Cross-sectional and longitudinal associations of threat and deprivation on cognition, emotional processing and psychopathology in children and adolescents

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Abstract

Background: Exposure to childhood adversity has been consistently associated with poor developmental outcomes, but it is unclear whether these associations vary across different forms of adversity. We examined cross-sectional and longitudinal associations between two types of adversity—threat and deprivation—with cognition, emotional processing, and psychopathology in a middle-income country.

Methods: The sample consisted of 2,511 children and adolescents (6-17 years old) from the Brazilian High-Risk Cohort for Psychiatric Disorders. Parent reports on childhood adversity were used to construct threat and deprivation latent constructs. Psychopathology was measured by the CBCL which generated a measure of general psychopathology (the “p” factor). Executive function (EF) and attention orienting toward angry faces were assessed using cognitive tasks. All measures were acquired at two time-points 3-years apart. Cross-lagged panel models were estimated to evaluate longitudinal associations.

Results: Psychopathology was associated with threat and deprivation cross-sectionally, and higher levels of threat and deprivation predicted increases in general psychopathology at follow-up. For EF, worse performance was more strongly associated with deprivation than threat at baseline, and only with deprivation at follow-up. Deprivation was associated with attention orienting away from angry faces cross-sectionally, but neither form of adversity was associated with changes over time in attention bias.

Conclusion: Both types of adversity are associated with current and future psychopathology and with current, but not future, EF. Threat was more strongly linked to higher psychopathology, whereas deprivation was more strongly linked to lower EF. Lack of longitudinal associations between deprivation and EF mean reverse causality cannot be excluded.

Key words: Childhood adversity; Threat; Deprivation; Psychopathology; Executive Function; Cognition.

Introduction

Childhood adversity involves negative environmental experiences that require considerable adaptation by an average child, including physical, emotional, and sexual abuse, neglect, domestic violence, and parental absence (McLaughlin, 2016). These experiences are highly prevalent around the world (Costello *et al.*, 2002) and especially in low and middle income countries (Viola *et al.*, 2016). Exposure to childhood adversity represents a public health problem due to its extensive costs to the society and individuals (Magruder, McLaughlin and Elmore Borbon, 2017), leading to poorer mental health (Green *et al.*, 2010; McLaughlin *et al.*, 2012) and academic achievement, such as lower grades, higher school-days absence, and more frequent suspensions (Lansford *et al.*, 2002). Determining how distinct adverse childhood experiences influence emotional and cognitive development is critical to identify novel strategies for preventing the emergence of psychopathology and developmental problems in children who have experienced adversity.

Previous findings have suggested that different types of adverse experiences might influence development in different ways and, therefore, should be distinguished (McLaughlin and Sheridan, 2016). One prominent model proposes that childhood adversities encompass two types of abnormal inputs (Humphreys and Zeanah, 2014): *threat*, the presence of an unexpected input that represents threat to the physical integrity, or well-being of the child; and *deprivation*, the absence of some type of expected input (McLaughlin, Sheridan and Lambert, 2014; McLaughlin, 2016). Examples of experiences involving high levels of threat are physical, sexual, and emotional abuse, witnessing domestic violence, and exposure to violence in the community, or at school; while experiences involving low levels of cognitive and social stimulation, such as neglect, institutional rearing, other forms of parental absence, and material deprivation associated with chronic poverty are characterized by high levels of deprivation (McLaughlin, Sheridan and Lambert, 2014; Sheridan and McLaughlin, 2014; McLaughlin, 2016; McLaughlin *et al.*, 2019).

A growing number of studies have showed that threat and deprivation influence child development differently. More specifically, children who have experienced violence, and not deprivation, require less perceptual information to identify anger (Pollak *et al.*, 2000; Pollak and Sinha, 2002), classify a wider range of negative emotion as anger (Pollak and Kistler, 2002), and exhibit attention biases to threatening social information (Shackman and Pollak, 2014). On the other hand, exposure to deprived environments has been associated with poor performance on complex cognitive tasks, particularly those encompassing language abilities and executive function (EF) (McLaughlin, Sheridan and Nelson, 2017; Lawson, Hook and Farah, 2018). Hence, while threat seems to have strong influences on emotional processing—particularly in relation to cues that are potentially threatening, deprivation seems to be associated with reduced performance on complex tasks reflecting EF (McLaughlin, 2016). Moreover, as it

is of knowledge, the relationship between childhood adversity and psychopathology is already well-established. Although the dimensional model does not make differential predictions about how threat and deprivation influence psychopathology, emerging evidence from population-based longitudinal studies, suggests that threat may have stronger associations with psychopathology than deprivation (Platt *et al.*, 2018).

The previous literature is limited in two important ways. First, most research using this theoretical framework has focused on youth living in high-income countries. However, most of the world's youth live in poor countries and face adversities for which there is limited data available (Viola *et al.*, 2016). Second, most existing research investigating the associations between childhood adversity, psychopathology, and cognition is cross-sectional and does not examine how these experiences influence developmental trajectories of emotion, cognition, and psychopathology or address the possibility of bias due to reverse causality.

In this study we examined the longitudinal associations of threat and deprivation with cognition, emotion, and psychopathology in children and adolescents in a large school-based community sample from a middle-income country. Specifically, we aimed to: (1) to investigate the goodness of fit of the threat and deprivation model in a large community sample from Brazil; and (2) to investigate the associations of threat and deprivation with EF, emotional processing as measured by attention orienting toward angry faces, and psychopathology. We hypothesized that a model specifying distinctions among adversities reflecting threat and deprivation would provide a good fit to the data. We also expected that attention bias toward angry faces would be associated with threat, but not with deprivation; that worse EF would be associated with deprivation, but not with threat (McLaughlin, 2016), and that psychopathology would be associated with both threat and deprivation

Methods and Materials

Study design, procedures and participants

Data for this study is drawn from the baseline and 3-year follow-up waves of the Brazilian High-Risk Cohort for Psychiatry Disorders (BHRCS), a school-based community cohort from the cities of São Paulo and Porto Alegre. Briefly, in the year 2010, 9937 parents of 6-14-years-old children from 57 schools in São Paulo and Porto Alegre were screened using the Family History Survey (FHS; Weissman *et al.*, 2000). From this sample, two subgroups were recruited for further assessments. One subgroup was randomly selected (n=957), while the other was selected from a high-risk score procedure used to identify children with current symptoms and/or family history of psychiatric disorders (n=1554). A total of 2,511 children/adolescents and their parents were assessed at two time points through questionnaires and

interviews about the history of exposure to adversities, and psychopathology. Children/adolescents also completed neurocognitive tests at both time points. The Institutional Review Boards of all institutions involved in the study have given approval for the research protocol, and every participant, parents, or caregivers who participated has given written, or verbal informed consent. For a detailed description of the study, its procedures, and sample see Salum *et al.*, 2014.

Measures

Exposure to Adversity

Selected variables from the BHRCS were chosen based on theoretical models of adversity. A detailed description of the selected questions and response options is depicted in the Supplemental Table S1. All baseline data was drawn considering lifetime exposure, while follow-up data was drawn considering, only, exposure over the last three years from baseline to the follow-up assessment.

Variables selected for measuring exposure to threat were drawn from two parent report sources. First, exposure to physical and sexual abuse, attack or threat, witnessing domestic violence and witnessing attack, were investigated using the Posttraumatic Stress Disorder (PTSD) assessment of the Development and Well-Being Assessment (DAWBA; Goodman *et al.*, 2000). Second, questionnaires specifically designed for the BHRCS were used to evaluate exposure to bullying, and the frequency of exposure to psychological, physical and sexual abuse (never, once or twice, from time to time, and often) (Salum *et al.*, 2016).

Exposure to deprivation experiences was measured through the assessment of the mother's educational level (ranging from without any study to postgraduate education), family income (measured in quintiles), socioeconomic classification (A/B – the wealthiest, C, or D/E – the poorest), father contact (in contact, non-contact, deceased, or unknown), and the frequency (never, once or twice, from time to time, and often) of exposure to neglect (Salum *et al.*, 2016).

Cognition

Executive Function

Three dimensions of executive function (EF), measured by two tasks each, were calculated in order to create a second order model of EF. The dependent variable was a single EF standardized score encompassed by working memory, inhibitory control, and temporal processing scores after regressing out effects of age and gender on the task parameters. Higher scores represent better EF.

Working memory was measured by the *digit span* (a subtest of the WISC-III; Wechsler, 2002) and *corsi blocks* tasks (Vandierendonck *et al.*, 2004). Both tasks involve the repetition of a given sequence. While in the *digit span task* the participants hear and repeat an increasingly difficult sequence of numbers,

either forward and backward, in the *corsi blocks task* they repeat an increasingly difficult spatial sequence tapped by a researcher on up to nine identical blocks. Both outcomes are the level at which a correct repetition failed twice consecutively.

Inhibitory control was measured by the *conflict control task* (CCT; Hogan *et al.*, 2005) and the *go/no-go* task (GNG; Bitsakou *et al.*, 2008). Both consist of an arrow based visual stimuli with a total 100 trials divided into two different instructions. In the *conflict control task*, participants are asked to press a button indicating the direction or opposite direction of arrows shown on the screen. Participants either press the button indicating the correct direction of a green arrow (75 congruent trials), or press the button indicating the opposite direction of a red arrow (25 incongruent trials). The *go/no-go* task requires participants to completely suppress the tendency to press the buttons indicating the direction of the green arrows (75 *go* stimuli trials) when a double-headed green arrow (25 *no-go* stimuli trials) appears on the screen. For both tasks, intertrial interval was 1,500 ms, and the stimulus duration was 100 ms. The outcomes were the percentage of correct responses in the incongruent trials (CCT) and the percentage of failed inhibitions in the *no-go* trials (GNG).

Finally, *temporal processing* was measured by both *time anticipation (TA) tasks 400 ms and 2,000 ms* (Toplak and Tannock, 2005) on baseline, and only *time anticipation 400 ms* on the follow-up. These tasks require participants to anticipate when a visual stimulus will appear. In a game-like manner, the task involves an allied spaceship running out of oxygen and the participant has to give it to them in order to save the crew. In each task, the allied spaceship is visible for the first 10 trials, while for the remaining 16 trials the spaceship is invisible due to an invisible shield. Then, participants are asked to press a button to anticipate when it arrives. A 750-ms window of time to respond correctly and feedback after every trial are given. In task 1, the anticipation interval is 400ms, while in task 2 it is 2,000ms. The outcome is the mean percentage of button pressed in the correct time window interval for the invisible part of the task. Tasks involving temporal delays with flexible cognitive demands have been proposed to be a part of EF in some models (Barkley, 1997). Temporal processing tasks used have previously been well-correlated with the other EF tasks in our sample (Martel *et al.*, 2016; Manfro *et al.*, 2019). Results for EF model fit are reported in the Supplemental Material.

Emotional Processing

Attention orienting toward angry faces

Attention orienting toward angry faces was assessed using a dot-probe task in Eprime 2.0 (Psychology Software Tools, USA). The task consists of two versions, one longer than the other, of the same identical stimuli presentation, which are paired threatening (angry) and neutral face photographs followed by a probe at the location of one of the two photographs. In both versions, each trial starts with a

central fixation cross (for 500ms), followed by the face pair (for 500 or 1250 ms) which is replaced with the probe (for 1100ms). Participants are instructed to press one of the response keys to indicate whether the probe appeared in the left, or right side of the screen. Trials are, randomly, either congruent (16 trials for the short version and 32 for the long version), with threatening faces and probes appearing on the same side of the screen, and incongruent (16 trials for the short version and 32 for the long version), with threatening faces appearing on opposite sides of the screen. The inter-trial interval varies randomly from 750 to 1250ms. Since the neutral and the threatening stimuli are in different screen locations, they compete for attention. Therefore, attention orienting toward angry faces is measured as the difference in reaction time between the task's trials in which the probe replaces a neutral stimulus versus those in which the probe replaces a threatening stimulus. Response times were excluded as errors from trials where the response was incorrect or did not occur before probe offset. Additionally, response times less than 200ms or more than 2 standard deviation above each participant's mean were excluded as outliers, as well as attention bias scores were not calculated if more than 50% response times data were missing. Therefore, the dependent variable was a standardized score of attention orienting toward angry faces after regressing out effects of age and gender on the task parameters. Scores greater than zero represent biases in attention toward threats and lower than zero biases in attention away from threats.

Psychopathology

Psychopathology was measured dimensionally at baseline and follow-up through the Child Behavior Checklist (CBCL; Achenbach and Rescola, 2001; Bordin *et al.*, 2013). The CBCL is a parent-report questionnaire that assesses the child's emotional, behavioral, and social problems yielding a total score (including all items), as well as an internalizing and externalizing score. A bifactor model with one dimension of general psychopathology (the "p" factor) was fitted to the data with two residualized dimensions of internalizing and externalizing psychopathology. Only general psychopathology scores were used for further analysis. More detail on the model's structure are described in the Supplemental Material.

Data Analysis

First, we conducted factor analyses in order to assess the latent structure of threat and deprivation models of exposure to adversity, as well as the EF and psychopathology models. Missing data was accounted for using full information maximum likelihood estimation. Model goodness of fit was evaluated using root-mean-square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI). According to the literature, a RMSEA equal or below .06, and a CFI and a TLI above .95 indicate good fit (Hu and Bentler, 1999; Kline, 2013). Second, we used the observed factor

scores from the validated models to test the longitudinal associations of threat and deprivation with psychopathology, cognition, and emotional processing through Cross-Lagged Panel Models (CLPM) with baseline and 3-year follow-up assessments. Given that EF was comprised of multiple distinct tasks, we additionally examined associations of threat and deprivation with each of the three components of EF. Such analysis was chosen to investigate longitudinal associations due to CLPM estimation of the directional influence variables have over time, while controlling for correlations within time-points and autoregressive effects (or stability) across time, which provide a robust strategy for estimating longitudinal associations and minimizing bias due to reverse causality (Kearney, 2018). Data analysis were performed using the *Mplus* software for categorical data and the *lavaan* package from R for continuous data and CLPMs.

Results

Descriptive Statistics

The total sample was comprised of 2,511 children and adolescents with a mean age of 10.42 years old at baseline and 13.71 years old on follow-up. Among those, 1375 (54.8%) were female, and 1256 (50.1%) were from the city of São Paulo. Descriptive data on variables of interest are shown on Table 1 and additional descriptive data is found in the Supplemental Material.

Threat and Deprivation Latent Structure

The model of threat and deprivation as latent variables (Supplemental Figure S1) was tested at both the baseline and follow-up assessments. The baseline model, consisting of nine variables informing the threat dimension and five variables informing the deprivation dimension, showed acceptable fit indexes (CFI = 0.942, TLI = 0.928, RMSEA = 0.036). For the follow-up model, frequency of exposure was considered for the three-year time frame between baseline and follow-up assessments. Due to low frequency on both variables assessing sexual abuse exposure over the last three years, these variables were combined. Therefore, the follow-up model consisted of eight variables informing the threat dimension and five variables informing the deprivation dimension, presenting acceptable goodness of fit (CFI = 0.923, TLI = 0.903, RMSEA = 0.037). Detailed information is provided on Table 2.

Cross-sectional and cross-lagged effects from the Cross-Lagged Panel Models

The analysis investigating effects of threat and deprivation and psychopathology, EF and attention orienting toward angry faces from the CLMP are depicted in Table 3 and summarized below.

Executive Function

Executive function was moderately stable over the course of development ($\beta=0.435$, $p<0.001$). Cross-sectional analysis showed worse EF performance was more strongly associated with deprivation ($\beta=-0.155$, $p<0.001$) than threat ($\beta=-0.086$, $p<0.001$) at baseline and executive function was only associated with deprivation at follow-up ($\beta=-0.061$, $p=0.008$). Longitudinal analysis showed no significant effects of either threat or deprivation on change in executive function over the three-year follow-up (Figure 1 – Panel B).

Post hoc analyses were conducted in order to investigate the impact of adversity on specific dimensions of EF and are shown on Table 4. All dimensions of EF were stable over the course of three years (WM, $\beta=0.432$, $p<0.001$; IC, $\beta=0.310$, $p<0.001$; TP, $\beta=0.296$, $p=0.025$). Cross-sectional results indicate that threat was associated with worse performance in working memory ($\beta= -0.079$, $p<0.001$) and temporal processing tasks ($\beta= -0.082$, $p<0.001$) at baseline, but not follow up. Also, deprivation was associated with all three dimensions (working memory, inhibitory control and temporal processing) of executive function at baseline (WM, $\beta= -0.146$, $p<0.001$; IC, $\beta= -0.052$, $p<0.001$; TP, $\beta= -0.154$, $p=0.025$), and working memory ($\beta= -0.057$, $p=0.014$) and inhibitory control ($\beta= -0.067$, $p=0.004$) at follow up. Longitudinal results indicate that deprivation, and not threat, at baseline predicted worsening performance on inhibitory control tasks over time ($\beta= -0.086$, $p<0.001$), but no other dimension of EF.

Attention orienting toward angry faces

Biases toward angry faces at follow-up was significantly predicted by baseline levels, even though it was less stable than EF and general psychopathology ($\beta= 0.064$, $p=0.025$). Cross-sectional analysis showed deprivation was associated with bias *away* from angry faces at follow-up ($\beta= -0.057$, $p=0.024$), but longitudinal analysis did not reveal any significant associations (Figure 1 – Panel C).

General psychopathology (the “p” factor)

General psychopathology was moderately stable over the course of three years ($\beta=0.336$, $p<0.001$). Cross-sectional analysis revealed psychopathology was more strongly associated with threat than with deprivation at both baseline (Threat, $\beta=0.430$, $p<0.001$; Deprivation, $\beta=0.160$, $p<0.001$) and follow-up (Threat, $\beta=0.349$, $p<0.001$; Deprivation, $\beta=0.058$, $p=0.010$). Longitudinal predictions showed that both, threat ($\beta=0.121$, $p<0.001$) and deprivation ($\beta=0.064$, $p=0.003$), predicted increases in general psychopathology three years later (Figure 1 – Panel A).

Bidirectional effects

Despite not being part of our primary hypothesis, our CLPM detected some bidirectional associations. We found that higher general psychopathology at baseline predicted future exposure to both threat and deprivation. Similarly, worse EF performance at baseline modestly predicted higher levels of exposure to deprivation three years later.

Discussion

This study examined theoretical predictions of a dimensional model of childhood adversity (McLaughlin et al., 2014). Specifically, we evaluated the associations of threat and deprivation assessed dimensionally and modeled as latent factors with EF, attention orienting to threat, and psychopathology over time using a large sample in a middle-income country.

In accordance to previous findings, our results also suggest that threat and deprivation have differential associations with cognitive and emotional development, as well as psychopathology, even though not all hypotheses were supported. In particular, threat was more strongly associated with psychopathology than deprivation, and deprivation more strongly associated with EF than threat. However, threat was not uniquely associated with attention bias towards threat as expected, and instead deprivation was associated with attention bias *away* from threat. This pattern of findings has theoretical implications for conceptual models of adversity and development, as well as clinical implications regarding potential targets for early interventions aimed at preventing the long-term consequences of adversity for mental health and academic achievement.

There is mounting evidence showing that childhood adversity is associated with high levels of general psychopathology, both cross-sectionally and prospectively (Green *et al.*, 2010; Dunn *et al.*, 2017; McLaughlin et al., 2012). This link tends to span all forms of psychopathology, including both internalizing and externalizing domains (Salum *et al.*, 2016) – and therefore associations with general expressive indexes of psychopathology (such as the “p” factor) are expected (Miller *et al.*, 2016), as we confirmed here. Also, in line with some previous evidence and theoretical models (Busso, McLaughlin and Sheridan, 2017), we showed associations between adversity and psychopathology were revealed for both types of adversity domains. However, the associations of with psychopathology were stronger for threat than deprivation, which might reveal a more prominent role of the threat domain on shared expression of psychopathology, as already noted by direct and indirect effects of threat and deprivation, respectively, on psychopathology (Miller *et al.*, 2016; Platt *et al.*, 2018).

Although both threat and deprivation were each associated with worse performance on EF tasks at baseline, the associations were stronger for deprivation when compared to threat, and only deprivation predicted changes in EF over the follow-up period. This pattern is consistent with previous cross-sectional

studies that observing that experiences characterized by deprivation, and not threat, are related to deficits in EF (Bos, 2009; Beckett *et al.*, 2010; Sheridan *et al.*, 2017; Machlin *et al.*, 2019; Lambert *et al.*, 2017). In contrast to our hypotheses, neither threat nor deprivation predicted overall changes in general EF over time. However, *post hoc* analyses showed that deprivation predicted worsening performance on inhibitory control tasks over time. This suggests that different adversity types may differentially influence the development of specific domains of EF, consistent with prior work suggesting that specific types of adversity exposure might differentially impact specific cognitive abilities (Noble, McCandliss and Farah, 2007; Lambert *et al.*, 2017), and that cognitive control might be a domain of particular relevance for children who have experienced deprivation. These findings are broadly consistent with theoretical predictions arguing that deprivation may uniquely influence the development of EF in children and adolescents (McLaughlin *et al.*, 2014; Sheridan & McLaughlin, 2014).

Different from what was expected, no associations were found between both dimensions of childhood adversity exposure and attention orienting *toward* angry faces. Conversely, a slight cross-sectional association between deprivation and attention orienting *away* from angry faces was found at follow-up. Even though previous research has already shown that children and adolescents exposed to different forms of adversity present higher attention bias toward angry faces when compared to those not exposed (Pollak and Tolley-Schell, 2003; Briggs-Gowan *et al.*, 2015; Miller, 2015), this association might depend on the developmental period of assessment. Attention bias toward threat tend to decrease from childhood through adolescence (Reinholdt-Dunne *et al.*, 2012), suggesting that with the coming of age the ability to deliberately direct attention away from threat might increase. Supporting that notion and the association between deprivation and attention bias *away* from threat found at follow up, the association between exposure to adversity and attention bias away from threat among adolescents, and not children, has already been documented (Weissman *et al.*, 2019). Such results should be interpreted with caution due to the low stability of the attention bias measure in this study, considering that the utility of using the dot-probe has already been called into question due to its low-retest reliability (Chapman, Devue and Grimshaw, 2019).

Our study has a number of strengths. First, by using a dimensional approach to childhood adversities, we were able to distinguish possible differential impacts of distinct experiences on psychopathology, EF, and attention orienting toward angry faces supporting evidence of the pathways through which adversity impacts child development. Second, our longitudinal design allowed us to explore the associations of threat and deprivation with developmental change in these domains over time, which has rarely been done in existing studies of adversity dimensions. Some limitations also should be

noted. First, our study used a school-based sample assessed mainly with parent-reported events. Child-reported information would be an important piece of information to be investigated in future studies. Second, literature suggests that the deprivation dimension is characterized by cognitive stimulation, or an enriched cognitive environment (Sheridan and McLaughlin, 2014). Our deprivation dimension did not account for any of those specific variables, suggesting that we might not be capturing deprivation as a whole. Third, attention orienting toward angry faces might captures only one relatively constrained domain of emotional processing. Because no other measure of emotional information processing was assessed in this study, we were not able to capture the effects of adversity on other domains of emotional processing argued to be particularly likely to be influenced by threat-related adversity, including emotional reactivity, emotional learning, and emotion regulation (McLaughlin & Lambert, 2017).

Exposure to adversity, especially during childhood, is a complex phenomena with meaningful and well-established effects on child development. Because adversity can take upon many forms, dimensional models—as the one investigated here—might help to disentangle the specific developmental impacts of different forms of exposure. This knowledge facilitates the identification of the risks conferred to certain individuals when exposed to certain types of adversity, as well as which interventions could be more effective in buffering these negative impacts on development. Bidirectional results suggest that reverse causality cannot be excluded, but they should be interpreted with caution given the lack of a genetically sensitive design. Therefore, further investigations on bidirectional longitudinal relationships among the variables using genetic informed models and on possible moderators and mediators for the relationships found in this paper seem to be a promising direction. Such investigations could generate more information in order to more effectively support healthy and adaptive child development through targeted interventions to high-risk populations.

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Conflict of Interest

Dr. Pan has received payment for the development of educational material for AstraZeneca and Janssen-Cilag. Dr. Rohde has served on speakers bureaus, on advisory boards, or as a consultant for Eli Lilly, Janssen-Cilag, Medice, Novartis, and Shire; he receives royalties from Oxford University Press and ArtMed; the ADHD and Pediatric Bipolar Disorder Outpatient Programs chaired by him have received unrestricted educational and research support from Eli Lilly, Janssen-Cilag, Novartis, and Shire; and he has received travel grants from Shire and Novartis to attend annual association meetings. Dr. Manfro and Dr. Salum received research grants from the national funding agencies FAPERGS, CAPES and CNPq. Dr. Miguel received research grants from the national funding agencies CAPES, CNPq and FAPESP. The other authors no conflict interests which impact this work.

Ethical Standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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Table 1 – Sample description

	Baseline				3-year follow-up			
	N	%	Valid N					
Sex: male	1375	54.8	2511					
Site: São Paulo	1256	50	2511					
	Mean (sd)	Min	Max	Valid N	Mean (sd)	Min	Max	Valid N
Age (years)	10.2 (1.9)	5.83	14.37	2511	13.5 (1.9)	9.2	17.87	2010
Family income (BRL)	757.6 (536.6)	29.94	4910.18	2110	783.8 (656.8)	21.65	8658.01	1679
CBCL: Total CBCL scores	17.2 (16.1)	0	101	2511	14.6 (15.0)	0	90	2010
Working Memory								
Corsi block (backward)	4.8 (2.1)	0	14	2223	5.6 (2.5)	0	13	1880
Digit span (backward)	3.5 (1.6)	0	12	2249	4.1 (2.0)	0	13	1880
Inhibitory Control								
CCT % Correct Inhibitions	0.6 (0.2)	0	1	2165	0.7 (0.3)	0	1	1704
Go/No-Go: Comission	0.3 (0.2)	0	1	2158	0.2 (0.2)	0	1	1701
Temporal Processing								
Time Anticipaion (0.4s): hits	0.6 (0.2)	0	1	2185	0.8 (0.2)	0	1	1701
Time Anticipaion (2s): hits	0.3 (0.2)	0	1	2180	NA	NA	NA	NA
Attention orienting toward angry faces (ms)	5.2 (53.0)			2148	2.9 (40.0)			1603

Note: crude scores for psychopathology, executive function tasks, and attention orienting toward angry faces are presented in order to inform about the variables' characteristics on the sample.

Table 2 - Factor loadings of the Threat and Deprivation Models at baseline and follow-up

	Baseline				Follow-up			
	Estimate	S.E.	Est./S.E.	p-value	Estimate	S.E.	Est./S.E.	p-value
Threat								
Bullying exposure	0.458	0.033	13.687	<0.001	0.436	0.043	10.090	<0.001
DAWBA: Physical abuse	0.838	0.035	23.741	<0.001	0.848	0.042	19.987	<0.001
Physical abuse	0.654	0.035	18.630	<0.001	0.634	0.047	13.539	<0.001
Emotional abuse	0.532	0.029	18.263	<0.001	0.619	0.036	17.207	<0.001
DAWBA: Sexual abuse	0.555	0.079	7.044	<0.001	-	-	-	-
Sexual abuse	0.576	0.062	9.293	<0.001	-	-	-	-
Sexual abuse (combined)	-	-	-	-	0.363	0.079	4.624	<0.001
DAWBA: Attack or threat	0.532	0.049	10.803	<0.001	0.544	0.054	10.106	<0.001
DAWBA: Domestic violence witnessing	0.682	0.037	18.452	<0.001	0.736	0.043	17.038	<0.001
DAWBA: Attack witnessing	0.690	0.042	16.300	<0.001	0.740	0.049	15.002	<0.001
Deprivation								
Mother's educational level	0.355	0.030	11.835	<0.001	0.411	0.058	7.072	<0.001
ABEP 2009: Stratified Score	0.641	0.035	18.129	<0.001	0.576	0.077	7.501	<0.001
Father status	0.406	0.041	9.821	<0.001	0.235	0.060	3.881	<0.001
Neglect	0.621	0.038	16.148	<0.001	0.465	0.071	6.527	<0.001
Family income	0.756	0.039	19.427	<0.001	0.842	0.108	7.775	<0.001

Model fit baseline: CFI= 0.942, TLI= 0.928, RMSEA= 0.036; **Model fit follow-up:** CFI= 0.923, TLI= 0.903, RMSEA= 0.037

Table 3 – Cross-lagged Panel Models results

Cross-sectional						
	Baseline			Follow-up		
	β	p value	CI 95%	β	p value	CI 95%
Threat						
Psychopathology	0.430	<0.001	0.398, 0.462	0.349	<0.001	0.311, 0.388
Executive Function	-0.086	<0.001	-0.125, -0.046	0.014	0.532	-0.031, 0.060
Attention Bias	0.033	0.125	-0.009, 0.075	0.042	0.092	-0.007, 0.091
Deprivation						
Psychopathology	0.160	<0.001	0.122, 0.198	0.058	0.010	0.014, 0.101
Executive Function	-0.155	<0.001	-0.194, -0.116	-0.061	0.008	-0.106, -0.016
Attention Bias	-0.027	0.210	-0.069, 0.015	-0.057	0.024	-0.106, -0.008
Longitudinal associations						
	Adversity → Outcome			Outcome → Adversity		
	β	p value	CI 95%	β	p value	CI 95%
Psychopathology						
Threat	0.121	<0.001	0.076, 0.167	0.123	<0.001	0.078, 0.168
Deprivation	0.064	0.003	0.022, 0.107	0.038	0.047	0.000, 0.076
Executive Function						
Threat	-0.031	0.160	-0.074, 0.012	-0.031	0.150	-0.074, 0.012
Deprivation	-0.041	0.069	-0.085, 0.003	-0.056	0.002	-0.091, -0.021
Attention bias						
Threat	-0.044	0.096	-0.096, 0.008	-0.010	0.650	-0.055, 0.034
Deprivation	0.013	0.619	-0.039, 0.066	-0.030	0.109	-0.067, 0.007
Autoregressive						
	Autoregressive					
	β	p value	CC 95%			
Psychopathology	0.336	<0.001	0.295, 0.378			
Threat	0.280	<0.001	0.234, 0.326			
Deprivation	0.638	<0.001	0.609, 0.667			
Executive Function	0.435	<0.001	0.398, 0.473			
Threat	0.330	<0.001	0.288, 0.371			
Deprivation	0.631	<0.001	0.601, 0.660			
Attention bias	0.064	0.025	0.008, 0.120			
Threat	0.331	<0.001	0.289, 0.373			
Deprivation	0.637	<0.001	0.608, 0.666			
Outcome: either psychopathology, executive function, or attention orienting toward angry faces						
Adversity: either Threat or Deprivation						
Note: Threat at baseline did not predict Deprivation at Follow-up (β=-0.036, p=0.115, CI95% -0.080 to 0.009), but deprivation at baseline predicted modestly lower levels of threat at follow-up ((β=-0.053, p=0.008, CI95% -0.093 to -0.014).						

Table 4 – Post hoc Cross-lagged Panel Models results

Cross-sectional						
	Baseline			Follow-up		
	β	p value	CI 95%	β	p value	CI 95%
Threat						
Working memory	-0.079	<0.001	-0.119, -0.039	0.015	0.519	-0.030, 0.060
Inhibitory control	-0.039	0.057	-0.079, 0.001	-0.011	0.629	-0.057, 0.034
Temporal processing	-0.082	<0.001	-0.122, -0.042	0.019	0.417	-0.027, 0.064
Deprivation						
Working memory	-0.146	<0.001	-0.185, -0.107	-0.057	0.014	-0.102, -0.011
Inhibitory control	-0.052	0.010	-0.092, -0.013	-0.067	0.004	-0.112, -0.022
Temporal processing	-0.154	<0.001	-0.193, -0.115	-0.044	0.054	-0.090, 0.001
Longitudinal associations						
	Adversity → Outcome			Outcome → Adversity		
	β	p value	CI 95%	β	p value	CI 95%
Working memory						
Threat	-0.041	0.064	-0.084, 0.002	-0.019	0.373	-0.062, 0.023
Deprivation	-0.023	0.302	-0.067, 0.021	-0.050	0.005	-0.085, -0.015
Inhibitory control						
Threat	-0.010	0.659	-0.056, 0.035	-0.027	0.196	-0.069, 0.014
Deprivation	-0.086	<0.001	-0.132, -0.040	-0.028	0.108	-0.062, 0.006
Temporal processing						
Threat	-0.026	0.259	-0.072, 0.019	-0.033	0.133	-0.076, 0.010
Deprivation	-0.041	0.084	-0.088, 0.006	-0.053	0.004	-0.088, -0.017
Autoregressive						
	Autoregressive					
	β	p value	CC 95%			
Working memory	0.432	<0.001	0.395, 0.470			
Threat	0.330	<0.001	0.288, 0.372			
Deprivation	0.632	<0.001	0.603, 0.661			
Inhibitory control	0.310	<0.001	0.269, 0.350			
Threat	0.330	<0.001	0.288, 0.371			
Deprivation	0.638	<0.001	0.609, 0.667			
Temporal processing	0.296	0.025	0.254, 0.339			
Threat	0.330	<0.001	0.288, 0.371			
Deprivation	0.631	<0.001	0.601, 0.660			
Outcome: either working memory, inhibitory control, and temporal processing						
Adversity: either Threat or Deprivation						

Figure 1 – Cross Lagged Panel Models showing cross-sectional and longitudinal associations between general psychopathology, executive function, attention orienting toward angry faces and threat and deprivation in baseline and 3-year follow-up assessments

Panel A – General psychopathology

* $p < 0.05$. ** $p < 0.001$.

Panel B – Executive Function

* $p < 0.05$. ** $p < 0.001$.

Panel C – Attention orienting toward angry faces

* $p \leq 0.05$. ** $p < 0.001$.

Supplemental Material

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Supplemental Table S1 – Threat and Deprivation variable description

Variable	Label	Response options
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1. Adversity

Threat and deprivation variables were selected according to documented theoretical models in order to encompass both dimensions of childhood adversity. Selected variables, their label and ranges are described below (Supplemental Table S1), as well as descriptive data for each selected variable (Supplemental Table S2). At baseline, all exposure questions were asked considering the lifetime time range, while at follow-up exposure was assessed and considered positive only if it happened over the past three-year time range.

Confirmatory factor analysis, using the full maximum likelihood to deal with missing data, were conducted using baseline and follow-up data. The threat and deprivation model at baseline was available for 2511 participants, and at follow up 2010 participants (Supplemental Figure S1).

Threat		
Bullying exposure	Has the child ever been bullied in his life?	No Yes
DAWBA: Physical abuse	Has the child ever suffered physical violence (maltreatment) that he/she remembers?	No Yes
Physical abuse	Has your child been seriously picked up by an adult (including yourself), to the point of leaving marks in his body?	Never Yes, once or twice Yes, from time to time Yes, often happen
Emotional abuse	Has your child ever been cursed by some adult, with words like 'ass', 'idiot', 'stupid', or being yelled that you were no good?	Never Yes, once or twice Yes, from time to time Yes, often happen
DAWBA: Sexual abuse	Has the child ever been exposed to sexual abuse?	No Yes
Sexual abuse	Has anybody ever done sexual things with your child, or have threatened your child if he/she didn't do sexual things?	Never Yes, once or twice Yes, from time to time Yes, often happen
DAWBA: Attack or threat	Has the child ever been attacked or threatened?	No Yes
DAWBA: Domestic violence witnessing	Has the child ever witnessed serious domestic violence?	No Yes
DAWBA: Attack witnessing	Has the child ever seen a family member, or friend being seriously attacked, or threatened?	No Yes
Deprivation		
Mother's educational level	Mother's educational level	Postgraduate Graduate (complete) Graduate (incomplete) High School (complete) High School (incomplete) Middle School(complete) Middle School(incomplete) Without study
ABEP 2009: Stratified Score	Socio economic class	D/E (poorest) C A/B (wealthiest)
Father status	What is the current contact status of the child's father?	In contact No-contact Deceased Unknown
Neglect	Has it ever happened to your child of not having anything to eat and/or having to wear dirty or torn clothes?	Never Yes, once or twice Yes, from time to time Yes, often happens
Family income	What is the family total income?	Divided into quintiles

Supplemental Table S2 – Threat and Deprivation variable frequency

		Baseline (lifetime)			3-year follow-up (past three years)		
		N	%	Valid N	N	%	Valid N
Bullying exposure: yes		950	38.7	2455	503	25.5	1976
Physical abuse (DAWBA): yes		86	3.4	2511	37	1.8	2010
Physical abuse	Never	2139	85.3	2507	1878	93.5	2010
	Yes, once or twice	293	11.7		101	5	
	Yes, from time to time	66	2.6		25	1.2	
	Yes, it often happens	9	0.4		5	0.3	
Emotional abuse	Never	1397	55.7	2510	1289	64.3	2005
	Yes, once or twice	443	17.6		246	12.3	
	Yes, from time to time	524	20.9		352	17.5	
	Yes, it often happens	146	5.8		118	5.9	
Sexual abuse (DAWBA): yes		29	1.2	2511	11	0.5	2010
Sexual abuse	Never	2442	97.7	2500	1986	99	2002
	Yes, once or twice	51	2		16	0.8	
	Yes, from time to time	5	0.2		0	0	
	Yes, it often happens	2	0.08		0	0	
Attack or threat (DAWBA): yes		97	3.9	2511	17	0.8	2010
Domestic violence witnessing (DAWBA): yes		177	7	2511	56	2.8	2010
Attack witnessing (DAWBA): yes		101	4	2511	56	2.8	2010
Mother's educational level	Postgraduate	15	0.6	2483	11	0.6	1961
	Graduate (complete)	70	2.8		75	3.8	
	Graduate (incomplete)	126	5		121	6.2	
	High School (complete)	808	32.5		619	31.6	
	High School (incomplete)	460	18.5		238	12.1	
	Middle School(complete)	397	16		259	13.2	
	Middle School(incomplete)	562	22.6		600	30.6	
	Without study	45	1.8		38	1.9	
ABEP 2009: Stratified Score	A/B	998	39.7	2511	767	38.2	2009
	C	1435	57.1		1188	59.1	
	D/E	78	3.1		54	2.7	
Father status	In-contact	1836	73.1	2511	1474	73.4	2008
	No-contact	427	17		312	15.5	
	Deceased	130	5.2		131	6.5	
	Unknown	118	4.7		91	4.5	
Neglect	Never	2261	90	2511	1947	97	2008
	Yes, once or twice	176	7		38	1.9	
	Yes, from time to time	61	2.4		17	0.8	
	Yes, it often happens	13	0.5		6	0.3	

Supplemental Figure S1 – Threat and Deprivation model depiction at baseline and follow-up

2. Psychopathology

Confirmatory factor analysis, using the diagonally weighted least squares (DWLS) estimator, were conducted using CBCL baseline and follow-up data using a bifactor model in which all items are loaded in a general factor (the “p” factor) and residuals variance is captured by internalizing and externalizing domains as outlined by the CBCL scoring system. The psychopathology model at baseline was available for 2511 participants and showed adequate fit indexes (CFI= 0.984, TLI= 0.983, RMSEA= 0.020). The psychopathology model at follow up was available for 2010 participants and also showed adequate fit indexes (CFI= 0.973, TLI= 0.972, RMSEA= 0.025). Factor loadings for baseline and follow-up data are found on Supplemental Table S3.

Supplemental Table S3 - Factor loadings of the General Psychopathology Model at baseline and follow-up

	Baseline				Follow-up			
	Estimate	S.E.	<i>p-value</i>	β	Estimate	S.E.	<i>p-value</i>	β
Psychopathology								
CBCL14	0.293	0.006	<0.001	0.468	0.242	0.006	<0.001	0.453
CBCL29	0.174	0.006	<0.001	0.259	0.133	0.006	<0.001	0.223
CBCL30	0.067	0.003	<0.001	0.212	0.051	0.003	<0.001	0.187
CBCL31	0.101	0.004	<0.001	0.201	0.054	0.005	<0.001	0.110
CBCL32	0.118	0.005	<0.001	0.192	0.062	0.006	<0.001	0.097
CBCL33	0.482	0.007	<0.001	0.696	0.425	0.007	<0.001	0.641
CBCL35	0.298	0.006	<0.001	0.579	0.264	0.006	<0.001	0.515
CBCL45	0.491	0.007	<0.001	0.688	0.471	0.007	<0.001	0.660
CBCL50	0.341	0.007	<0.001	0.493	0.294	0.007	<0.001	0.434
CBCL52	0.148	0.004	<0.001	0.387	0.105	0.004	<0.001	0.296
CBCL71	0.249	0.006	<0.001	0.398	0.192	0.007	<0.001	0.291
CBCL91	0.118	0.004	<0.001	0.356	0.099	0.004	<0.001	0.367
CBCL112	0.189	0.005	<0.001	0.325	0.193	0.006	<0.001	0.324
CBCL5	0.343	0.006	<0.001	0.559	0.344	0.007	<0.001	0.526
CBCL42	0.184	0.005	<0.001	0.347	0.233	0.006	<0.001	0.371
CBCL65	0.220	0.005	<0.001	0.440	0.231	0.006	<0.001	0.425
CBCL69	0.251	0.006	<0.001	0.381	0.252	0.007	<0.001	0.339
CBCL75	0.154	0.006	<0.001	0.245	0.067	0.006	<0.001	0.100
CBCL102	0.117	0.004	<0.001	0.306	0.147	0.005	<0.001	0.321
CBCL103	0.207	0.005	<0.001	0.435	0.224	0.006	<0.001	0.483
CBCL111	0.134	0.004	<0.001	0.335	0.139	0.005	<0.001	0.321
CBCL47	0.249	0.006	<0.001	0.439	0.152	0.005	<0.001	0.333
CBCL49	0.123	0.005	<0.001	0.234	0.081	0.005	<0.001	0.161
CBCL51	0.136	0.004	<0.001	0.337	0.143	0.005	<0.001	0.337
CBCL54	0.341	0.006	<0.001	0.563	0.328	0.007	<0.001	0.494
CBCL56a	0.160	0.005	<0.001	0.344	0.143	0.005	<0.001	0.304
CBCL56b	0.280	0.006	<0.001	0.399	0.245	0.006	<0.001	0.356
CBCL56c	0.157	0.005	<0.001	0.320	0.150	0.005	<0.001	0.311
CBCL56d	0.125	0.004	<0.001	0.273	0.058	0.003	<0.001	0.174
CBCL56e	0.088	0.004	<0.001	0.191	0.047	0.004	<0.001	0.112
CBCL56f	0.212	0.005	<0.001	0.371	0.172	0.006	<0.001	0.314
CBCL56g	0.091	0.004	<0.001	0.252	0.058	0.003	<0.001	0.196

Table continues on next page

	Baseline				Follow-up			
	Estimate	S.E.	<i>p-value</i>	β	Estimate	S.E.	<i>p-value</i>	β
CBCL2	0.017	0.002	<0.001	0.098	0.063	0.004	<0.001	0.199
CBCL26	0.273	0.006	<0.001	0.467	0.249	0.006	<0.001	0.448
CBCL28	0.312	0.006	<0.001	0.517	0.367	0.007	<0.001	0.588
CBCL39	0.061	0.003	<0.001	0.206	0.087	0.004	<0.001	0.239
CBCL43	0.213	0.006	<0.001	0.366	0.245	0.007	<0.001	0.451
CBCL63	0.249	0.006	<0.001	0.378	0.262	0.007	<0.001	0.374
CBCL67	0.040	0.002	<0.001	0.171	0.052	0.003	<0.001	0.212
CBCL72	0.064	0.003	<0.001	0.246	0.022	0.002	<0.001	0.130
CBCL73	0.028	0.002	<0.001	0.155	0.003	0.001	<0.001	0.032
CBCL81	0.036	0.003	<0.001	0.137	0.021	0.002	<0.001	0.117
CBCL82	0.033	0.002	<0.001	0.141	0.006	0.002	<0.001	0.042
CBCL90	0.265	0.006	<0.001	0.469	0.325	0.007	<0.001	0.511
CBCL96	0.056	0.003	<0.001	0.213	0.043	0.002	<0.001	0.181
CBCL99	0.008	0.001	<0.001	0.065	0.015	0.002	<0.001	0.079
CBCL101	0.074	0.003	<0.001	0.258	0.114	0.005	<0.001	0.283
CBCL105	0.009	0.001	<0.001	0.073	0.011	0.002	<0.001	0.074
CBCL106	0.027	0.002	<0.001	0.160	0.007	0.001	<0.001	0.062
CBCL3	0.456	0.007	<0.001	0.585	0.404	0.007	<0.001	0.534
CBCL16	0.069	0.003	<0.001	0.236	0.049	0.003	<0.001	0.233
CBCL19	0.481	0.007	<0.001	0.661	0.384	0.007	<0.001	0.579
CBCL20	0.220	0.006	<0.001	0.402	0.149	0.005	<0.001	0.355
CBCL21	0.181	0.005	<0.001	0.387	0.117	0.005	<0.001	0.317
CBCL22	0.346	0.006	<0.001	0.522	0.395	0.007	<0.001	0.622
CBCL23	0.214	0.006	<0.001	0.372	0.230	0.007	<0.001	0.408
CBCL37	0.182	0.005	<0.001	0.383	0.140	0.005	<0.001	0.350
CBCL57	0.083	0.004	<0.001	0.258	0.078	0.004	<0.001	0.288
CBCL68	0.338	0.006	<0.001	0.533	0.347	0.007	<0.001	0.565
CBCL86	0.520	0.007	<0.001	0.707	0.523	0.007	<0.001	0.729
CBCL87	0.513	0.007	<0.001	0.770	0.497	0.008	<0.001	0.717
CBCL88	0.574	0.007	<0.001	0.773	0.552	0.008	<0.001	0.749
CBCL89	0.431	0.007	<0.001	0.677	0.397	0.007	<0.001	0.605
CBCL94	0.274	0.006	<0.001	0.447	0.230	0.007	<0.001	0.369
CBCL95	0.479	0.007	<0.001	0.681	0.528	0.008	<0.001	0.743
CBCL97	0.063	0.003	<0.001	0.250	0.049	0.003	<0.001	0.229
CBCL104	0.301	0.006	<0.001	0.449	0.300	0.007	<0.001	0.478

3. Executive Function

Six executive function tasks were used as measures of working memory, inhibitory control and temporal processing. Missing data differs from one task to another over both time points due to assessment being performed over four sessions at baseline.

Executive function was derived from a second order model encompassing working memory inhibitory control and temporal processing at baseline and follow up. Due to the differing variability of the executive function tasks, scores were standardized regressing using General Additive Models regressing out effects of age and gender on the task parameters. At baseline, each executive function dimension was encompassed by two cognitive tasks, and at follow-up, due to the absence of one of the tasks data, the temporal processing dimension was encompassed by one task (Supplemental Figure S2).

Confirmatory factor analysis, using the full maximum likelihood to deal with missing data, were conducted using baseline and follow-up data. The executive function model at baseline was available for 2396 participants, and the follow up model for 1880 participants. Fit indexes and factor loadings are shown on Supplemental Table S4.

Supplemental Table S4 – Standardized factor loadings of the baseline Executive Function Model

	Baseline			Follow-up		
	λ	S.E.	<i>p</i> -value	λ	S.E.	<i>p</i> -value
Working Memory (WM)						
Digit span (back)	0.626	0.028	<0.001	0.703	0.024	<0.001
Corsi blocks (back)	0.669	0.029	<0.001	0.787	0.025	<0.001
Inhibitory Control (IC)						
CCT (% Inhibitions, inverse)	0.989	0.074	<0.001	0.577	0.043	<0.001
				-		
GNG (% Comission)	-0.401	0.035	<0.001	0.471	0.038	<0.001
Temporal Processing (TP)						
Hits (400ms)	0.630	0.026	<0.001	1.000	0.000	<0.001
Hits (2s)	0.736	0.028	<0.001	-	-	-
Executive Function						
WM	0.685	0.042	<0.001	0.721	0.046	<0.001
IC	0.462	0.046	<0.001	0.652	0.053	<0.001
TP	0.728	0.042	<0.001	0.590	0.039	<0.001
Model fit baseline: CFI= 0.999, TLI= 0.997, RMSEA= 0.011; Model fit follow-up: CFI= 1.000, TLI= 1.006, RMSEA= 0.000						

Supplemental Figure S2 –Executive Function Model baseline and follow=up