aiken & West, 1991; McClelland & Judd, 1993).

Once a significant interaction is found, the diathesis–stress and differential susceptibility models may be distinguished empirically by evaluating the pattern of the interaction. Statistical support for the diathesis–stress model comes from a pattern where an individual characteristic is related to an outcome and an ordinal (fan-shaped) interaction is found (Belsky et al., 2007). To support the differential susceptibility model, a disordinal (crossover) interaction must be found, where the slope of the susceptible group (e.g., children with difficult temperament) is significantly different from zero and significantly steeper than the slope of the non-susceptible group (e.g., those with easy temperament). Also, the susceptibility variable should ideally not be significantly correlated to the environmental factor or to the outcome (Belsky et al., 2007; Belsky & Pluess, 2009). However, when the environmental and individual variables are mildly correlated, the residual score from the environmental variable on the individual characteristic can be used (e.g., Nederhof, Belsky, Ormel, & Oldehinkel, 2012; Ramchandani, van IJzendoorn, & Bakermans-Kranenburg, 2010; Rioux et al., 2016).

While these criteria were previously considered sufficient to distinguish the two models, additional statistical tests have now been proposed to differentiate ordinal from disordinal interactions. The first option would be to conduct a *region-of-significance* analysis (Aiken & West, 1991; Preacher, Curran, & Bauer, 2006), which was suggested by Kochanska, Kim, Barry, and Philibert (2011) in the context of a test of the differential susceptibility model. Roisman et al. (2012) also suggested two additional metrics that can be used to supplement the region-of-significance analysis. Another procedure can statistically differentiate ordinal from disordinal interactions by estimating the crossover point and its confidence interval (Widaman et al., 2012). Finally, a model fitting approach can also be used to directly test the two models without using multiple regression to test for significant interactions (Belsky, Pluess, & Widaman, 2013).

Objectives of the present review

The first objective of this review was to synthesize the findings of studies examining the interactions between temperament and the family environment in the prediction of adolescent substance use and externalizing behaviors. The second objective was to re-examine the results of relevant studies according to the diathesis–stress and differential susceptibility models by qualitatively examining the plotted interactions (see the Methods section for details).

Methods

We included studies identified through a systematic literature search using Web of Science™, PsycINFO® and Medline®. Journal articles in English or French (French keywords not listed) were searched using the following keywords in a Boolean search: adolescen* AND externalizing OR “substance use” OR alcohol OR drug OR tobacco OR cannabis OR marijuana AND parent* OR famil* OR paternal OR maternal OR mother OR father AND temperament* OR emotionality OR “emotional reactivity” OR “negative affect*” OR “positive affect*” OR “activity level” OR “distress to limitations” OR approach/withdrawal OR impulsivity OR “behavioral undercontrol” OR “behavioural undercontrol” OR “motor activation” OR inhibition OR “inhibitory control” OR “effortful control” OR “attention* focus*” OR “attention* shift*” OR sociability OR persistence OR “duration of orienting” AND moderat* OR interact*. Specific family variables were not specified in the search in order to include all environmental family variables that could be identified through the primary search criteria. No date restrictions were applied to the selection of literature and articles were searched up to May 4, 2015. Searches in PsycINFO® and Medline® were also limited to human studies. The retrieved titles and abstracts from the literature search were screened for relevance. For every abstract that was identified as potentially relevant, the full-text article was retrieved for evaluation. The reference lists of relevant articles were also searched.

To be included in the review, studies had to meet the following eligibility criteria: (1) substance use or externalizing behaviors were assessed as outcomes; (2) substance use or externalizing behaviors were measured in adolescence, between 12 and 18 years of age; (3) the family variables were environmental – for example, heritability variables were excluded;

(4) the individual characteristics studied were temperament and not related characteristics such as personality – the authors' definitions and the questionnaires used were used to determine whether the variable fit the definition of temperament outlined above, and (5) the study examined moderation effects between temperament and the family environment (studies examining mediation only were excluded).

Effect sizes

Effect sizes are provided to facilitate comparison across studies and because of the power issues that can arise when testing interactions (Aguinis et al., 2005; Chaplin, 1991). When articles did not provide standardized results, the information was requested from authors via electronic mail. Electronic mail addresses were obtained from the articles' contact information or from a Google search. The corresponding authors of eight articles were contacted. Of those, three provided the requested data, three did not have access to the information and two could not be reached.

Standardized regression coefficients (standardized betas) are provided as effect size estimates (Nieminen, Lehtiniemi, Vähäkangas, Huusko, & Rautio, 2013; Rosenthal & DiMatteo, 2001). Standardized coefficients of 0.10, 0.30 and 0.50 were considered small, medium and large effect sizes respectively (Cohen, 1988, 1992). These coefficients represent the effect size of the interaction between temperament and family variables on substance use or externalizing behaviors while controlling for the other variables included in the tested model of the various studies. Because control variables and other predictors differ between studies, the coefficients are not equivalent (Lipsey & Wilson, 2001), which is a limitation. However, they still provide useful information about the size of the effect.

Comparing the diathesis–stress and differential susceptibility models

The statistical approaches previously described should be applied when conducting analyses and comparing differential susceptibility from diathesis–stress models. However, most studies to date were conducted within a diathesis–stress frame of reference and do not report the statistical information necessary for rigorously testing the differential susceptibility model (Belsky & Pluess, 2009). Thus, the following more liberal criteria were used in this review. The first criterion for either model was to find a significant interaction. Plotted results of the significant interactions were then qualitatively examined as either ordinal (fan-shaped), which is consistent with the diathesis–stress model, or disordinal (crossover), which is consistent with the differential susceptibility model. Specifically, when the crossover point was in the middle range of the family variable, the interaction was considered disordinal. When the crossover point was in the lower/higher range of the family variable or outside of the observable data, the interaction was considered ordinal. When plots were not included in the articles, results were plotted using the coefficients provided and following the guidelines of Frazier, Tix, and Barron (2004) and Cohen, Maier-Sperger, Gower, and Turner (2003). When significance of simple slopes were provided in the article, they were also used to interpret the findings, i.e., to determine whether the slope for the susceptible group was significantly different from zero and significantly steeper than the slope for the non-susceptible group. One criterion for supporting the differential susceptibility model requires that the susceptibility variable not be significantly correlated to the environmental factor.

This criterion was not applied because it can be controlled for statistically when formally testing the model by using residual scores, a procedure which does not seem to have a significant impact on results (Ramchandani et al., 2010; Rioux et al., 2016). Importantly, since the criteria applied are more liberal when re-examining previously published studies, results should be seen as indicative of support for one or the other model rather than as providing clear support. Plotted results of significant interactions from included studies that were not plotted in the original studies are provided in the Supplementary material.

Results

Fig. 2 summarizes the results of the different steps of the literature search. The Boolean search ($N = 414$) and a search through other sources ($N = 1$) resulted in identifying 415 articles. Screening of the titles and abstracts resulted in the exclusion of 365 articles that did not meet inclusion criteria. This left 50 full-text articles out of which 36 were further excluded because they did not meet eligibility criteria. The review will therefore include 14 studies. Among these 14 studies, we retained the study that had been identified in the first step through other sources than search engines, which was from our laboratory (Rioux et al., 2016). Temperament variables examined in the reviewed studies include overarching temperament profiles, reactivity measures and self-regulation measures. The family environment variables examined in the studies fell within these three broad categories: parent–child relation (e.g., parental support, parent–child conflict), parenting practices (e.g., parental control, coercive parenting) and home environment (e.g., familial stress, parent separation). Details regarding the design, measures and results of all reviewed studies are summarized in Table 3. Results of reviewed studies are presented separately in subsections for (a) overarching temperament profiles, (b) reactivity dimensions and (c) self-regulation dimensions. Within subsections, cross-sectional studies are covered before prospective and longitudinal studies and organized chronologically. Cross-sectional studies had data at only one time point, prospective studies had data at several time points with no repeated measures and longitudinal studies had data at several time points with repeated measures of substance use or externalizing behaviors.

Overarching temperament profiles

In a first early study, Windle (1992) conducted a cross-sectional study with 975 participants averaging 15.5 years (range not provided). In that study, the interaction between parental support and difficult temperament was not significant for girls, with an effect size close to zero ($\beta = 0.04$), but it was significant for boys, with a small effect size ($\beta = -0.13$). Low parental support was associated with higher delinquency levels for boys with a higher score of difficult temperament, but not for boys with a lower score. Plotting the coefficients provided revealed a fan-shaped interaction, supporting the diathesis–stress model (see Supplementary Fig. S1a).

In a second study, Wills, Sandy, Yaeger, and Shinar (2001) followed 1269 adolescents assessed three times, at 12, 13 and 14 years of age. They assessed protective temperament, defined as high levels of task attentional orientation and positive emotionality, and difficult temperament, defined as high levels of physical activity and negative emotionality. Results

showed that the association between parent–child conflict and substance use at 12 years was low among participants with higher levels of self-reported and teacher-reported protective temperament between 12 and 14 years. The association between parent–child conflict and substance use at 12 years was also high among participants with a higher level of teacher-reported difficult temperament, but the interaction with self-reported difficult temperament was not significant. Effect sizes could not be obtained for this study. Plotting the coefficients provided revealed fan-shaped interactions, supporting the diathesis–stress model (see Supplementary Fig. S7a–c). The interaction between parent–child conflict and temperament (self-reported and teacher-reported protective and difficult temperament) did not predict change in substance use from 12 to 14 years.

In summary, only two studies examined interactions between the family environment and overarching temperament profiles, with one predicting delinquency (Windle, 1992) and one predicting substance use (Wills et al., 2001). Both studies collected data exclusively during adolescence and the significant interactions in both studies supported the diathesis–stress model.

Reactivity

In addition to using a difficult temperament score (see overarching temperament profiles section), the cross-sectional study of 15.5-year-old adolescents by Windle (1992) also examined interactions with activity level. No significant interactions were found between activity level and parental support in the prediction of boys' and girls' delinquency and effect sizes were close to zero ($\beta = -0.03$ for boys; $\beta = -0.06$ for girls).

A second cross-sectional study conducted by Carlo, Roesch, and Melby (1998) with 80 participants averaging 14 years found no significant interactions between anger, sociability and maternal and paternal support in the prediction of antisocial behaviors, most likely due to the very small sample size; whereas some effect sizes were close to zero ($\beta = -0.01$ to 0.07), there was a small effect size ($\beta = 0.14$) for the interaction between sociability and maternal support.

A third cross-sectional study conducted by Stice and Gonzales (1998) with 631 participants aged 16–19 years examined interactions of impulsivity and negative affectivity with maternal and paternal control and support in the prediction of antisocial behaviors, alcohol use and illicit substance use. They found three significant interactions in the prediction of antisocial behaviors. These results showed that low levels of maternal control, maternal support and paternal control were associated with higher levels of antisocial behaviors when impulsivity was higher, but not when it was lower. One significant interaction was found in the prediction of alcohol use, showing that low levels of paternal control were associated with higher levels of alcohol use when negative affect was low, but not when it was high. Finally, three interactions were found in the prediction of illicit substance use. Low levels of maternal control and support were associated with higher levels of illicit substance use when negative affect was lower and low levels of paternal support were associated with higher levels of illicit substance use when impulsivity was higher, but not when it was lower. Plotting the coefficients provided revealed fan-shaped interactions, supporting the diathesis–stress model (see Supplementary Fig. S3a–g). Non-significant interactions had effect sizes

close to zero ($\beta = 0.00-0.05$), whereas significant interactions had small effect sizes ($\beta = 0.08-0.13$).

A fourth cross-sectional study conducted by Padilla-Walker and Nelson (2010) with 134 participants averaging 16 years found no significant interaction with fearfulness and maternal support, for which the effect size was small ($\beta = 0.15$). However, a significant three-way interaction was found between sex, fearfulness and maternal appropriateness, with a moderate effect size ($\beta = -0.34$). Although the two-way interaction was not significant for girls, it was significant for boys: low levels of maternal appropriateness were associated with higher levels of antisocial behaviors for boys who reported lower levels of fearfulness, but not boys reporting higher levels of fearfulness. Plotting the coefficients provided revealed a fan-shaped interaction, supporting the diathesis–stress model (see Supplementary Fig. S4).

One prospective study conducted by Rioux et al. (2016) followed 209 participants from 6 to 15 years, and assessed the interactions of impulsivity at 6 years with coercive parenting at 6 years and parental monitoring at 14 years in the prediction of alcohol use frequency at 15 years. The interaction between impulsivity and parental monitoring was not significant and had an effect size close to zero ($\beta = 0.07$). A significant interaction with a small effect size ($\beta = 0.16$) was found between impulsivity and coercive parenting, showing that higher levels of coercive parenting at 6 years were associated with more frequent alcohol use at 15 years for children higher on impulsivity at 6 years, but not children lower in impulsivity. Furthermore, children higher in impulsivity also showed lower alcohol use frequency compared to children lower in impulsivity when coercive parenting was low. This study further examined the interaction using the crossover point estimation method (Widaman et al., 2012, see introduction – comparing the diathesis–stress and differential susceptibility models) and found that it supported the differential susceptibility model.

A first longitudinal study conducted by Leve, Kim, and Pears (2005) followed 337 participants from 5 to 17 years and modeled externalizing behaviors across these years with linear growth curves with the intercept centered at 17 years. Models were tested separately for boys and girls and they examined the interactions of impulsivity and fearfulness/shyness with coercive parenting. No significant interactions were found for boys and effect sizes were close to zero ($\beta = 0.01-0.07$), but interactions were found in the prediction of girls' intercept and slope, with small to moderate effect sizes ($\beta = 0.21-0.28$). Higher levels of coercive parenting at 5 years were associated with higher levels of externalizing behaviors at 17 years for girls with higher levels of impulsivity and lower levels of fear/shyness at 5 years, but not for girls with lower levels of impulsivity and higher levels of fear/shyness. Higher levels of coercive parenting at 5 years were also associated with higher increases in externalizing behaviors from 5 to 17 years for girls with higher levels of impulsivity and lower levels of fear/shyness at 5 years. Plotted results provided in the article showed a crossover interaction where girls with higher levels of impulsivity and lower levels of fear/shyness also decreased more in externalizing behaviors from 5 to 17 years when exposed to lower levels of coercive parenting, supporting the differential susceptibility model. Coefficients for the effects on the intercept at 17 years were in the same direction and magnitude, suggesting the same pattern of interaction.

A second longitudinal study conducted by Measelle, Stice, and Springer (2006) followed 493 girls from 13 to 17 years and found no significant interaction between negative affect and parental support in the prediction of substance abuse initiation. Effect sizes could not be obtained for this study. Similarly, a third longitudinal study conducted by Sentse, Ormel, Veenstra, Verhulst, and Oldehinkel (2011) followed 1274 participants from 11 to 16 years and found no significant interaction between fearfulness at 11 years and parental separation between 11 and 16 years in the prediction of externalizing behaviors at 16 years, with an effect size close to zero ($\beta = -0.05$).

A fourth longitudinal study conducted by Burk et al. (2011) followed 362 participants from birth until the age of 16. They assessed disinhibition, an average of activity level and approach, familial stress and authoritative parenting. No significant interactions were found between negative affect and authoritative parenting or familial stress in childhood in the prediction of alcohol use at 16 years or between disinhibition and authoritative parenting. However, a three-way interaction between sex, disinhibition and familial stress was found. The two-way interaction was significant for girls, but not for boys. High levels of familial stress in childhood were associated with higher levels of alcohol use at 16 years for girls with higher levels of disinhibition in childhood, but not for girls with lower levels of disinhibition. Effect sizes could not be obtained for this study. Plotting the coefficients provided revealed a crossover interaction, where girls with higher levels of disinhibition also showed lower levels of alcohol use when familial stress was low, supporting the differential susceptibility model (see Supplementary Fig. S13).

A fifth longitudinal study conducted by Armstrong et al. (2013) and using the same sample as Burk et al. (2011) followed 374 participants from 3.5 years until Grade 12 and modeled alcohol use quantity from Grades 9 to 12 with a quadratic growth curve and the intercept centered at Grade 9. They assessed disinhibition, authoritative parenting and authoritarian parenting in childhood. Although the interaction between authoritative parenting and disinhibition in childhood was not significant in the prediction of growth in alcohol use quantity between Grades 9 and 12 (either linear or quadratic slopes), it was significant in the prediction of alcohol use quantity at Grade 9 (intercept). Lower levels of authoritative parenting were associated with higher levels of alcohol use in Grade 9 when disinhibition was higher in childhood, but not when it was lower. Effect sizes could not be obtained for this study. Plotting the coefficients provided revealed a crossover interaction where children higher in disinhibition also had lower levels of alcohol use when authoritative parenting was higher, supporting the differential susceptibility model (see Supplementary Fig. S14a). Regarding authoritarian parenting, the interaction between disinhibition and authoritarian parenting in childhood was not significant in the prediction of the alcohol use quantity in Grade 9 (intercept), but was significant in the prediction of growth in alcohol use quantity across time (both linear and quadratic slope factors). For children lower in disinhibition, low authoritarian parenting was associated with a steeper slope that leveled off by the end of high school and high authoritarian parenting was associated with a steeper increase at the end of high school. A three-way interaction with sex showed that the effect of authoritarian parenting was not significant for boys with high levels of disinhibition, but was significant for girls high on disinhibition. For these girls, low authoritarian parenting was associated with a linear increase in alcohol use and high authoritarian parenting was associated with a

steeper slope that leveled off by the end of high school. The interactions predicting the alcohol use slope did not support the diathesis–stress or differential susceptibility models and the pattern for girls was more consistent with contrastive effects (see Supplementary Fig. S14b).

In summary, negative affect was examined in three studies (Burk et al., 2011; Measelle et al., 2006; Stice & Gonzales, 1998), with small significant interactions in the prediction of alcohol and illicit substance use found in one study only (Stice & Gonzales, 1998), which was the better powered study of the three ($N = 631$ vs $N = 493$ and $N = 280$), raising the possibility that non-significant moderation effects in the Burk et al. (2011) and Measelle et al. (2006) studies may be due to lack of power. Furthermore, the participants in the study by Stice and Gonzales (1998) were assessed in late adolescence, while the other samples were assessed in early to middle adolescence. Fearfulness assessed in adolescence was examined in two studies (Padilla-Walker & Nelson, 2010; Sentse et al., 2011), with only one study showing a medium sized significant interaction with maternal appropriateness in the prediction of externalizing behaviors, supporting the diathesis–stress model (Padilla-Walker & Nelson, 2010). A study assessing a combination of fearfulness and shyness in childhood (Leve et al., 2005) found small interactions with coercive parenting supporting the differential susceptibility model in the prediction of externalizing behaviors. Impulsivity was examined in three studies. The first of these three studies found small interactions supporting the diathesis–stress model with parental control and support assessed in adolescence in the prediction of antisocial behaviors, alcohol use and illicit substance use (Stice & Gonzales, 1998). The two other studies found interactions between impulsivity and coercive parenting assessed in childhood predicting adolescent externalizing behaviors (Leve et al., 2005) and alcohol use frequency (Rioux et al., 2016), reporting small effect sizes and supporting the differential susceptibility model. Finally, two studies using the same sample examined disinhibition with family stress, authoritative and authoritarian parenting assessed in childhood in the prediction of alcohol use, with two significant interactions supporting the differential susceptibility model and one interaction that did not support either model (Armstrong et al., 2013; Burk et al., 2011).

Self-regulation

In addition to examining overarching temperament profiles and reactivity measures, the cross-sectional study of 15.5-year-old adolescents by Windle (1992) reviewed earlier also examined interactions between parental support and duration of orienting, as well as attentional focusing. The interaction between duration of orienting and parental support was not significant for girls, with an effect size close to zero ($\beta = 0.01$), but it was significant for boys, with a small effect size ($\beta = 0.13$): lower levels of parental support were associated with higher levels of delinquency when boys had lower duration of orienting. Conversely, the interaction between attentional focusing and parental support was not significant for boys, with an effect size close to zero ($\beta = -0.02$), but it was significant for girls, with a small effect size ($\beta = 0.11$): lower levels of parental support were associated with higher levels of delinquency when girls had lower attentional focusing. Plotting the coefficients provided revealed fan-shaped interactions, supporting the diathesis–stress model (see Supplementary Fig. S1b–c).

A prospective study of self-regulation conducted by Olson, Bates, Sandy, and Lanthier (2000) followed 116 participants from 6 months until 17 years and found no significant interaction between inhibitory control and mother–infant affectionate contact in infancy in the prediction of externalizing behaviors at 17 years. Standardized coefficients could not be obtained for this study. However, the interaction had a R^2 change statistic of 0.02, which represents a small portion of variance explained (Cohen, 1992).

In addition to examining reactivity measures, the prospective study by Rioux et al. (2016) reviewed in the previous section also examined a measure of inhibitory control in the prediction of alcohol use frequency at 15 years. In that study, no significant interaction was found between inhibitory control at 6 years and coercive parenting at 6 years and the effect size was small ($\beta = 0.15$). The interaction between inhibitory control at 6 years and parental monitoring at 14 years was also not significant, but the effect size was moderate in magnitude ($\beta = 0.44$).

A longitudinal study conducted by Loukas and Roalson (2006) followed 459 participants, averaging 12 years of age at baseline (ranging from 10 to 14 years), for one year. There was no significant interaction between effortful control and parent–child conflict assessed at 12 years in the prediction of conduct problems one year later and the effect size was close to zero ($\beta = -0.06$). A small interaction between effortful control and negative family relations was significant ($\beta = -0.10$) and a three-way interaction with ethnicity was found ($\beta = -0.11$): the interaction was not significant for Latino adolescents, but was significant for Caucasian adolescents. Higher levels of negative family relations at 12 years were associated with higher levels of conduct problems at 13 years for Caucasian adolescents with lower levels of effortful control at 12 years, but not for those with higher levels of effortful control. Plotted results provided in the article showed a fan-shaped interaction, supporting the diathesis–stress model.

In addition to examining reactivity measures, the longitudinal study by Sentse et al. (2011) reviewed in the previous section also examined a measure of effortful control and found a small significant interaction ($\beta = -0.16$). Parental separation between 11 and 16 years was associated with higher levels of externalizing behaviors at 16 years when effortful control at 11 years was low, but not when it was high. Plotted results provided in the article showed a fan-shaped interaction, supporting the diathesis–stress model.

Finally, a last longitudinal study conducted by Bakker, Ormel, Verhulst, and Oldehinkel (2011) used the same sample as Sentse et al. (2011), following 2230 participants from 11 to 16 years. In that study, higher levels of family adversity between 11 and 16 years were associated with higher levels of externalizing behaviors at 16 years when effortful control at 11 years was low, but not when it was high. The effect size was very small ($\beta = -0.05$). Plotted results provided in the article showed a fan-shaped interaction, supporting the diathesis–stress model.

In summary, six studies examined self-regulatory measures of temperament. Two studies used a measure of inhibitory control and did not find significant interactions (Olson et al., 2000; Rioux et al., 2016). Effect sizes were small when the interaction involved coercive

parenting and mother–infant affectionate contact, but it was of medium magnitude when the interaction involved parental monitoring. Conversely, three studies examined effortful control and found significant interactions that supported the diathesis–stress model (Bakker et al., 2011; Loukas & Roalson, 2006; Sentse et al., 2011), all with small effect sizes and large sample sizes. These three studies used data exclusively in adolescence and two of them used data from the same sample (Bakker et al., 2011; Sentse et al., 2011). The last study examined duration of orienting and attentional focus and also found interactions with small effect sizes that supported the diathesis–stress model using a cross-sectional design (Windle, 1992).

Discussion

The aim of this review was first to examine how temperament and the family environment interact in the prediction of adolescent substance use and externalizing behaviors and second to determine if studies supported the diathesis–stress or differential susceptibility models as this may be helpful for research into prevention and early intervention. Evidence for the interactions between temperament and various family factors was found in the studies reviewed. Support for the differential susceptibility model was found in studies examining temperament and the family environment in childhood, which mostly examined reactivity dimensions of temperament. Support for the diathesis–stress model was found in studies examining temperament and the family environment in adolescence, which examined both reactivity and self-regulatory dimensions of temperament.

Interactions between temperament and the family environment

The studies reviewed examined overarching temperament profiles, reactivity measures and self-regulation measures. Two studies assessed overarching temperament profiles and found significant interaction effects (Wills et al., 2001; Windle, 1992). Six of the ten studies assessing reactivity measures found significant interactions (Armstrong et al., 2013; Burk et al., 2011; Leve et al., 2005; Padilla-Walker & Nelson, 2010; Rioux et al., 2016; Stice & Gonzales, 1998), with four of the six studies showing a further moderating effect of sex (Armstrong et al., 2013; Burk et al., 2011; Leve et al., 2005; Padilla-Walker & Nelson, 2010). Results for self-regulatory measures of temperament were consistent, although based on only a few studies. Two studies examined inhibitory control and did not find significant interactions (Olson et al., 2000; Rioux et al., 2016) and three studies examined effortful control, finding significant interactions (Bakker et al., 2011; Loukas & Roalson, 2006; Sentse et al., 2011). One additional cross-sectional study examined duration of orienting and attentional focus and found significant interactions (Windle, 1992).

The majority of significant interactions had small effect sizes, while the majority of non-significant interactions had effect sizes close to zero. There were some exceptions where non-significant interactions had small to medium effect sizes (Carlo et al., 1998; Padilla-Walker & Nelson, 2010; Rioux et al., 2016), but these effects were found in studies with relatively small samples ($n = 80–209$). Whereas most significant interaction effects were small in size, larger effect sizes were found in studies with relatively homogeneous samples. For example, participants in the Rioux et al. (2016) study came from a mostly Caucasian and

French-speaking urban sample and participants in the Padilla-Walker and Nelson (2010) study were sampled from one high school. Small effect sizes found in most studies reviewed, which are usually the norm in moderation studies (Aguinis et al., 2005), along with some findings showing further moderating effects of sex and ethnicity, highlight the need for large sample sizes when testing these effects.

Overall, the significant interactions reported in most studies reviewed showed higher levels of substance use and externalizing behaviors in adolescence when more adverse family environments were combined with high levels of impulsivity and disinhibition, which includes activity level and approach, as well as low levels of effortful control, negative affect, fearfulness and shyness. Certain studies also showed that children with some of these temperament traits had lower levels of substance use and externalizing behaviors in adolescence compared to children without those temperament traits when exposed to positive family environments. These temperament traits are similar, but sufficiently different from what is usually described as a difficult temperament, for which negative affect and its subcomponents fearfulness and shyness are high. Although high levels of negative affectivity are associated with some developmental problems, including internalizing problems, the guilt and anxiety associated with negative affectivity has been considered to be a protective factor for later externalizing behaviors (Kochanska, 1993). Furthermore, other individual traits associated with externalizing behaviors are associated with lower negative affect. Notably, children and adolescents with callous-unemotional traits, which are strongly associated with antisocial behaviors and conduct problems (Frick, Ray, Thornton, & Kahn, 2014; Frick & White, 2008), tend to have lower levels of fearfulness (Barker, Oliver, Viding, Salekin, & Maughan, 2011; Pardini, Lochman, & Frick, 2003; Roose, Bijttebier, Van der Oord, Claes, & Lilienfeld, 2013). Overall, this indicates that specific temperament traits or dimensions may provide more comprehensive information than prevailing overarching temperament profiles such as difficult temperament regarding susceptibility to specific problematic developmental outcomes.

As a whole, these temperament traits (i.e., high levels of impulsivity, disinhibition, activity level and approach; low levels of effortful control, negative affect, fearfulness and shyness) could be considered more indicative of an “adventurous” tendency or disposition, rather than of a difficult temperament. It should be noted that while these traits show a similar pattern of associations with substance use and externalizing behaviors, they are also different and there may be different unique mechanisms underlying these different associations. Nevertheless, to simplify the discussion, and for the sake of clarity, the term “adventurous” will be used throughout the discussion. Since “adventurous” temperament characteristics were not examined as a composite score in the studies reviewed, future studies could examine whether some children show an overarching “adventurous temperament profile”, and whether this hypothetical profile is associated with specific developmental outcomes such as externalizing behaviors. Indeed, such a temperamental profile may be more strongly associated with an increased risk for externalizing behaviors and substance use compared to difficult temperament traits (when exposed to an adverse family environment) because impulsive traits are here combined with an absence of negative emotional states, which serve to inhibit behaviors when faced with real or imagined punishment (Rothbart, Ahadi, & Hershey, 1994). Because it has been previously found that temperament dimensions

interacted with each other (Muris et al., 2007), future studies could also examine three-way interactions between two “adventurous” temperament traits and the family environment.

Similar “adventurous” temperament traits have been identified previously in adults. A study of parents whose daughters had eating disorders identified an “explosive/adventurous temperament” characterizing mothers who were notably high in impulsivity and novelty seeking, but low in shyness, anxiety, depression and sentimentality (Amianto, Daga, Bertorello, & Fassino, 2013). Furthermore, “adventurous” temperament traits could be associated with specific personality profiles later in life. The “adventurous” temperament traits identified in this review have been associated with high extraversion and agreeableness and low neuroticism and conscientiousness using the Big Five personality approach (De Pauw & Mervielde, 2010). Specifically, (a) high activity level was associated with high extraversion (Hagekull & Bohlin, 2003), (b) low effortful control and high impulsivity were associated with low conscientiousness (Digman & Shmelyov, 1996; Grist & McCord, 2010; Shafer, 2001) and (c) low negative affectivity was associated with low neuroticism (Grist & McCord, 2010; Hagekull & Bohlin, 2003; Shafer, 2001; Watson & Clark, 1992), low conscientiousness (Farrell, Brook, Dane, Marini, & Volk, 2015; Grist & McCord, 2010) and high agreeableness (Farrell et al., 2015; Shafer, 2001). Besides one study which was prospective (Hagekull & Bohlin, 2003), other studies were concurrent. Future studies could examine concurrently or prospectively whether “adventurous” temperament traits are associated with other personality measures in addition to those of the Big Five. For example, the temperamental dimensions of impulsivity and inhibitory control may be associated with the personality dimension of impulsivity, and temperamental disinhibition shares some similarities with the personality dimension of sensation seeking/venturesomeness (Eysenck & Eysenck, 1978). Since personality has been shown to be associated with externalizing behaviors and substance use (Castellanos-Ryan & Conrod, 2012; DeYoung, Peterson, Séguin, & Tremblay, 2008; Mezquita et al., 2015; Zvolensky, Taha, Bono, & Goodwin, 2015), future longitudinal studies could test a mediated moderation model (Muller, Judd, & Yzerbyt, 2005) examining whether the interaction between temperament and the family is mediated by personality in the prediction of externalizing behaviors and substance use. Other variables than personality that could potentially mediate the association include peer affiliation (Dishion & Tipsord, 2011; Leung, Toumbourou, & Hemphill, 2014; Marschall-Lévesque, Castellanos-Ryan, Vitaro, & Séguin, 2014), self-control abilities (Wills & Dishion, 2004) as well as the internalization of social norms and positive morals and the effectiveness of socialization (Kochanska, 1993; Kochanska & Aksan, 2006).

Support for the differential susceptibility model and implications

Support for the differential susceptibility model was found in four studies (Armstrong et al., 2013; Burk et al., 2011; Leve et al., 2005; Rioux et al., 2016), all assessing reactivity measures of temperament. In those studies, in addition to higher levels of externalizing behaviors or alcohol use in adverse family environments, more impulsive and disinhibited children as well as those low in fearfulness/shyness had lower levels of externalizing behaviors and alcohol use in positive family environments or in the absence of adversity compared to children lower in impulsivity and disinhibition and higher in fearfulness/shyness. Prospective interactions with reactivity measures other than impulsivity,

disinhibition and fearfulness/shyness (e.g., anger, or activity level and approach alone as opposed to combined in a disinhibition score) should be examined to help determine whether the effects are specific to these measures or more generalizable across reactivity measures.

Importantly, all the studies that showed support for the differential susceptibility model were prospective in nature with temperament and the family environment being assessed in childhood, whereas studies supporting the diathesis–stress model assessed all of these variables in adolescence. Thus, although support for the differential susceptibility model was only found with reactivity measures of temperament, the dearth of prospective studies assessing overarching temperament profiles and self-regulation in childhood could explain the lack of support for the differential susceptibility model using these other measures of temperament. More long-term prospective studies are needed to determine whether overarching temperament profiles and self-regulatory measures are also susceptibility factors in childhood.

The fact that the interaction between temperament and family variables in childhood predicted outcomes in adolescence following a differential susceptibility pattern is compatible with the suggestion that enhanced susceptibility should lead to developmental changes that are sustained in time (Ellis et al., 2011). Furthermore, our finding that only studies using predictors in childhood support the differential susceptibility model is consistent with Belsky and Pluess's (2009) observation that evidence for temperamental differential susceptibility comes from research showing that it is temperament in childhood, and not later in development, that moderates the effect of environmental factors on behavioral development. Thus, “adventurous” temperament traits could be indicators of susceptibility to both positive and negative environments in childhood but no longer in adolescence. Indeed, the mechanisms underlying adventurous temperament traits may not be the same in childhood and adolescence, with temperament being primarily under genetic influence in infancy and increasingly reflecting an influence of the environment over time. Within a differential susceptibility framework, when temperament traits are measured later in development, the measure of temperament traits themselves could already reflect the interaction between being more susceptible and the environment. Future studies could clarify this developmental process explicitly by assessing whether an interaction between “adventurous” temperament traits and the family environment in childhood predicts “adventurous” temperament traits in adolescence, and examining whether this differs among temperament traits. Furthermore, studies could assess “adventurous” temperament traits and the family environment across development and examine if the pattern of their interaction in the prediction of externalizing behaviors and substance use changes from a differential susceptibility to a diathesis–stress pattern as participants go from childhood into adolescence.

It is generally assumed by developmentalists that plasticity is greatest in infancy and childhood. However, it has been suggested that, although on average plasticity might be greater earlier in development, some individuals might show greater plasticity later in life. Thus, individuals of all ages might vary in their susceptibility, with individual variations in terms of when children and adults show greater plasticity (Belsky & Pluess, 2013; Ellis et

al., 2011). Furthermore, plasticity has also been observed in adolescence, with important neurobiological changes occurring during this period (Spear, 2000, 2013; Steinberg, 2008). Thus, while temperament assessed early in development may be more strongly associated with plasticity than when assessed later in development, variability in susceptibility at later ages may still be captured using other measures. For example, measures of individual differences in the reactivity of neurobiological stress response systems, highlighted in the biological sensitivity to context literature, may be better indices of susceptibility later in development than more behavioral temperament measures (Blandin, 2013; Boyce & Ellis, 2005). One of these individual characteristics is referred to as sensory-processing sensitivity in the personality literature, or sometimes more generally as high sensitive personality (Aron & Aron, 1997). While related to temperament, this personality trait is broader, encompassing a sensitive nervous system, awareness of subtle stimuli, a tendency to be easily over-stimulated by the environment and a deep processing of novel situations, leading these individuals to reexamine their cognitive maps following some experiences. An important element of sensory-processing sensitivity is the depth of emotional and mental processing. Evidence of differential susceptibility from studies examining this trait (Aron, Aron, & Jagiellowicz, 2012; Belsky & Pluess, 2009) suggests it may be a good index of susceptibility in adolescence and adulthood.

An important limitation of the current literature is that the authors of most studies examined and interpreted their results explicitly or implicitly within a diathesis–stress frame of reference in mind. Notably, the only study that explicitly compared the models using childhood predictors showed support for the differential susceptibility model (Rioux et al., 2016). Other studies were re-examined using a more “qualitative” appraisal of plotted results. The criteria applied when using the coefficients in published studies to see if they support the differential susceptibility model are liberal compared to the analyses that should be conducted with the full data, making our results only indicative regarding the support of both models. Thus, more long-term prospective studies that specifically compare the two models are needed to help determine which temperamental characteristics are vulnerability or susceptibility factors, under which environmental conditions, and at what age.

Clarifying those issues is important because accrued support for the differential susceptibility model would suggest that the conception of some individual “vulnerability” factors needs revising. Although both models support targeting children with “adventurous” temperament traits early for interventions, adopting the differential susceptibility model could lead to a change in the expectations of parents, teachers and clinicians regarding what could be achieved by these children. Indeed, considering these temperament traits as risk factors and children with these temperament traits as “vulnerable” could misrepresent their malleable nature and deflect from the fact that their temperament could also be an asset in the right environment (Belsky & Pluess, 2009). This would keep the focus on a need for screening children (in order to identify the most vulnerable or susceptible), but clearly shift the intervention content to focus on the environment. Furthermore, the common term “difficult” temperament itself may then no longer be appropriate due to its negative connotation and its implied vulnerability, a point already raised when research on temperament was in its beginning stages (Rothbart, 1982).

Experimental research is also needed for testing these models. Studies evaluating whether the impact of interventions targeting the family environment (e.g., improving parenting practices, parent–child relationship or marital relationship) on substance use and externalizing behaviors is moderated by temperament could be conducted. To test the differential susceptibility model, these studies would have to randomize the familial intervention, whereas temperament would be a fixed factor (Bakermans-Kranenburg & van IJzendoorn, 2015). This review would suggest the hypothesis that interventions in childhood might be more effective because temperament in childhood, but not in adolescence, might be a susceptibility factor. For example, parents exhibiting adverse parenting practices with their children could be randomized to a parenting intervention and control condition to examine whether the intervention effects observed on externalizing behavior outcomes in adolescence differ between the children with “non-adventurous” temperament traits and those with “adventurous” temperament traits. If the children with “adventurous” temperament traits benefit more from interventions than children without those temperament traits and thus have better outcomes, it would demonstrate susceptibility to positive family environments. This, in combination with findings showing that control participants with “adventurous” temperament traits and adverse family environment have worse outcomes than participants with “non-adventurous” temperament traits and adverse family environment, as supported by the literature, would provide support for the differential susceptibility model.

Integrating findings into prevention programs

There are already a variety of evidence-based interventions that could be used in experimental studies to test the hypotheses raised above by examining whether their positive impact on substance use and externalizing behaviors is greater for children with “adventurous” temperament traits compared with those with “non-adventurous” temperament traits. Interventions on parenting practices can be especially useful, particularly since they can be delivered early in child development. Parenting programs can support parents in monitoring their children’s behavior and establishing a strong parent–child relationship by teaching them how to model healthy behaviors, communicate effectively with their children, develop problem-solving skills and provide appropriate reinforcement (Essau, 2004). A recent meta-analysis showed that parenting interventions based on social learning and cognitive-behavioral principles are the most effective in reducing problem behaviors (Dretzke et al., 2009). A low cost group-based parenting intervention developed using cognitive-behavioral theories is the Webster-Stratton parenting program (Webster-Stratton, 1998; Webster-Stratton & Herbert, 1994; see incredibleyears.com), which employs a collaborative approach building on parents’ strengths and expertise. Other programs have used the media (e.g., Triple P program; Sanders, 1999) and schools (e.g., Adolescent Transitions Program; Dishion & Kavanagh, 2000, 2003) to decrease the costs of the intervention and reach more parents. In programs such as the Triple P and Adolescent Transitions Program, general interventions are delivered to the majority of the population through the media or through schools, but regular practitioner interventions are also delivered to higher-risk families. Since children with “adventurous” temperament traits exposed to dysfunctional parenting practices have the highest risk for externalizing behaviors and substance use, identifying children with “adventurous” temperament traits

could be an important factor when selecting high-risk families in need of the practitioner-delivered interventions.

Conclusion

This review showed that the recent literature supports an interaction between temperament and the family environment in the prediction of externalizing behaviors and substance use, at least for certain dimensions. Most significant interactions showed that “adventurous” temperament traits combined with adverse family environments predicted higher levels of substance use and externalizing behaviors in adolescence. These temperament traits included high levels of impulsivity and disinhibition, as well as low levels of effortful control, negative affect, fearfulness and shyness, a combination that differs from the most common overarching temperament profile labeled as difficult temperament. Support for the differential susceptibility model was found in studies assessing temperament (specifically those assessing reactivity) and family environments in childhood while studies assessing them in adolescence supported the diathesis–stress model. It is thus possible that “adventurous” temperament traits would be indicators of susceptibility to both enriched and adverse environments in childhood but no longer in adolescence, when it would only be an indicator of vulnerability to adverse environments.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix: Supplementary material

Supplementary data to this article can be found online at doi:10.1016/j.dr.2016.03.003.

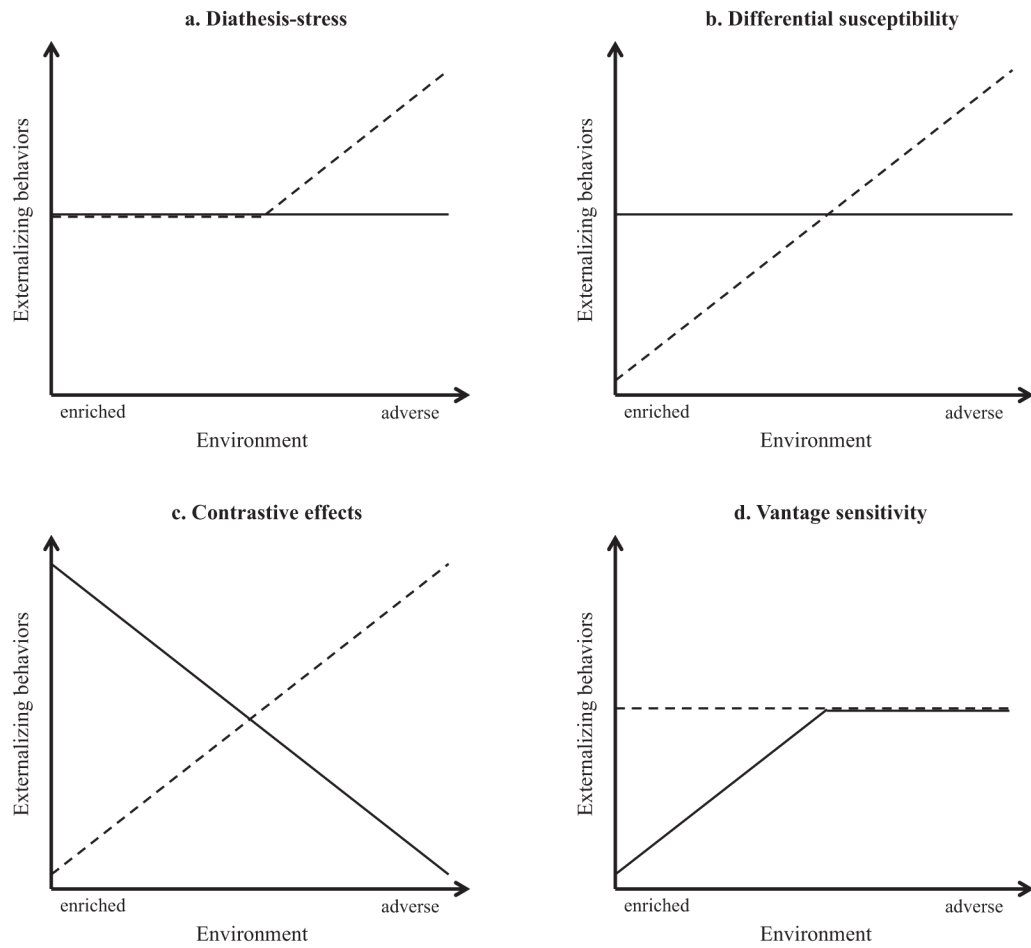


Fig. 1. Graphical representation of different moderation models. The lines depict high or low levels of an individual characteristic: for example, continuous lines represent an easy temperament and dashed lines represent a difficult temperament.

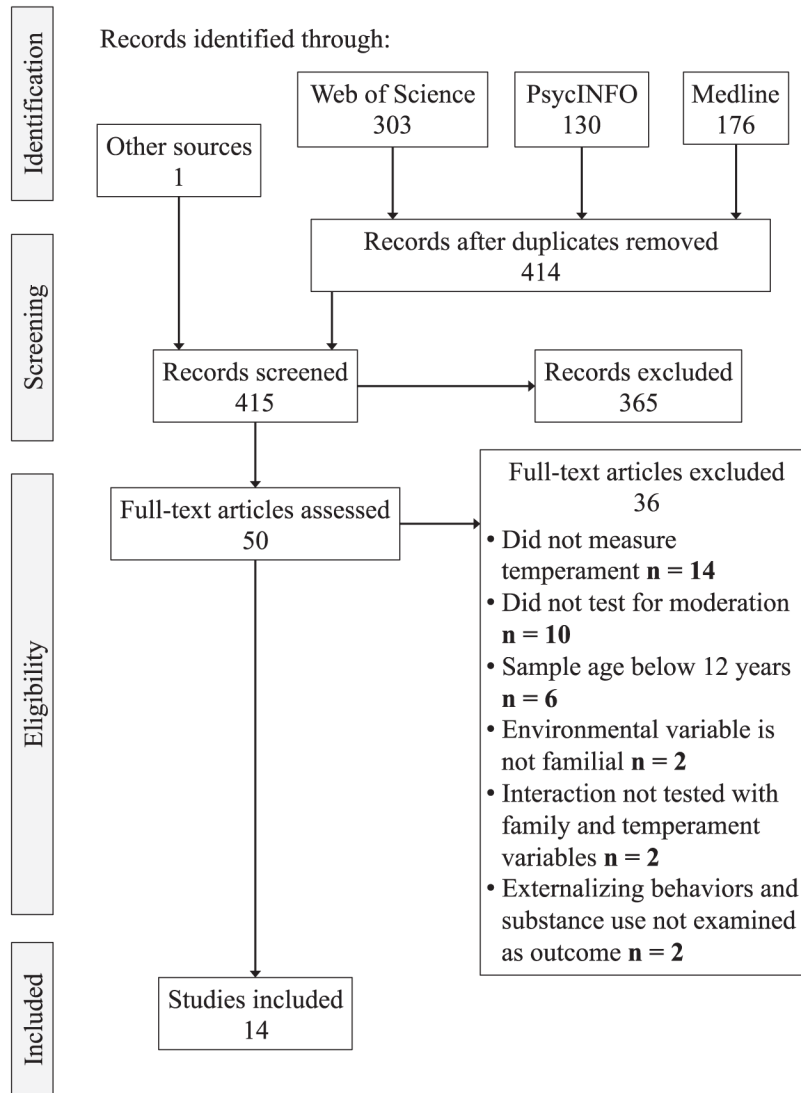


Fig. 2.
Flow diagram for study selection.

Table 1

Classification and definition of observed temperament overarching profiles and dimensions.

Overarching temperament profiles
<p>Difficult temperament</p> <p><i>Various characteristics making the child more difficult to handle</i> (Goldsmith et al., 1987).</p> <p>General characteristics (characteristics vary among studies): Irregular eating and sleeping daily routines, withdrawal from people and novel stimuli, low adaptability or inflexibility to changes in the environment, high intensity responses and irritable mood quality (Thomas & Chess, 1977)</p> <p>Protective temperament</p> <p><i>Tendency to focus on tasks, persist until finished, have a cheerful mood and smile frequently</i> (Wills et al., 2001)</p> <p>Extravert/aggressive</p> <p><i>In a doll-play situation: High amount of bodily movement, easily roused to excite behavior, low tendency to stick with one activity, tendency to respond, show aggression, be rough and show nonrealistic fantasy</i> (Score based on factor analysis; Wennberg & Bohman, 2002).</p> <p>Extravert/outgoing</p> <p><i>In a doll-play situation: attempts to change occupation/terminate the play, low concern for neatness, low concerns regarding getting dirty, tendency to seek attention from the examiner, shows high degree of pleasure</i> (Score based on factor analysis; Wennberg & Bohman, 2002).</p>
Temperament dimensions
<p>Reactivity</p> <p>Activity level</p> <p><i>Gross motor activity, including rate and extent of locomotion</i> (Rothbart, Ahadi, Hershey, & Fisher, 2001).</p> <p>Impulsivity</p> <p><i>Speed of response initiation</i> (Rothbart et al., 2001).</p> <p>Approach</p> <p><i>Amount of excitement and anticipation for expected pleasurable activities</i> (Rothbart et al., 2001).</p> <p>Sociability</p> <p><i>Enjoyment derived from social interaction and preference for being in the presence of others rather than being alone</i> (Evans & Rothbart, 2007; Goldsmith et al., 1987).</p> <p>Disinhibition</p> <p><i>Combination of activity level and approach</i> (Armstrong et al., 2013; Burk et al., 2011).</p> <p><u>Negative affectivity</u> (Synonyms: negative mood, negative emotionality)</p> <p><i>Distress: proneness to negative emotional experiences such as frustration, fear and shyness</i> (Ellis, 2002)</p> <ul style="list-style-type: none"> • Fearfulness <p><i>Negative affectivity, including unease, worry, or nervousness, which is related to anticipated pain or distress and/or potentially threatening situations</i> (Rothbart et al., 2001).</p> <ul style="list-style-type: none"> • Shyness <p><i>Slow or inhibited speed of approach and discomfort in social situations</i> (Rothbart et al., 2001).</p> <ul style="list-style-type: none"> • Frustration (synonym: anger) <p><i>Negative affect related to interruption of ongoing tasks or goal blocking</i> (Rothbart et al., 2001).</p>
<p>Self-regulation</p> <p>Effortful control</p> <p><i>Combination of volitional skills, including attentional, inhibitory, and activational control that allow the inhibition of a dominant response in order to perform a subdominant response</i> (Ellis, 2002).</p> <p><u>Attentional control</u></p>

- Attentional focusing
Capacity to maintain attentional focus on task-related channels (Rothbart et al., 2001).
- Duration of orienting (Synonym: persistence)
The child's vocalization, looking at, and/or interaction with a single object for extended periods of time when there has been no sudden change in stimulation (Rothbart, 1981).

Inhibition of dominant responses

- Inhibitory control
Capacity to plan and suppress inappropriate approach responses under instructions or in novel or uncertain situations (Rothbart et al., 2001).
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Table 2

Definition of observed parenting variables.

<ul style="list-style-type: none"> • Parental control <i>Consistent discipline, monitoring of activities and enforcement of consequences</i> (Stice & Gonzales, 1998). • Appropriateness <i>Adolescents' perception of how well their parent's reactions fit the situation</i> (Padilla-Walker & Nelson, 2010) • Coercive parenting <i>Use of harsh physical and/or verbal discipline, from over-reacting to relatively extreme forms of physical and verbal punishment</i> (Leve et al., 2005; Rioux et al., 2016). • Monitoring <i>Parenting behaviors involving attention to and track of the child's whereabouts, activities, and adaptations</i> (Dishion & McMahon, 1998). • Authoritative parenting <i>Parenting style characterized by clear rules and monitoring and efforts to foster openness, support exploration and respond non-punitively</i> (Armstrong et al., 2013; Baumrind, 1971). • Authoritarian parenting <i>Parenting style characterized by control, criticism and punishment</i> (Armstrong et al., 2013; Baumrind, 1971).
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Table 3

Studies examining the interaction of temperament and family factors in the prediction of substance use and externalizing behaviors.

Design	Author, Year	Sample	Measures	Family	Outcome	Findings (effect sizes) supported model
Cross-sectional	Windle, 1992	975 (53% girls) – mean age 15.5 – from the USA	Temperament Overarching profiles – Difficult temperament, Reactivity – Activity level and Self-regulation – Duration of orienting and Attentional focusing with the DOTS-R. <i>Self-Report</i>	Parent-child relation – Parental support (from Procidano & Heller, 1983). <i>Self-report</i> .	Externalizing behaviors – Delinquency with 19 items extracted from previous research. <i>Self-report</i> .	Non-significant interactions Difficult temperament * Support – Females ($\beta = 0.04$) Activity level * Support – Males ($\beta = -0.03$) Activity level * Support – Females ($\beta = -0.06$) Attentional focus * Support – Males ($\beta = -0.02$) Duration of orienting * Support – Females ($\beta = 0.01$) Significant interactions^d Difficult temperament * Support – Males ($\beta = -0.13$) Parental support negatively associated with delinquency when difficult temperament was high, but not when it was low. <i>Diathesis-stress</i> . Attentional focus * Support – Females ($\beta = 0.11$) Parental support negatively associated with delinquency when attentional focus was low, but not when it was high. <i>Diathesis-stress</i> . Duration of orienting * Support – Males ($\beta = 0.13$) Parental support negatively associated with delinquency when duration of orienting was low, but not when it was high. <i>Diathesis-stress</i> .
	Carlo et al., 1998	80 (51% girls) – mean age 14 – from the USA	Reactivity – Anger and Sociability with the EASI. <i>Parent report</i>	Parent-child relation – Parental support with items from the NRI and additional items designed to be consistent with the instrument. <i>Parent report</i> .	Externalizing behaviors – Antisocial behaviors with the YSR. <i>Self-report</i> .	Non-significant interactions Anger * Father support ($\beta = -0.04$) Anger * Mother support ($\beta = 0.07$) Sociability * Father support ($\beta = -0.01$) Sociability * Mother support ($\beta = 0.14$) Antisocial behavior Non-significant interactions Negative affect * Mother control ($\beta = 0.02$) Negative affect * Mother support ($\beta = 0.00$) Impulsivity * Father support ($\beta = -0.03$) Negative affect * Father support ($\beta = 0.01$) Negative affect * Father support ($\beta = 0.04$) Significant interactions Impulsivity * Mother control ($\beta = -0.08$) Maternal control negatively associated with antisocial behaviors when impulsivity is high, but not when it is low. <i>Diathesis-stress</i> . Impulsivity * Mother support ($\beta = -0.08$) Maternal support negatively associated with antisocial behaviors when impulsivity is high, but not when it is low. <i>Diathesis-stress</i> . Impulsivity * Father control ($\beta = -0.08$) Paternal control negatively associated with antisocial behaviors when impulsivity is high, but not when it is low. <i>Diathesis-stress</i> . Alcohol use Non-significant interactions
	Slice & Gonzales, 1998	631 (51% girls) – 16–19 years – from the USA	Reactivity – Impulsivity and Negative affectivity with the GTS. <i>Self-report</i>	Parent-child relation – Parental support with items from the NRI and Parenting practices – Parental control with item from the PBI. <i>Self-Report</i> .	Externalizing behaviors – Antisocial behavior with items from the National Longitudinal Youth Survey Delinquency Scale. Substance use – Alcohol use and Illicit Substance use frequency in the last 6 months. <i>Self-report</i> .	

Design	Author, Year	Sample	Measures	Family	Outcome	Findings (effect sizes) supported model
			Temperament			<p>Impulsivity * Mother control ($\beta = 0.01$)</p> <p>Impulsivity * Mother support ($\beta = 0.01$)</p> <p>Negative affect * Mother control ($\beta = 0.05$)</p> <p>Negative affect * Mother support ($\beta = 0.03$)</p> <p>Impulsivity * Father control ($\beta = -0.02$)</p> <p>Impulsivity * Father support ($\beta = 0.02$)</p> <p>Negative affect * Father control ($\beta = -0.01$)</p> <p>Significant interaction</p> <p>Negative affect * Father support ($\beta = 0.10$)</p> <p>Paternal support negatively associated with alcohol use when negative affect is low, but not when it is high. <i>Diatheisis-stress</i>.</p> <p>Illicit substance use</p> <p>Non-significant interactions</p> <p>Impulsivity * Mother control ($\beta = -0.05$)</p> <p>Impulsivity * Mother support ($\beta = 0.00$)</p> <p>Impulsivity * Father control ($\beta = -0.04$)</p> <p>Negative affect * Father control ($\beta = 0.01$)</p> <p>Negative affect * Father support ($\beta = 0.03$)</p> <p>Significant interactions</p> <p>Negative affect * Mother control ($\beta = 0.09$)</p> <p>Maternal control negatively associated with illicit substance use when negative affect is high and when it is low, with a stronger effect when it is low. <i>Diatheisis-stress</i>.</p> <p>Negative affect * Mother support ($\beta = 0.13$)</p> <p>Maternal support negatively associated with illicit substance use when negative affect is low, but not when it is high. <i>Diatheisis-stress</i>.</p> <p>Impulsivity * Father support ($\beta = -0.08$)</p> <p>Paternal support negatively associated with illicit substance use when impulsivity is high, but not when it is low. <i>Diatheisis-stress</i>.</p> <p>Non-significant interactions</p> <p>Fearfulness * Support ($\beta = 0.15$)</p> <p>Fearfulness * Support * Gender ($\beta = -0.04$)</p> <p>Fearfulness * Appropriateness ($\beta = 0.07$)</p> <p>Significant interaction</p> <p>Fearfulness * Appropriateness * Gender ($\beta = -0.34$)</p> <p>Maternal appropriateness negatively associated with antisocial behaviors for boys low in fearfulness, but not boys high in fearfulness. Not significant for girls. <i>Diatheisis-stress</i>.</p> <p>Non-significant interaction</p> <p>Inhibitory control * affection ($R^2 = 0.02$)</p>
						<p>Externalizing behaviors – Antisocial behaviors with the YSR. <i>Self-report</i>.</p>
						<p>Parent-child relation – Maternal support with the IPPA and Parenting practices – Maternal appropriateness (from Padilla-Walker & Carlo, 2004). <i>Self-report</i>.</p>
						<p>Reactivity – Fearfulness with an adaptation of the CBQ. <i>Self-report</i></p>
	Padilla-Walker & Nelson, 2010	134 (54% girls) – mean age 16.2 – from the USA				
Prospective	Olson et al., 2000	116 (43% girls) – followed from 6 months to 17 years – from the USA				
						<p>Self-regulation – Inhibitory control with the IFQ. <i>Mother report, 6, 13 and 24 months.</i></p>
						<p>Reacting practices – Coercive parenting: Items from the PPS and the NLSYC. <i>Mother report, assessed at 6 years.</i> Parental monitoring: 2 items used in previous studies.</p>
	Rioux et al., 2016	209 (52% girls) – followed from 6 to 15 years – from Canada				
						<p>Alcohol use – Alcohol use frequency in the last year. <i>Self-report, assessed at 15 years.</i></p>

Design	Author, Year	Sample	Measures	Family	Outcome	Findings (effect sizes) supported model
Longitudinal	Wills et al., 2001	1269 (50% girls) – followed 3 years, mean age 11.5 at onset – from the USA	Overarching profiles – Proactive temperament: task attentional orientation and positive emotionality subscales of the DOTS-R; Difficult temperament: physical activity level subscale of the DOTS-R, and negative emotionality subscale of the EASI. <i>Teacher and self-report, assessed at 12, 13 and 14 years.</i>	Parent-child relation – Parent-child conflict: 3 item scale derived from research by Barrera, Chassin, and Rogosch (1993). <i>Self-report, assessed at 12, 13 and 14 years.</i>	Substance use – Typical frequency of cigarette, alcohol and marijuana use. <i>Self-report, assessed at 12, 13 and 14 years.</i>	Significant interaction Impulsivity * Coercive parenting ($\beta = 0.16$) Coercive parenting positively associated with alcohol use when impulsivity was high, but not when it was low. <i>Differential susceptibility.</i> Substance use intercept (12 years) Non-significant interaction Self-reported difficult temperament * Conflict Significant interactions Teacher-reported difficult temperament * Conflict Parent-child conflict more strongly positively associated with substance use for children with high difficult temperament. <i>Diathesis-stress.</i> Self-reported protective temperament * Conflict Teacher-reported protective temperament * Conflict Parent-child conflict more strongly positively associated with substance use for children with low protective-temperament. <i>Diathesis-stress.</i> Substance use slope Non-significant interactions Self-reported difficult temperament * Conflict Teacher-reported difficult temperament * Conflict Self-reported protective temperament * Conflict Teacher-reported protective temperament * Conflict
	Leve et al., 2005	337 (48% girls) – followed from 5 to 17 years – from the USA	Reactivity – Impulsivity and fearfulness/shyness with the CBQ. <i>Mother and father report, assessed at 5 years.</i>	Parenting practices – Coercive parenting: Interview regarding discipline practices	Externalizing behaviors with the CBCL. Mother and father report at 5, 7, 10, 14 and 17 years.	Externalizing behaviors Externalizing behaviors intercept (17 years) Non-significant interactions Impulsivity * Coercive parenting – Boys ($\beta = 0.05$) Fear/shyness * Coercive parenting – Boys ($\beta = 0.07$) Significant interactions Impulsivity * Coercive parenting – Girls ($\beta = 0.23$) Coercive parenting positively associated with externalizing behaviors when impulsivity was high, but not when it was low. <i>Differential susceptibility.</i> Fear/shyness * Coercive parenting – Girls ($\beta = -0.21$) Coercive parenting positively associated with externalizing behaviors when fear/shyness was low, but not when it was high. <i>Differential susceptibility.</i> Externalizing behaviors slope Non-significant interactions Impulsivity * Coercive parenting – Boys ($\beta = -0.02$) Fear/shyness * Coercive parenting – Boys ($\beta = 0.01$) Significant interactions Impulsivity * Coercive parenting – Girls ($\beta = 0.24$) Coercive parenting positively associated with increases in externalizing behaviors when impulsivity was high, but not when it was low. <i>Differential susceptibility.</i> Fear/shyness * Coercive parenting – Girls ($\beta = -0.28$) Coercive parenting positively associated with increases in externalizing behaviors when fear/shyness was low, but not when it was high. <i>Differential susceptibility.</i>
	Loukas & Roalson, 2006	459 (53% girls) – followed 1 year, mean	Self-regulation – Effortful control with the EATQ-R. <i>Self-report, assessed at 12 years.</i>	Parent-child relation – Parent-child conflict with the CoBQ and Home environment – Negative family	Externalizing behaviors – Conduct problem subscale of the	Non-significant interaction Effortful control * Parent-child conflict ($\beta = -0.06$) Significant interactions

Design	Author, Year	Sample	Measures	Family	Outcome	Findings (effect sizes) supported model
			Temperament	relations with the PES. <i>Self-report, assessed at 12 years.</i>	SDQ. <i>Self-report, assessed at 12 (control) and 13 years (outcome).</i>	Effortful control * Negative relations ($\beta = -0.10$) Effortful control * Negative relations * Ethnicity ($\beta = -0.11$) Negative family relations positively associated with conduct problems when effortful control was low, but not when it was high. Significant for Caucasian adolescents, but not for Latino adolescents. <i>Diatheisis-stress.</i>
	Measelle et al., 2006	493 girls – followed 4 years, mean age 13 at onset – from the USA	Reactivity – Negative affectivity with the EASI. <i>Self-report, assessed at 13 years.</i>	Parent-child relation – Parental support with the NRI. <i>Self-report, assessed at 13 years.</i>	Substance use – Scale assessing DSM-IV symptoms of general substance abuse, including both alcohol and illicit substances. <i>Self-report, assessed at 13, 14, 15, 16 and 17 years.</i>	Non-significant interaction Negative affect * Support
	Bakker et al., 2011*	2230 (51% girls) – followed from 11 to 16 years – from Netherlands	Self-regulation – Effortful control with the EATQ-R. <i>Parent report, assessed at 11 years.</i>	Home environment – Family adversity with the EHC. <i>Adolescent report, assessed at 16 years (asking about events between 11 and 16 years).</i>	Externalizing behaviors with the CBCL (<i>parent report</i>), the YSR (<i>adolescent report</i>) and the TCP (<i>teacher report</i>), assessed at 11 (<i>control</i>) and 16 years (<i>outcome</i>), mean from three respondents.	Significant interaction Effortful control * Adversity ($\beta = -0.05$) Family adversity positively associated with externalizing behaviors when effortful control was low, but not when it was high. <i>Diatheisis-stress.</i>
	Sentse et al., 2011*	1274 (51% girls) – followed from 11 to 16 years – from Netherlands	Reactivity – Fearfulness and Self-regulation – Effortful control with the EATQ-R. <i>Parent report, assessed at 11 years.</i>	Home environment – Parent separation; EHC adapted into an interview. <i>Self-report, assessed at 16 years (asking about events between 11 and 16 years).</i>	Externalizing behaviors with the CBCL (<i>parent report</i>), the YSR (<i>self-report</i>) and the TCP (<i>teacher report</i>). Assessed at 11 (<i>control</i>) and 16 years (<i>outcome</i>), mean from three respondents.	Non-significant interaction Fearfulness * Separation ($\beta = -0.05$) Significant interaction Effortful control * Separation ($\beta = -0.16$) Parent separation positively associated with externalizing behaviors when effortful control was low, but not when it was high. <i>Diatheisis-stress.</i>
	Burk et al., 2011 ^o	362 (53% girls) – followed from birth to age 16 – from the USA	Reactivity – Disinhibition: Activity Level and Approach scales from the CBQ. Negative affectivity: Anger, Fear and Sadness scales of the CBQ. <i>Mother report, assessed at 3.5 and 4.5 years.</i>	Parenting practices – Authoritative parenting with the CRPR and Home environment – Familial stress: composite of depression, expressed anger (e.g., marital conflict), parenting stress, role overload and financial stress. <i>Mother and father report, assessed at 1, 4 and 12 months, 3.5 and 4.5 years and in Grade 3.</i>	Alcohol use – Typical number of alcoholic drinks consumed per drinking occasion in the last 30 days and asking about lifetime abstinence. <i>Self-report, assessed at 15 (control) and 16 years (outcome).</i>	Non-significant interactions Negative affect * Authoritative parenting Disinhibition * Authoritative parenting Negative affect * Familial stress Significant interaction Disinhibition * Familial stress * Gender Familial stress positively associated with girls' alcohol use when disinhibition was high, but not when it was low. Non-significant for boys. <i>Differential susceptibility.</i>
	Armstrong et al., 2013 ^o	374 boys and girls (followed from 3.5 years to Grade 12) from the USA	Reactivity – Disinhibition: Activity Level and Approach scales from the CBQ. <i>Mother report, assessed at 3.5 and 4.5 years.</i>	Parenting practices – Authoritative and authoritarian parenting with the CRPR. <i>Mother and father report, assessed at 4.5 years and in Grade 3.</i>	Alcohol use – Typical number of alcoholic drinks consumed per drinking occasion in the last 30 days and asking about lifetime abstinence. <i>Self-report, assessed in Grades 9, 10, 11 and 12.</i>	Alcohol use intercept Non-significant interaction Disinhibition * Authoritarian Significant interaction Disinhibition * Authoritative Authoritative parenting negatively associated with alcohol use when disinhibition was high, but not when it was low. <i>Differential susceptibility.</i> Alcohol use slope and quadratic Non-significant interaction Disinhibition * Authoritative Significant interaction Disinhibition * Authoritarian

Design	Author, Year	Sample	Measures Temperament	Family	Outcome	Findings (effect sizes) supported model
						<p>For children low in disinhibition, low authoritarian parenting is associated with a steeper slope that levels off by the end of high school and high authoritarian parenting is associated with a steeper increase at the end of high school. Parenting not significant for high disinhibition. <i>Neither model.</i></p> <p>Disinhibition * Authoritarian * Gender For girls low in disinhibition, pattern was as described above. For girls high in disinhibition, low authoritarian parenting is associated with a linear increase and high authoritarian parenting is associated with a steeper slope that levels off by the end of high school. <i>Neither model.</i></p>

CBCL = Child Behavior Checklist (Achenbach & Edelbrock, 1983); CBQ = Children's Behavior Questionnaire (Rothbart et al., 2001); CoBQ = Conflict Behavior Questionnaire (Prinz, Foster, Kent, & O'Leary, 1979); CRPR = Child-Rearing Practices Report (Block, 1965); DAS = Dyadic Adjustment Scale (Spanier, 1976); DOTS-R = Dimensions of Temperament Survey-Revised (Windle & Lerner, 1986); EASI = Emotionality Activity and Sociability Inventory (Buss & Plomin, 1984); EATQ-R = Early Adolescent Temperament Questionnaire-Revised (Ellis, 2002; Ellis & Rothbart, 2001); EHC = Event History Calendar (Caspi et al., 1996); FES = Family Environment Scale (Moos & Moos, 1986); GTS = General Temperament Survey (Watson & Clark, 1993); IFQ = Infant Characteristics Questionnaire (Bates, Freeland, & Lounsbury, 1979); IPPA = Inventory for parent and peer attachment (Armsden & Greenberg, 1987); NLSKY = National Longitudinal Survey of Children and Youth (Statistics Canada, 1995); NRI = Network Relationships Inventory (Furman & Buhrmester, 1985); PBI = Parental Behavior Inventory (Schaefer, 1965); PPS = Parent Practices Scale (Strayhorn & Weidman, 1988); SDQ = Strengths and Difficulties Questionnaire (Goodman, 1997); TCP = Teacher Checklist of Psychopathology (Huisman et al., 2008); YSR = Youth Self-Report of the CBCL (Achenbach, 1991).

Note. Sample sizes are analyzed (final) samples.

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° Indicates same sample in multiple studies.

^a Interpretation of significant interactions was not provided and was based on visual interpretation of plotted results.