



Fear Conditioning Deficits in Children and Adolescents with Psychopathic Traits: a Study in a Clinical Population

Anastasiya Ivanova-Serokhvostova¹ · Beatriz Molinuevo¹ · David Torrents-Rodas² · Albert Bonillo³ · Iris Pérez-Bonaventura^{4,5} · Montserrat Corrales^{1,6,7,8} · Montserrat Pamias^{4,5,7} · Josep Antoni Ramos-Quiroga^{1,6,7,8} · Rafael Torrubia¹

Accepted: 22 October 2021 / Published online: 10 January 2022
© The Author(s) 2021

Abstract

Deficits in fear conditioning related to psychopathy have been widely studied in adults. However, evidence in children and adolescents is scarce and inconsistent. This research aimed to expand knowledge about fear conditioning in psychopathy and its dimensions in child and early adolescent clinical populations. Participants were 45 boys (outpatients) aged 6–14 years ($M = 10.59$, $SD = 2.04$). They were assessed with the parents' and teachers' versions of the Child Problematic Traits Inventory (CPTI). A fear conditioning paradigm (Neumann et al., in *Biological Psychology*, 79(3), 337–342, 2008) for children and adolescents was used. Conditioned stimuli (CS+ and CS-) were geometric shapes and the unconditioned stimulus (US) was an unpleasant sound of metal scraping on slate (83 dB). Difference scores (CS+ minus CS-) in skin conductance responses (SCR) and self-reported cognitive and affective measures were considered as indices of fear conditioning. Results showed that: a) deficits in fear conditioning were related to some psychopathy dimensions but not to psychopathy as a unitary construct; b) the Impulsivity-Need for Stimulation dimension was a predictor of impaired fear conditioning at a cognitive level; c) the interaction of Callous-Unemotional and Impulsivity-Need for Stimulation dimensions was a significant predictor of impaired electrodermal fear conditioning; d) by contrast, the Grandiose-Deceitful dimension, was marginally associated with a greater electrodermal fear conditioning. In conclusion, psychopathy dimensions and their interactions, but not psychopathy as a whole, predicted deficits in fear conditioning as measured by SCR and cognitive indices. These findings confirm the notion that psychopathic traits are associated with deficits in fear conditioning in child and adolescent clinical populations and provide support for a multidimensional approach to youth psychopathy.

Keywords Psychopathy · Fear conditioning · Skin conductance · Children · Adolescents · Child problematic traits inventory

Psychopathic personality is defined as a constellation of interpersonal (e.g., grandiosity, deceitfulness), affective (e.g., callousness, absence of remorse and guilt), behavioral/lifestyle (e.g., irresponsibility, impulsivity), and antisocial traits related to antisocial behavior (Hare & Neumann, 2008). These traits have proven to be very relevant for designating an important subgroup of antisocial adults, as they show a more severe, violent, and stable pattern of antisocial behavior (see Leistico et al., 2008 for a meta-analysis).

More recently, there has been increasing interest in the study of early development of psychopathy because research has shown that psychopathy does not emerge suddenly in

early adulthood, but instead has its roots in childhood and adolescence (Frick & Marsee, 2018). Understanding how psychopathic traits manifest themselves in earlier stages of development may help to design more successful intervention and prevent major personal and social harm (Frick et al., 2014a, b). However, the construct of psychopathy in youths is still subject to debate.

Factor analytic studies with young populations have shown that, in line with adult literature, psychopathy is multidimensional, with at least three correlated factors named differently across psychopathy measures but representing similar traits: grandiose-deceitful (GD), callous-unemotional (CU), and impulsive-need for stimulation (INS) (Andershed et al., 2002; Colins et al., 2014; Frick & Hare, 2001). Empirical research has been focused mainly on CU traits as they have purportedly been linked to more severe, stable, and aggressive antisocial

✉ Anastasiya Ivanova-Serokhvostova
Anastasya.Ivanova@uab.cat

Extended author information available on the last page of the article

behavior starting in early childhood as a result of distinct emotional, cognitive, and personality characteristics (Frick et al., 2014b; Frick & White, 2008). Nevertheless, CU traits, though relevant and necessary to understand serious conduct problems, only represent the affective facet of the multidimensional construct of psychopathy, and reporting on all three dimensions when exploring their correlates could be more informative (Salekin, 2016, 2017). Recently, research in children and adolescents has begun to consider this multidimensional model of psychopathy. This approach will allow the study of the relevance of the whole construct and also of each one of its components to explain associations with psychological or biological correlates. In fact, a growing body of research suggests that different, and even contrary, deficits underlying neurobiological correlates for the three psychopathy dimensions exist (see Salekin, 2017 for a review).

One of the proposed correlates has been impaired fear processing as a sign of emotional arousal dysfunction that could affect moral development at early ages (Chen et al., 2021; Cohn et al., 2013; Kochanska, 1991). In this sense, given that the presence of psychopathic traits is related to behaviors that violate the basic rights of others or social norms considered appropriate for the child's age, it is important to understand how these traits and fear processing are related. Deficits in fear processing could play a relevant role in explaining the greater engagement in antisocial behaviors, causing serious harm to others since these children are not concerned about negative consequences of their acts (Van Goozen et al., 2007). A series of studies supported this idea linking adult psychopathy, especially the interpersonal-affective factor, to impaired fear processing (see Hoppenbrouwers et al., 2016; Kozuharova et al., 2019 for reviews), and to structural and functional abnormalities in fear processing areas, such as the amygdala and the orbitofrontal regions (Blair et al., 2005; Glenn & Raine, 2008; Patrick, 2007).

One of the most widely employed approaches to objectively study fear processing has been the use of fear conditioning paradigms. In simple fear conditioning, a neutral stimulus becomes a conditioned stimulus (CS) after being paired with an unconditioned aversive stimulus (US; e.g., mild electric shock or unusual sound). Discrimination or differential conditioning consists of presenting two CSs, one paired (CS+) and the other unpaired (CS-) with the US. After the association between CS+ and US is produced, the CS+ becomes a threat cue, and the CS- a safe cue. If the association has been successful, then the CS+ evokes a greater conditioned response (CR) than the CS-. CRs can include two components: automatic reactions (e.g., changes in skin conductance, heart rate, respiration, body temperature or the startle reflex) and conscious experience (US expectancy, CS-US contingency awareness, valence ratings, or arousal ratings) (see Hoppenbrouwers et al., 2016; Lonsdorf et al., 2017, for reviews). Importantly,

the automatic responses and the conscious experience of fear could be independent. Despite correct cognitive processing of fearful stimuli, automatic emotional reactions may not occur and vice versa (LeDoux, 2014).

Studies about fear conditioning processes with adults have found deficits related to psychopathy as a unitary construct (Birbaumer et al., 2005; Flor et al., 2002; Rothmund et al., 2012) and also with some interpersonal-affective measures of psychopathy (López et al., 2013; Veit et al., 2013). Nevertheless, psychopathy has been associated with impaired physiological responses, but not with cognitive or affective measures of fear conditioning (Birbaumer et al., 2005; Flor et al., 2002; López et al., 2013; Rothmund et al., 2012). Taken together, it is suggested that adult psychopaths may be consciously aware of the CS-US association, but do not process the emotional significance of that information as a result of reduced physiological responsiveness (Hoppenbrouwers et al., 2016).

In children and adolescents, the literature is still scarce and inconclusive. To the best of our knowledge, only four published papers (Chen et al., 2021; Cohn et al., 2013, 2016; Fairchild et al., 2010) have investigated psychopathic traits and their association with differential fear conditioning indices in child or youth populations. The most recent revealed that, in a community-recruited children sample, CU traits were associated with a reduced electrodermal conditioning, but not GD or INS traits (Chen et al., 2021). By contrast, two studies (Cohn et al., 2013, 2016) conducted with arrested adolescent samples with disruptive behavior disorders evinced no associations between GD, CU or INS traits and electrodermal fear conditioning. Another study (Fairchild et al., 2010) with conduct-disordered adolescent girls also reported no associations between electrodermal fear conditioning and psychopathy. Nevertheless, the psychopathy dimensions were not considered. Consistent with findings in adults (Hoppenbrouwers et al., 2016), none of these studies detected deficits in conscious measures of fear experience such as CS-US contingency awareness, arousal or valence ratings. In addition, consistent with results in adult samples, neuroimaging studies in youths also suggest that deficits in fear conditioning acquisition could be underlied by abnormalities in amygdala and other fear-related areas (Cohn et al., 2013; Fanti et al., 2020).

In sum, although in adults there is considerable accumulated evidence regarding the role of fear conditioning in psychopathy, the number of studies in children and adolescents is limited. It is important to ascertain to what extent deficits are observed only in the physiological response, or whether cognitive and affective components are also altered. Finally, it is important to analyze whether the supposed deficits in conditioning are linked to the overall psychopathy construct or only to some of its dimensions.

The Present Study

This research aimed to expand knowledge about fear conditioning in psychopathy¹ and its dimensions in child and adolescent clinical populations. To this end, we selected a sample *without* Attention-Deficit / Hyperactivity Disorder (ADHD)-like symptomatology from a research project aimed at studying emotional, attentional, and psychometric correlates of psychopathic traits (EMPROLIMIT study). We conducted a multi-informant (parents and teachers) assessment of psychopathic traits with the CPTI (Colins et al., 2014), and used an adaptation of a paradigm of differential fear conditioning for children and adolescents developed by Neumann et al. (2008). Previous results from research on fear conditioning with young populations were inconclusive and hardly comparable, so the hypotheses were mainly based on those obtained in adult samples.

The first aim was to ascertain whether the association between psychopathy and fear conditioning is better explained by psychopathy considered as a unitary construct or by one or more of the psychopathy dimensions (either single or additive effects). Prior research in this field in adults has found evidence in both directions, that is, deficits in fear conditioning have been related with psychopathy as a unitary construct (Birbaumer et al., 2005; Flor et al., 2002; Rothmund et al., 2012), and also with some dimensions of psychopathy instead of the whole construct (López et al., 2013; Veit et al., 2013). On the other hand, in children and adolescents, only one of the above mentioned studies has considered the global construct of psychopathy and the rest have analyzed only the psychopathy dimensions. Furthermore, considerable evidence exists showing that psychopathy dimensions present different cognitive, emotional and biological correlates (Salekin, 2017). For all of the above, analyzing the data using both approaches would be the most appropriate. Thus, it was hypothesized that an approach based on the psychopathy dimensions would provide a better comprehension of differences in fear conditioning than one based on the whole construct, and that the most relevant to this particular deficit would be the CU dimension (Chen et al., 2021).

A second aim was to investigate two-way interaction effects of psychopathy dimensions on fear conditioning. Although there are no previous data about the role of psychopathy dimensions interactions on deficits in fear processing, this could be a fruitful approach, as some authors have proposed (Fanti et al., 2017; Salekin, 2016, 2017; Somma et al., 2018). As no previous research surveys have studied this topic in fear conditioning, no hypothesis was formulated.

Finally, the third aim was to explore whether physiological, cognitive, and affective indices of conditioning have differential associations with psychopathy dimensions. As previous studies in both children and adults have found no associations between psychopathy and cognitive and affective measures of conditioning (Birbaumer et al., 2005; Cohn et al., 2013; Fairchild et al., 2010; Flor et al., 2002; López et al., 2013; Rothmund et al., 2012), it was expected that the associations would be found only with physiological indices. This research could shed light on the potential childhood precursors to psychopathy to better understand the developmental processes that may lead to this personality disorder. It also would facilitate its identification and treatment at early stages.

Method

Participants

The sample was composed of a pre-selection of children and early adolescents who took part in a research project aimed at studying emotional, attentional, and psychometric correlates of psychopathic traits (EMPROLIMIT study). A total of 45 boys aged 6–14 years ($M = 10.59$ years, $SD = 2.04$), treated as outpatients at two psychiatric services in the area of Barcelona (Spain) [Vall d'Hebron Hospital ($n = 31$; 69%) and Parc Taulí Hospital ($n = 14$; 31%)], participated in the present study. The inclusion criteria in the pre-selection phase were: a) male participants; b) Vocabulary and Matrix test scaled scores of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, 2003) greater than 4 (less than two SD s below the median of the scale scores $M = 10$, $SD = 3$); c) absence of explicit difficulties in speaking and understanding the Spanish language; d) absence of schizophrenia, psychotic disorders, autism spectrum disorder symptoms, and significant sensorial or motor deficits (MINI-KID interview and in 7 cases by clinical criteria); and f) absence of a severe ADHD diagnosis² (see footnote for more details). Due to recording problems during the fear conditioning task, four participants were excluded. Thus, the final sample consisted of 41 boys aged 6–14 years ($M = 10.58$ years, $SD = 1.96$).

² The criteria for exclusion of a severe ADHD diagnosis was applied when participants had 1) an ADHD diagnosis on the basis of either the Mini International Neuropsychiatric for Children and Adolescents for DSM-5 (MINI-KID 7.0.2; Sheehan et al., 2010) or the Supplement for Attention Deficit and Hyperactivity and Conduct Disorders of the Schedule for Affective Disorders and Schizophrenia for School-Age Children- Present and Lifetime version (K-SADS-PL; Kaufman et al., 1997); and 2) a mean total score greater than 2 (Quite a bit) on the Spanish version (de Extremadura, 2008) of the Swanson, Nolan, and Pelham-IV rating scale (SNAP-IV; Bussing et al., 2008).

¹ In this study we understand psychopathy from a dimensional approach. We use the term psychopathy to refer to children/adolescents with high scores on dimensional measures of psychopathy.

[Vall d'Hebron Hospital ($n = 31$; 76%) and Parc Taulí Hospital ($n = 10$; 24%)]. Participants were predominantly Caucasian (85%), followed by Latins (10%), and others (5%). Parents were most commonly university/college graduates (55% mothers, 36% fathers) or high school graduates (25% mothers, 47% fathers). The ethnic composition and educational level of the parents were similar to those of previous epidemiological studies with larger samples in our country (Ezpeleta et al., 2014). Diagnostic characteristics of the child and adolescent participants were classified as externalizing disorders (at least one of the following diagnoses: Conduct disorder (CD), oppositional defiant disorder (ODD), or ADHD³), internalizing disorders (at least one: major depression, suicidal behavior, specific phobia, social phobia, obsessive-compulsive disorder, separation anxiety, or generalized anxiety disorder), and other (tic) disorders according to MINI-KID 7.0.2 ($n = 34$; Sheehan et al., 2010) or K-SADS-PL ($n = 7$; Kaufman et al., 1997). Sixteen participants (39%) showed externalizing disorders; two participants (5%) presented internalizing disorders; four participants (10%) met criteria both for internalizing and externalizing disorders; two participants (5%) had externalizing and other disorders; one participant showed externalizing, internalizing and other (tic) disorders; and sixteen (39%) participants did not meet criteria for any disorder.

Material

Psychopathic Traits Assessment

The Child Problematic Traits Inventory (CPTI; López-Romero et al., 2019) The authorized Spanish version of the Child Problematic Traits Inventory was used to assess psychopathic traits. Parents ($n = 41$) and teachers ($n = 38$) rated the 28 items on a 4-point Likert scale ranging from 1 (*Does not apply at all*) to 4 (*Applies very well*), based on how the child usually behaves rather than on current behavior. To avoid underreporting by an informant and incorporate information about different settings, scores from parents and teachers were combined by using the higher score from either informant for each item. This method has been recommended for the measure of psychopathic traits when used in multiple settings (Frick & Hare, 2001; Frick et al., 2005). The 28 items were designed to assess the corresponding psychopathy dimensions: Grandiose-Deceitful (GD; 8 items); Callous-Unemotional (CU; 10 items); and Impulsive-Need for Stimulation (INS; 10 items). The total score of each scale, as well as the total CPTI score, were computed as

the mean of the responses to items. In the current study, Cronbach's alphas of the parents (teachers) version were .92 (.93), .89 (.93), .80 (.84), and .91(.96) for the, GD, CU, INS traits, and the CPTI total score, respectively.

Inclusion Variables Assessment

Vocabulary and Matrix Subtests of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, 2003) The WISC-IV is a four-factor intelligence battery for children who are between 6 and 16 years of age. This battery is comprised of 10 core subtests that combine to form four psychometrically validated factor scores. The two-subtest form was used, which presents greater associations with the total IQ score: Vocabulary ($r = .73$) and Matrix Reasoning ($r = .63$). The Vocabulary subtest measures word knowledge, verbal concept formation, and fund of knowledge, and the Matrix Reasoning subtest measures visual information processing and abstract reasoning skills. The subtest scaled scores present $M = 10$ and $SD = 3$. In this study, a score greater than 4 (less than 2 SDs below the median) was considered an inclusion criterion.

Swanson, Nolan, and Pelham–IV Parent's Version (SNAP-IV; Bussing et al., 2008) The Spanish version (de Extremadura, 2008) of SNAP-IV was used to assess ADHD symptoms. It comprises 18 items that measure ADHD symptoms: Inattention (9 items) and Hyperactivity/Impulsivity (9 items). Parents rated the items on a 4-point Likert scale ranging from 0 (*Not at all*) to 3 (*Very much*). In the current study, Cronbach's alphas were .93, .87, and .92 for Inattention, Hyperactivity, and Total score, respectively.

Mini International Neuropsychiatric Interview for Children and Adolescents for DSM-5 (MINI-KID 7.0.2; Sheehan et al., 2010) For most participants ($n = 34$), the authorized Spanish version of the MINI-KID for DSM-5 was used for the assessment of neuropsychiatric disorders. The MINI-KID is a widely used short standardized diagnostic interview for psychiatric disorders in children and adolescents aged 6–16. It covers a broad range of diagnoses applicable to children and adolescents. This interview has been shown to be reliable and valid. The MINI-KID was administered to children/adolescents in the presence of their parents.

Supplement for Attention Deficit and Hyperactivity and Conduct Disorders of the Schedule for Affective Disorders and Schizophrenia for School-Age Children- Present and Lifetime Version (K-SADS-PL; Kaufman et al., 1997) Neuropsychiatric disorders were first assessed ($n = 7$) with the K-SADS-PL. The K-SADS-PL is a valid and reliable semi-structured interview for the diagnosis of psychiatric disorders in school-children and adolescents aged between 6–18.

³ The participants with ADHD included in the study did not meet the exclusion criteria based on MINI-KID/K-SADS-PL and SNAP-IV.

It consists of two parts: a screening interview for affective, psychotic, and other disorders, and five diagnostic supplements. Supplement 4, which includes the diagnosis of ODD, CD, and ADHD was employed.

Psychophysiological Data Recordings

Physiological responses were recorded during all the phases of the study by using a Biopac 150 polygraph (Biopac Systems, Inc). SCR were recorded from the distal phalanges of the index and the middle left-hand fingers by means of two Ag/AgCl electrodes filled with electrolyte. The GSR100C module (Biopac Systems) was used to provide a constant voltage of 0.5 V and to amplify the recorded signal. The signal was sampled at a rate of 125 Hz.

We adapted a paradigm of differential fear conditioning developed by Neumann et al. (2008) to be used with children and adolescents. It consisted of three experimental phases (pre-acquisition, acquisition, and post-acquisition). In this study, the paradigm was modified concerning the number of trials (8 trials instead of 12 in the acquisition and the post-acquisition phases to reduce the duration of the experiment). Six training trials were also added before the experiment.

The CSs were geometrical white shapes presented against a black background. The figures were an isosceles triangle (17.5 cm base and height) and a circle (17.5 cm diameter), both presented 52 cm from the participant via a computer screen. A fixation-cross appeared on the screen when no stimulus was presented (inter-trial interval). The US was a 3-s recording of a three-pronged garden fork scraping a slate (Neumann & Waters, 2006), which was presented binaurally through headphones at a maximum intensity of 83 dB.

Each CS presentation lasted 8 s. For half of the participants, the triangle was the CS+ (paired with the US before its offset) and the circle was the CS-; for the remaining participants, the pairing was reversed. Trials for all the phases were presented in quasi-random order with the restriction that no more than two stimuli of the same class appeared consecutively. The onset of the US coincided with CS+ offset in the acquisition phase. The inter-trial intervals varied randomly from 13 to 16 s (CS offset to CS onset).

Online ratings of the perceived risk of US appearance (risk ratings, RR) at each trial were obtained. These were defined as the judgments that children make about the possibility of the appearance of the US (noise) after each CS (shape). The children were instructed to answer the question “*Will the sound appear after the triangle/circle?*” during each CS presentation. For this purpose, the children used a 3-point Likert scale (*No risk* [= 0], *I do not know* [= 1], *Yes, risk* [= 2]) and clicked once as fast as possible on the appropriate option when the CS appeared. Both the question and the options were present on the screen during

the whole experiment, but the answers were only considered when a shape appeared.

Subjective ratings of valence and arousal of the two CSs were assessed at the end of each phase with a paper-and-pencil adaptation of the Self-Assessment Manikin (SAM; Center for the Study of Emotion and Attention (CSEA) NIMH, 1990). Each page contained an image of a CS and two 5-point rating scales that used anchors based on the SAM. The participants rated on a 5-point Likert scale the dimensions of emotional valence (1 = *Very pleasant*, 5 = *Very unpleasant*) and arousal (1 = *Very calm*, 5 = *Very arousing*). The same scales were also used to obtain valence and arousal ratings of the US.

Stimuli presentation, timing, and response recording were controlled by the free software package Affect 4.0 (Spruyt et al., 2009).

Procedure

This study was approved by Ethics Committees from the Vall d’Hebron and Parc Taulí Hospitals. Authorization of the Education Department of the Catalan Government was also obtained to contact the boys’ teachers so they could answer some questionnaires online about their traits and behaviors. The recruitment was carried out at each hospital by mental health professionals with experience in child psychopathology assessment. The interviewers assessed the children and adolescents in the presence of their parents.

Pre-selection of participants at each hospital consisted of a session in which the children were assessed for intelligence with the WISC-IV Matrix and Vocabulary subtests, and the SNAP-IV and either the MINI-KID ($n = 34$) or the K-SADS-PL ($n = 7$) for clinical assessment. Additionally, some other questionnaires not used in the present study were also administered. The session lasted 2 h approximately. If the candidates fulfilled the criteria to be included, they and their families were formally invited to participate in it. After the boys and their parents both agreed, they were referred to the psychophysiology lab. Participants and their families signed informed consent either at the end of the preselection session or at the beginning of the session at the psychophysiology lab. The consent also included parents’ permission for the children’s teachers to be contacted by the researchers to complete some questionnaires online about their sons’ traits and behaviors. All participants were instructed to refrain from using psychostimulant medication for at least 24 h before the experimental task.

The psychological assessment and the fear conditioning task were performed in two different places. The participants (children and parents) recruited at the Vall d’Hebron Hospital were tested in that hospital. For this purpose, a room of the Psychiatry Service was adapted to carry out psychophysiological recordings, and another room was used

for psychological assessment with the parents. The participants and their families recruited at the Parc Taulí Hospital were tested at the Human Psychophysiology lab located in the Medical Psychology Unit at the University Campus. All psychophysiological recordings were carried out with the same polygraph. Light conditions, temperature (between 19 and 22 °C), and humidity (between 50 and 65%) were kept constant at both places during the entire study.

An assessment session to obtain information about sociodemographic data, personality, and clinical symptoms of each participant was carried out with the parents as informants. Testing included a questionnaire developed by the research team to collect sociodemographic data, the CPTI, completed by one of the parents, and other questionnaires not used in the present study. Nevertheless, sometimes this second session had to be split in two to adjust the assessment to the families' needs or the children's characteristics. Some days after this session, information about participants' personality traits and behavior was also obtained online from their schoolteachers to obtain data from a second information source. The CPTI and other questionnaires not used in this study were completed by the teachers.

The fear conditioning paradigm for each child was conducted in parallel with the second assessment session for parents. A researcher (AI) who was blinded to the participants' diagnosis carried out this part of the study. Upon arrival at the lab and after washing their hands, the instructions for the experiment were read to the participants, and they were asked to be quiet and to relax. Next, the electrodes and the headphones were placed. The participant was invited to sit in front of a screen, and the experimenter sat behind him so that the participant could not see her. For the training phase, the children were told that they would see letters (A or B) on the screen in front of them and hear a sound (a cockcrow). The children were further instructed on the use of the US RR scale and asked to answer just once each time that the letter appeared (results not presented here). During this phase, the instructions were read again in case the children had not understood the task or had used the RR scale incorrectly. For the experiment proper, participants were told that they would see geometrical shapes (a triangle and a circle) on the screen in front of them and then hear an "unusual sound". When the geometrical shapes did not appear on the screen, participants were instructed to fix their eyes on the fixation-cross. They were not informed about the CS-US contingency but were told that they might learn to predict the sound if they attended to the presented stimuli.

The pre-acquisition phase consisted of two CS+ and two CS- trials presented in the absence of the US. The acquisition phase consisted of 8 CS+ always followed by the US (100% reinforcement) and 8 CS- trials. The post-acquisition phase consisted of 8 CS+ and 8 CS- always presented without the US. It is important to point out that this phase was

included to extinguish the fear conditioning responses of participants for ethical reasons. Hence, extinction processes were not an aim of the present study. Online RR of perceived risk for US in the presence of each CS was registered during each phase. At the end of each phase, participants rated arousal and valence of CS+ and CS-. At the end of the acquisition, contingency awareness was also assessed by asking the participants "Did you notice if the sound was paired with any of the figures?" If so, "With which one?" Individuals who correctly identified the CS+ were considered contingency-aware. Finally, in the post-acquisition phase, participants also rated the US valence and arousal.

Data Scoring

SCR to the stimuli were analyzed following the criteria established by Lonsdorf et al. (2017). The scorer was blinded to the task conditions. SCR magnitudes in microsiemens (μS) were computed as the difference $\geq 0.05 \mu\text{S}$ between the maximum SCR occurring between 1–8 s after CS/US onset and the previous minimum value during the latency window. A response to CS/US was considered only when the changes in SCR started between 1–4 s after each stimulus onset. Trials in which no response could be detected or with responses $< 0.05 \mu\text{S}$ were considered non-response trials and coded as 0. SCR were visually inspected to ensure that responses were related to stimulus presentation and were not due to artifacts (defined as fluctuations in the skin conductance level occurring prior to stimulus onset which could interfere with the detection of a response). Trials showing artifacts were rejected. SCR data were square-root transformed to normalize the distributions.

Data Analyses

To determine whether the fear conditioning procedure was successful in the whole group, fear conditioning data were analyzed using paired *t*-tests to examine differences between stimuli (CS+ versus CS-) for each experimental phase (pre-acquisition, acquisition, and post-acquisition) and measure (SCR, RR, arousal, and valence). To analyze the influence of psychopathy dimensions on responses to the US (SCR, arousal, and valence), multiple regression analyses were carried out with CPTI dimensions as predictor variables and responses to the US as criterion variables. To study the association of total CPTI with these responses, zero-order correlations were performed.

To test the association between responses to CS+ versus CS- and psychopathy, first, we calculated the difference scores (CS+ minus CS-) for SCR, RR, arousal, and valence as indices of differential conditioning. The association between these conditioning indices and psychopathy and its dimensions was further examined at each phase using zero-order correlations

between scores on the CPTI (total score and dimensions) and the difference scores (CS+ minus CS-).

To examine the predictive capacity of the distinct psychopathy dimensions and also of the interactions between dimensions (GD*INS; GD*CU; and CU*INS) over difference scores (CS+ minus CS-) in SCR, RR, arousal, and valence, multiple regression analyses were performed at acquisition phase. The first step consisted of multiple regression analyses with CPTI dimensions entered together as predictor variables, and the difference scores (CS+ minus CS-) in SCR, RR, arousal, and valence as criterion variables. These analyses would allow us to ascertain the relevance of each dimension and also whether some traits may act as suppressors for the others (Cohen et al., 2003). In a second step, we performed a second-level multiple regression analysis adding the two-way interactions of the three dimensions. In the end, however, these analyses were not considered because a collinearity problem (tolerance < .10) was detected. Third, to overcome the above limitation, as recommended in Allen (1997), we examined only the predictive effect of the two-way interactions of psychopathy dimensions on the difference scores (CS+ minus CS-) in SCR, RR, arousal, and valence without taking into account the main effects of the dimensions, which were tested at the first step of the analysis. Finally, if a significant effect of a two-way interaction (e.g., CU*INS) was detected, we added the remaining dimension (e.g., GD) to control for a possible confounding effect, and recalculated the model. In pre-acquisition

and post-acquisition phases, only psychopathy dimensions, but not their interactions, were included as predictors. To study the predictive capacity of the psychopathy dimensions on contingency awareness, logistic regression analyses were performed. Psychopathy dimensions were predictor variables, and contingency awareness was the criterion variable. All analyses were performed using SPSS 22.0 for Windows.

Results

Descriptive Statistics

The scores of participants in the CPTI were higher than those obtained in community samples. As no normative data is available with combined scores of CPTI, we compared teachers' scores from our study with the corresponding scores published in the authorized Spanish adaptation (López-Romero et al., 2019). The mean psychopathy scores were significantly higher than those obtained in child community samples in the total CPTI, $M = 1.94$, $SD = .63$, $t(37) = 5.03$, $p = .000$; GD, $M = 1.72$, $SD = .74$, $t(37) = 2.86$, $p = .007$; CU, $M = 1.91$, $SD = .75$, $t(37) = 4.37$, $p = .000$; and INS, $M = 2.15$, $SD = .59$, $t(37) = 6.52$, $p = .000$. Additionally, all psychopathy dimensions were significantly related with each other and with the total CPTI (Table 1).

Table 1 Descriptive statistics and zero-order correlations in acquisition phase between CPTI scores, fear conditioning indices and age ($N = 41$)

	1	2	3	4	5	6	7	8	9
	GD	CU	INS	CPTI Total	Fear conditioning indices (CS+ minus CS-)				Age
					SCR	RR	Arousal	Valence	
1	1								
2	.68***	1							
3	.65***	.51**	1						
4	.89***	.87***	.81***	1					
5	-.05	-.20	-.28 ^a	-.21	1				
6	-.01	.07	-.34*	-.09	.04	1			
7	-.11	-.07	-.02	-.08	.29 ^a	.02	1		
8	-.18	-.17	-.17	-.20	.29 ^a	-.17	.82***	1	
9	.28 ^a	.21	.00	.20	.21	.29 ^a	.15	-.02	1
Mean	2.06	2.09	2.71	2.30	.04	1.00	.63	.54	10.46
SD	.72	.72	.56	.57	.13	.89	1.83	1.71	1.96

GD grandiosity-deceitfulness, CU callous-unemotional, INS impulsivity-need for stimulation, CS+ threat conditioned stimulus, CS- safe conditioned stimulus, SCR skin conductance responses ($\sqrt{\mu S}$), RR risk ratings of US expectancy

* $p \leq .05$; ** $p < .01$; *** $p < .001$

^a $p < .08$

Preliminary Analyses

Fear Conditioning in the Whole Sample

First, we analyzed whether fear conditioning induction was successful in the whole sample. Descriptive statistics for the CS+/CS- fear conditioning indices are presented in Table 2. During the pre-acquisition phase, no differences between stimuli were found for SCR, RR, arousal, or valence. These results indicated that responses to CS+ and CS- before the presentation of the US were not significantly different. In the acquisition phase, the differences between stimuli were marginally significant for SCR and significant for RR. This revealed that the whole sample showed differential conditioning, with greater SCR and RR to CS+ than to CS-. At the end of the acquisition phase, participants also rated the CS+ as more arousing and marginally less pleasant than the CS-, suggesting that they experienced the CS+ as more aversive. In the post-acquisition phase, no differences between stimuli were found for SCR, RR, arousal, or valence, indicating that the participants extinguished the conditioned responses. These results support the idea of successful conditioning, as participants showed differential conditioning across acquisition and they extinguished this conditioning in the post-acquisition phase.

Psychopathy and SCR Across the Whole Task

To ensure that the mean SCR across the whole task was not related to the psychopathic traits and that the following analyses were not skewed as a result, a multiple regression analysis was performed entering psychopathy dimensions as predictors and mean SCR as the dependent variable. No significant predictors emerged. Also, a zero-order correlation between total CPTI and mean SCR was not significant.

Psychopathy and Responses to the US

In order to discard the possibility that psychopathic traits could be predicting responses to the US (SCR, arousal and valence), multiple regression analyses were performed with psychopathy dimensions as predictors. Equivalent analyses for total CPTI were made by calculating zero-order correlations. With respect to all three psychopathy dimensions (GD, CU, INS), these were not significant predictors of SCR to the US, thus suggesting that psychopathic traits were not related to US electrodermal responsiveness across the task. Only the CU dimension was significantly predictive of US arousal ratings, $\beta = -.49$, $t(37) = -2.34$, $p = .025$, and marginally predictive of US valence ratings, $\beta = -.40$, $t(37) = -1.84$, $p = .074$. These results indicated that participants with higher CU traits rated the US as less arousing and unpleasant. The zero-order correlations between the total CPTI and US SCR, valence and arousal ratings were not significant.

Total CPTI and Fear Conditioning

In the pre-acquisition phase, a marginal positive correlation emerged between the total CPTI and the CS+/CS- arousal difference ($r = .29$, $p = .068$). In the acquisition phase, as a marginal positive correlation was found between RR and age ($r = .29$, $p = .068$), age was included as a control variable in all subsequent analyses related to RR. Thus, a partial correlation between total CPTI and CS+/CS- RR differentiation controlling for age was performed. No more significant associations were detected between total CPTI and fear conditioning indices (SCR, RR after controlling for age, arousal and valence) in the pre-acquisition, acquisition, or post-acquisition phases.

Table 2 Mean scores and standard deviations of physiological, cognitive and affective measures for CS+, CS- and US and Student t-tests comparisons (CS+ vs. CS-)

	Pre-acquisition					Acquisition					Post-acquisition						
	CS+		CS-		<i>t</i>	CS+		CS-		<i>t</i>	US		CS+		CS-		<i>t</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
SCR	0.27	0.24	0.31	0.27	-1.16	0.27	0.22	0.23	0.19	1.95 ^a	0.56	0.30	0.22	0.16	0.20	0.14	0.56
RR	1.09	0.65	1.16	0.67	-0.54	1.53	0.53	0.53	0.53	7.26 ^{***}	n.a.	n.a.	0.64	0.55	0.53	0.51	1.09
Arousal	2.22	1.31	2.32	1.23	-0.44	2.71	1.50	2.07	1.23	2.22 [*]	3.00	1.57	1.95	1.45	2.10	1.48	-0.90
Valence	2.64	1.16	2.46	0.84	0.70	2.76	1.26	2.22	1.04	2.00 [*]	3.29	1.15	2.49	1.20	2.22	1.04	0.57

CS+ threat conditioned stimulus, CS- safe conditioned stimulus, SCR skin conductance responses ($\sqrt{\mu\text{S}}$), RR risk ratings of US expectancy; n.a. not applicable

* $p \leq .05$; ** $p < .01$; *** $p < .001$

^a $p < .06$

CPTI Dimensions and Fear Conditioning

Pre-acquisition Phase

Zero-order correlations showed a significant association between GD and CS+/CS- arousal difference ($r = .41$, $p = .007$), and a marginal association between INS and CS+/CS- valence difference ($r = .28$, $p = .077$). No effects emerged for CS+/CS- SCR and RR differences. In the regression analyses, no significant predictors (GD, CU, INS) of the CS+/CS- difference were found, either for SCR or RR after controlling for age. With regard to affective ratings, GD emerged as a significant predictor of a greater CS+/CS- arousal difference, $\beta = .63$, $t(37) = 2.77$, $p = .009$. When a similar analysis was conducted with the CS+/CS- valence difference, INS emerged as a significant predictor of a greater difference, $\beta = .43$, $t(37) = 2.12$, $p = .04$.

Acquisition Phase

In the acquisition phase, the correlations between the CPTI scores (total and dimensions) and the four fear conditioning indices (Table 1) revealed a marginal negative association between INS and CS+/CS- SCR difference ($r = -.28$; $p = .078$). Partial correlations between cognitive ratings and the psychopathic traits after controlling for age showed that INS and the CS+/CS- RR difference were significantly related ($r = -.36$, $p = .023$).

To study the predictive capacity of each psychopathy dimension (GD, CU, INS) and their interactions (GD*CU, CU*INS, GD*INS) on the CS+/CS- SCR difference, two regression models were calculated. In the first one, all three psychopathy dimensions were included, and only INS emerged as a marginally significant predictor, $\beta = -.40$, $t(37) = -1.98$,

$p = .056$ (Table 3). This revealed that higher INS scores marginally predicted a smaller CS+/CS- difference, and hence worse electrodermal fear conditioning. In the second regression model, we entered the two-way interactions GD*CU, GD*INS, and CU*INS. Only CU*INS marginally predicted a smaller CS+/CS- SCR differentiation, $\beta = -.77$, $t(37) = -1.96$, $p = .057$. Consequently, the regression model was recalculated, entering GD and CU*INS as predictor variables. This analysis revealed that, after controlling for GD, which was not a significant predictor and whose effect was in the opposite direction, the CU*INS interaction was a significant predictor of poorer fear conditioning, $\beta = -.50$, $t(38) = -2.12$, $p = .04$. The higher the scores in both CU and INS, the lesser was the CS+/CS- SCR difference. Figure 1 displays the nature of the CU*INS interaction at three levels (quartile 1, quartile 2, and quartile 3) in predicting mean CS+/CS- SCR difference scores after controlling for GD.

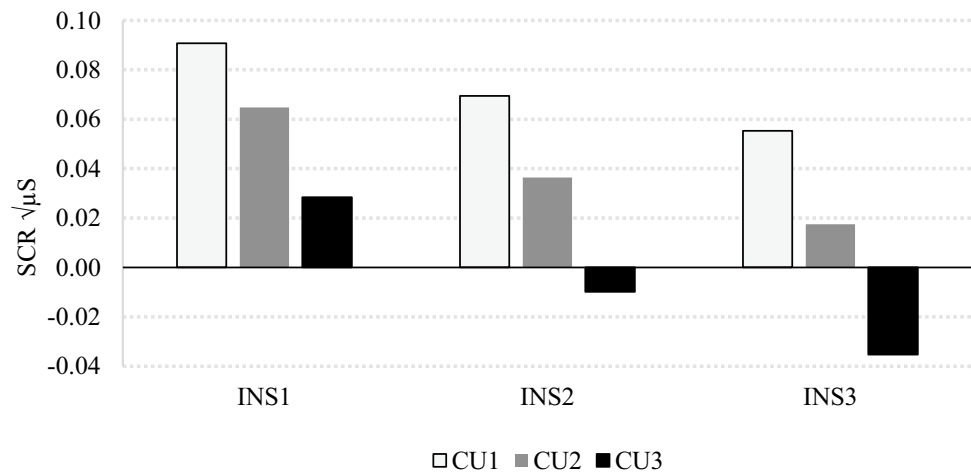
With regard to CS+/CS- RR difference, in the regression analyses, all three psychopathy dimensions and age were included as predictors of CS+/CS- RR difference (Table 3). A significant effect was observed only for INS, $\beta = -.54$, $t(36) = -2.75$, $p = .009$. This model revealed that higher INS predicted smaller CS+/CS- RR differentiation, and thus deficient fear conditioning at a cognitive level. When examining the two-way interaction effects, controlling for age, it was found that both GD*CU, $\beta = 1.08$, $t(36) = 2.45$, $p = .02$, and GD*INS interactions, $\beta = -.63$, $t(36) = -2.08$, $p = .045$, were significant predictors but in opposite directions. Given these interactions, models were recalculated for each one, controlling for the third dimension not included in the interaction. The first model included age, INS, and the GD*CU interaction, and only INS was a significant predictor of smaller CS+/CS- differentiation, $\beta = -.52$, $t(37) = -2.88$,

Table 3 Predictive effects of CPTI dimensions on fear conditioning indices during acquisition

	Skin conductance responses						Risk ratings of US expectancy						
	R ² change	p	Adjusted R ²				R ² change	p	Adjusted R ²				
	B	SE	beta	t(df)	p	Partial r	B	SE	beta	t(df)	p	Partial r	
GD	.07	.04	.39	1.65(37)	.107	.26	.19	.29	.15	1.31 (36)	.527	.11	
CU	-.05	.04	-.26	-1.27(37)	.213	-.20	.25	.24	.20	1.02(36)	.316	.17	
INS	-.09	.05	-.40	-0.20(37)	.056	-.31	-.86	.31	-.54	-2.75(36)	.009	-.42	
							Age	.09	.07	.21	1.32(36)	.195	.22
	Arousal ratings						Valence ratings						
	R ² change	p	Adjusted R ²				R ² change	p	Adjusted R ²				
	B	SE	beta	t(df)	p	Partial r	B	SE	beta	t(df)	p	Partial r	
GD	-.38	.64	-.15	-0.60(37)	.554	-.10	GD	-.16	.60	-.07	-0.27(37)	.788	-.05
CU	-.04	.57	-.02	-0.07(37)	.946	-.01	CU	-.18	.53	-.08	-0.34(37)	.738	-.06
INS	.28	.71	.09	0.40(37)	.689	.07	INS	-.28	.66	-.09	-0.42(37)	.680	-.07

GD grandiosity-deceitfulness, CU callous-unemotional, INS impulsivity-need for stimulation

Fig. 1 Interaction between Callous-Unemotional (CU) * Impulsive-Need for Stimulation (INS) traits in predicting mean CS+/CS- skin conductance difference scores after controlling for Grandiose-Deceitful (GD) traits (GD scores at median). CU and INS scores are considered at three levels: low (quartile 1), medium (quartile 2) and high (quartile 3)



$p = .007$). A similar analysis was performed, entering age, CU, and $GD*INS$, and no significant effect arose. Thus, INS was considered the only significant predictor of CS+/CS- RR difference. These results indicated that after controlling for age, GD and CU, higher INS traits were associated with a poorer CS+/CS- cognitive differentiation.

Most participants (65%) were able to correctly identify the CS+ at the end of the acquisition phase (i.e., aware; $n = 26$; $Mage = 10.73$, $SD = 2.10$). However, the other 35% of children were not able to correctly identify the CS+ (i.e., unaware $n = 14$; $Mage = 9.83$, $SD = 1.56$). Aware and unaware participants did not differ concerning age, $t(38) = -1.40$, $p = .17$. Logistic regression analyses were conducted to study the predictive capacity of psychopathic traits on CS+/US contingency awareness. No significant predictors were found, revealing that psychopathic traits were not related to CS+/US contingency awareness. Considering the affective ratings, no significant predictors of CS+/CS- valence or arousal differentiation emerged considering the dimensions or their two-way interactions in regression analyses.

Post-acquisition

In the post-acquisition phase, no significant correlations were found. In the regression analyses, no significant predictors (GD, CU, INS) of the CS+/CS- difference emerged for SCR, RR after controlling for age, arousal, and valence. We also analyzed whether psychopathic traits predicted the CS+/CS- difference scores during the first trials of this phase (2 CS+ versus 2 CS-), and no significant effect was found.

Discussion

The present study aimed to expand knowledge about the role of fear conditioning in psychopathy in a clinical sample of children and early adolescents. The empirical

evidence about this topic is very limited and, to the best of our knowledge, this is the first research to explore both the unique and interactive effects of psychopathy dimensions as predictors of fear conditioning in young clinical populations. Overall, findings showed that: a) deficits in fear conditioning were related to some psychopathic dimensions but not to psychopathy as a unitary construct; b) INS dimension was a significant predictor variable of deficient cognitive indices of fear conditioning; c) the $CU*INS$ interaction, after controlling for GD, was a significant predictor of impaired electrodermal fear conditioning; d) GD dimension was not a significant predictor of any indices, but, contrarily to the other dimensions, was marginally associated with a greater electrodermal fear conditioning.

Concerning the first aim, the results confirmed that psychopathy dimensions, but not psychopathy as a whole, were predictors of fear conditioning deficits. The entire psychopathy construct was not related to deficits in fear conditioning probably because these deficits were associated in a different way with the dimensions. These data give support to prior research with children and adolescents about fear conditioning (Chen et al., 2021) and other experimental procedures with psychophysiological measures that have shown divergent associations with psychopathy dimensions (Fanti et al., 2017; Gao et al., 2018; MacDougall et al., 2019; Wang et al., 2012). In adults, however, there is empirical evidence in fear conditioning supporting the relationship with both approaches: psychopathy as a unidimensional construct (Birbaumer et al., 2005; Flor et al., 2002; Rothmund et al., 2012) or a multidimensional one (Dvorak-Bertsch et al., 2009; López et al., 2013; Veit et al., 2013). Nevertheless, it must be pointed out that the studies with the first approach did not include data about the relationship between psychopathy dimensions and conditioning.

When analyzing the individual effect of each psychopathy dimension after controlling for the others, INS emerged as a significant predictor of poorer cognitive conditioning.

Importantly, this effect was observed only considering one of the cognitive indices (RR), but not the other (contingency awareness). The different results obtained in the present study with respect to these cognitive indices could be explained by the characteristics of the paradigm used: RR were assessed in each trial (directing participants' attention to the CSs/US contingency) and contingency awareness was assessed at the end of the acquisition phase. It is likely that individuals with higher INS scores needed more trials to learn the CS+/US contingency, which could be indicative of a relationship between the INS dimension and an impaired cognitive function or attention (Gao et al., 2018).

Of note is the fact that the association of INS with cognitive fear conditioning indices was greater when the effect of the other dimensions was controlled, a finding which lends support to the suppressive effect hypothesis between traits (i.e., when each variable accounts for more of the variance in the dependent variable in a regression model than when presented alone; Cohen et al., 2003), as shown by previous studies in the field of child/adolescent psychopathy (Fanti et al., 2017; Gao et al., 2018; MacDougall et al., 2019).

With respect to the second goal, the CU*INS interaction was significantly related to poorer electrodermal conditioning, after controlling for GD. This interactive effect meant that the higher the scores in both CU and INS traits, the poorer was electrodermal fear conditioning in the acquisition phase. Thus, both dimensions seem to be relevant in automatic processes of fear conditioning. It is important to point out that the observed results cannot be explained by a general reduced electrodermal reactivity to aversive stimuli, as no predictor effect was found for psychopathy on reactivity to the US. Rather, they are indicating that both CU and INS contribute to an emotional deficit to form associations in fear learning contexts. Previous studies in children have shown an impairment in electrodermal conditioning related only to CU traits (Chen et al., 2021). Similar results were reported in adult psychopathy (Dvorak-Bertsch et al., 2009; López et al., 2013; Veit et al., 2013). To the best of our knowledge, this is the first study that has analyzed the interaction effects between traits both in youths and adults, making our results difficult to compare with previous ones. Nevertheless, the deficits in fear conditioning related to psychopathy as a unitary construct reported previously might also be explained by this interaction between the CU and INS traits if this kind of analysis had been performed (Birbaumer et al., 2005; Flor et al., 2002; Rothmund et al., 2012). More studies are needed in order to ascertain if this effect is replicated and can be generalized to other populations.

It is worth noting that even though the GD dimension was not a significant predictor of fear conditioning indices, it presented a different pattern of associations as compared with the other dimensions and was marginally related to a greater electrodermal fear conditioning. These results indicate that

the GD dimension may be related to a preserved capacity to form associations between a threat cue and an aversive event at physiological level. Prior research is consistent with this finding, as it has been reported that GD dimension shows a different physiological reactivity response pattern than CU and INS dimensions (Wang et al., 2012); in addition, GD has been associated with higher cognitive abilities (Salekin, 2017) and with enhanced attention to novel stimuli (Gao et al., 2018). Altogether, these results could indicate that GD dimension is related to a better predisposition for successful conditioning. More studies with larger samples are needed to corroborate this effect and clarify the role of GD dimension in fear conditioning.

Altogether, these findings highlight the importance of considering psychopathy from a multidimensional perspective instead of relying only on total psychopathy scores. The results show that psychopathy dimensions are associated in different and even opposite directions with psychophysiological correlates canceling the effect of the total score. If future studies about psychopathy correlates consider this and report on both total and dimensions scores, it would help to understand how the configuration of these dimensions contributes to a full clinical picture of psychopathy (Lilienfeld, 2018; Lilienfeld et al., 2015).

Considering the third aim, it was hypothesized that the associations between psychopathy dimensions and fear conditioning would be found specifically for physiological indices but not for cognitive and affective measures. This hypothesis was not supported in this study, as we found both impaired electrodermal fear conditioning related to the CU*INS interaction, and deficits in one of the cognitive measures of fear conditioning related to INS. With respect to affective measures of conditioning, no association was detected. This occurred despite these variables being shown to be sensitive to conditioning induction in the acquisition phase, and despite a negative relationship between CU traits and US valence and arousal ratings.

Prior research has usually found that cognitive or affective indices of fear conditioning were not impaired in adults (Birbaumer et al., 2005; Flor et al., 2002; López et al., 2013; Rothmund et al., 2012) and youths with psychopathic traits (Cohn et al., 2013; Fairchild et al., 2010). One of the possible explanations of the results obtained in this study in relation to impaired fear conditioning at cognitive level could be the brain development differences between children, early adolescents, and adults. Youths evince higher sensation-seeking, impulsivity, and reward sensitivity because the maturation of connections between the prefrontal cortex and brain regions that control self-regulation and emotions is not completed until the early twenties (Steinberg & Icenogle, 2019). As a result, youths could present more impulsive behaviors and deficits in cognitive conditioning, but these characteristics may become less pronounced with age.

Mention should be made about the findings in the pre-acquisition and post-acquisition phases. In the pre-acquisition phase, some inconsistencies were detected regarding affective ratings. As in this phase US was not presented and in the acquisition phase these effects of psychopathic traits disappeared, the children were probably answering at random. In the post-acquisition phase, as all indices indicate, extinction was successful, which is important for ethical reasons. Even though extinction was not an aim of the study, psychopathic traits were not predictors of any fear conditioning indices in line with previous research (Cohn et al., 2016; Fairchild et al., 2010).

Finally, our study has several strengths: a) it was carried out in a child/early adolescent clinical sample, which helped to understand the predictive power of psychopathic traits on fear conditioning in a population with more prevalence of conduct problems (the scores of the CPTI were significantly higher than in community-based samples); b) we relied on multi-informant sources from different settings (parents and teachers); c) statistical analyses were carried out taking into account psychopathy as a whole, the three psychopathy dimensions and their interactions.

However, some limitations can affect the significance of our results: a) the size of our sample was relatively small; even so, it was adequate to detect significant effects that bear further investigation; b) the present results are not generalizable to girls; c) the heterogeneity of the sample characteristics (and the sample size) did not allow us to take the clinical diagnoses of participants into consideration, although this heterogeneity lends more ecological validity to the study and makes the results more generalizable to clinical samples; d) the high prevalence of psychopathology in the present sample could be relevant to explaining the pattern of the associations found between psychopathic traits and fear conditioning, but hinders the generalization of these results to community samples.

Conclusions

This study provides evidence for a multidimensional approach to psychopathy, as no significant effects were found considering psychopathy as a whole. The results give support to the notion that psychopathy dimensions could be rooted in distinct underlying etiologic-dispositional factors, as they are associated with different neurophysiological and cognitive correlates. The results obtained suggest that the study of psychopathy as a whole, and both single and interactive effects of psychopathy dimensions in fear conditioning, should be incorporated in the future. This approach could reconcile the inconsistent findings, help to better understand fear processing in youths with these characteristics and to progress in the study of psychopathy profiles. If deficits in fear conditioning were replicated in future studies in children and adolescents,

these deficits could be an important biomarker to identify youths with severe conduct problems with high risk to engage in antisocial behavior. This line of research would be fruitful to enhance clinical assessment, therapeutic intervention and programs in early stages of development for conduct problem youth.

Acknowledgements The authors want to express their gratitude to families, schools as well as staff of the Servei de Psiquiatria Vall d'Hebron and Mental Health Service of Parc Taulí Hospital for their kind support in the study. The authors wish to thank Marina Alonso and Ariadna Mas for assistance in data collection.

Funding Open Access Funding provided by Universitat Autònoma de Barcelona. This research was financially supported by the Ministerio de Economía y Competitividad, Spanish Government (MINECO/FEDER, UE), reference: PSI2015-67441-R and by the AGAUR, Generalitat de Catalunya (2017 SGR1586). A.I. is recipient of a Ph.D. fellowship by the Secretaria d'Universitats i Recerca of Generalitat de Catalunya and European Social Fund (FI-DGR 2017).

Declarations

Conflict of Interest The funding sources had no role in the study design, collection, analysis or interpretation of data, the writing of the article or decision to submit the article for publication. Anastasiya Ivanova-Serokhivostova, Beatriz Molinuevo, David Torrents-Rodas, Albert Bonillo, Iris Pérez-Bonaventura, Montserrat Corrales, Montserrat Pamias, Josep Antoni Ramos-Quiroga, and Rafael Torrubia declare that they have no conflicts of interest.

Experiment Participants

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Allen, M. P. (1997). The problem of multicollinearity. In *Understanding Regression Analysis* (pp. 176–180). Boston, MA: Springer US. https://doi.org/10.1007/978-0-585-25657-3_37
- Andershed, H., Kerr, M., Stattin, H., & Levander, S. (2002). Psychopathic traits in non-referred youths: Initial test of a new assessment tool. In E. Blaauw & L. Sheridan (Eds.), *Psychopaths: Current international perspectives* (pp. 131–158). Elsevier.
- Birbaumer, N., Veit, R., Lotze, M., Erb, M., Hermann, C., Grodd, W., & Flor, H. (2005). Deficient fear conditioning in psychopathy. *Archives of General Psychiatry*, 62(7), 799–805. <https://doi.org/10.1001/archpsyc.62.7.799>

- Blair, R. J. R., Mitchel, D., & Blair, K. (2005). *The psychopath: Emotion and the brain*. Blackwell.
- Bussing, R., Fernandez, M., Harwood, M., Hou, W., Garvan, C. W., Eyberg, S. M., & Swanson, J. M. (2008). Parent and teacher SNAP-IV ratings of attention deficit hyperactivity disorder symptoms: Psychometric properties and normative ratings from a school district sample. *Assessment*, *15*(3), 317–328. <https://doi.org/10.1177/1073191107313888>
- Center for the Study of Emotion and Attention (CSEA) NIMH. (1990). *The international affective picture system: Digitized photographs*. The Center for Research in Psychophysiology, University of Florida, Gainesville, FL.
- Chen, F. R., Raine, A., & Gao, Y. (2021). Reduced electrodermal fear conditioning and child callous - unemotional traits. *Research on Child and Adolescent Psychopathology*. <https://doi.org/10.1007/s10802-020-00727-3>
- Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.) Mahwah, NJ: Erlbaum.
- Cohn, M. D., Popma, A., Van Den Brink, W., Pape, L. E., Kindt, M., Van Domburgh, L., & Veltman, D. J. (2013). Fear conditioning, persistence of disruptive behavior and psychopathic traits: An fMRI study. *Translational Psychiatry*, *3*(10), e319–e328. <https://doi.org/10.1038/tp.2013.89>
- Cohn, M. D., van Lith, K., Kindt, M., Pape, L. E., Doreleijers, T. A. H., van den Brink, W., & Popma, A. (2016). Fear extinction, persistent disruptive behavior and psychopathic traits: FMRI in late adolescence. *Social Cognitive and Affective Neuroscience*, *11*(7), 1027–1035. <https://doi.org/10.1093/scan/nsv067>
- Colins, O. F., Andershed, H., Frogner, L., Lopez-Romero, L., Veen, V., & Andershed, A. K. (2014). A new measure to assess psychopathic personality in children: The child problematic traits inventory. *Journal of Psychopathology and Behavioral Assessment*, *36*(1), 4–21. <https://doi.org/10.1007/s10862-013-9385-y>
- de Extremadura, J. (2008). *Detección, diagnóstico y tratamiento del Trastorno de Atención/Hiperactividad en Pediatría* (Junta de Extremadura, Ed.). Badajoz.
- Dvorak-Bertsch, J. D., Curtin, J. J., Rubinstein, T. J., & Newman, J. P. (2009). Psychopathic traits moderate the interaction between cognitive and affective processing. *Psychophysiology*, *46*(5), 913–921. <https://doi.org/10.1111/j.1469-8986.2009.00833.x>
- Ezpeleta, L., De La Osa, N., & Doménech, J. M. (2014). Prevalence of DSM-IV disorders, comorbidity and impairment in 3-year-old Spanish preschoolers. *Social Psychiatry and Psychiatric Epidemiology*, *49*(1), 145–155. <https://doi.org/10.1007/s00127-013-0683-1>
- Fairchild, G., Stobbe, Y., van Goozen, S. H. M., Calder, A. J., & Goodyer, I. M. (2010). Facial expression recognition, fear conditioning, and startle modulation in female subjects with conduct disorder. *Biological Psychiatry*, *68*(3), 272–279. <https://doi.org/10.1016/j.biopsych.2010.02.019>
- Fanti, K. A., Konikou, K., Cohn, M. D., Popma, A., & Brazil, I. A. (2020). Amygdala functioning during threat acquisition and extinction differentiates antisocial subtypes. *Journal of Neuropsychology*, *14*(2), 226–241. <https://doi.org/10.1111/jnp.12183>
- Fanti, K. A., Kyranides, M. N., Georgiou, G., Petridou, M., Colins, O. F., Tuvblad, C., & Andershed, H. (2017). Callous-unemotional, impulsive-irresponsible, and grandiose-manipulative traits: Distinct associations with heart rate, skin conductance, and startle responses to violent and erotic scenes. *Psychophysiology*, *54*(5), 663–672. <https://doi.org/10.1111/psyp.12837>
- Flor, H., Birbaumer, N., Hermann, C., Ziegler, S., Patrick, C. J., Flor, H., & Patrick, C. J. (2002). Aversive Pavlovian conditioning in psychopaths: Peripheral and central correlates. *Psychophysiology*, *39*(4), 505–518. <https://doi.org/10.1017/S0048577202394046>
- Frick, P., & Hare, R. D. (2001). *Antisocial process screening device*. Toronto, Canada: Multi-Health Systems.
- Frick, P. J., & Marsee, M. A. (2018). Psychopathy and developmental pathways to antisocial behavior in youth. In C. J. Patrick (Ed.), *Handbook of psychopathy* (pp. 456–475). The Guilford Press.
- Frick, P. J., Ray, J. V., Thornton, L. C., & Kahn, R. E. (2014a). Annual research review: A developmental psychopathology approach to understanding callous-unemotional traits in children and adolescents with serious conduct problems. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *55*(6), 532–548. <https://doi.org/10.1111/jcpp.12152>
- Frick, P. J., Ray, J. V., Thornton, L. C., & Kahn, R. E. (2014b). Can callous-unemotional traits enhance the understanding, diagnosis, and treatment of serious conduct problems in children and adolescents? A comprehensive review. *Psychological Bulletin*, *140*(1), 1–57. <https://doi.org/10.1037/a0033076>
- Frick, P. J., Stickle, T. R., Dandreaux, D. M., Farrell, J. M., & Kimonis, E. R. (2005). Callous-unemotional traits in predicting the severity and stability of conduct problems and delinquency. *Journal of Abnormal Child Psychology*, *33*(4), 471–487. <https://doi.org/10.1007/s10648-005-5728-9>
- Frick, P. J., & White, S. F. (2008). Research review: The importance of callous-unemotional traits for developmental models of aggressive and antisocial behavior. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *49*(4), 359–375. <https://doi.org/10.1111/j.1469-7610.2007.01862.x>
- Gao, Y., Zhang, W., Eisenbarth, H., Fung, A. L. C., Lu, M., Raine, A., Li, X. (2018). P3 amplitude and psychopathic traits in youths: Distinct contributions of the grandiose-manipulative and daring-impulsivity traits. *Personality and Individual Differences*, *120*(July 2017), 87–94. <https://doi.org/10.1016/j.paid.2017.08.017>
- Glenn, A. L., & Raine, A. (2008). The neurobiology of psychopathy. *Psychiatric Clinics of North America*, *31*(3), 463–475. <https://doi.org/10.1016/j.psc.2008.03.004>
- Hare, R. D., & Neumann, C. S. (2008). Psychopathy as a clinical and empirical construct. *Annual Review of Clinical Psychology*, *4*(1), 217–246. <https://doi.org/10.1146/annurev.clinpsy.3.022806.091452>
- Hoppenbrouwers, S. S., Bulten, B. H., & Brazil, I. A. (2016). Parsing fear : A reassessment of the evidence for fear deficits in psychopathy. *Psychological Bulletin*, *142*(6), 573–600. <https://doi.org/10.1037/bul0000040>
- Kaufman, J., Birmaher, B., Brent, D., Rao, U., Flynn, C., Moreci, P., & Ryan, N. (1997). Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. *Journal of the American Academy of Child and Adolescent Psychiatry*, *36*(7), 980–988. <https://doi.org/10.1097/00004583-199707000-00021>
- Kochanska, G. (1991). Socialization and temperament in the development of guilt and conscience. *Child Development*, *62*(6), 1379–1392. <https://doi.org/10.1111/j.1467-8624.1991.tb01612.x>
- Kozuharova, P., Dickson, H., Tully, J., & Blackwood, N. (2019). Impaired processing of threat in psychopathy: A systematic review and meta-analysis of factorial data in male offender populations. *PLoS One*, *14*(10), 1–17. <https://doi.org/10.1371/journal.pone.0224455>
- LeDoux, J. E. (2014). Coming to terms with fear. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(8), 2871–2878. <https://doi.org/10.1073/pnas.1400335111>
- Leistico, A. A. R., Salekin, R. T., Decoster, J., & Rogers, R. (2008). A large-scale of psychopathy to antisocial conduct meta-analysis the Hare Measures. *Law and Society Review*, *32*(1), 28–45. <https://doi.org/10.1007/s10979-007-9096-6>
- Lilienfeld, S. O. (2018). The multidimensional nature of psychopathy: Five recommendations for research. *Journal of Psychopathology and Behavioral Assessment*, *40*(1), 79–85. <https://doi.org/10.1007/s10862-018-9657-7>

- Lilienfeld, S. O., Watts, A. L., Francis Smith, S., Berg, J. M., & Litzman, R. D. (2015). Psychopathy deconstructed and reconstructed: Identifying and assembling the personality building blocks of Cleckley's Chimera. *Journal of Personality*, 83(6), 593–610. <https://doi.org/10.1111/jopy.12118>
- Lonsdorf, T. B., Menz, M. M., Andreatta, M., Fullana, M. A., Golkar, A., Haaker, J., & Merz, C. J. (2017). Don't fear fear conditioning: Methodological considerations for the design and analysis of studies on human fear acquisition, extinction, and return of fear. *Neuroscience and Biobehavioral Reviews*, 77, 247–285. <https://doi.org/10.1016/j.neubiorev.2017.02.026>
- López-Romero, L., Molinuevo, B., Bonillo, A., Andershed, H., Colins, O. F., Torrubia, R., & Romero, E. (2019). Psychometric properties of the Spanish version of the child problematic traits inventory in 3- to 12-year-old Spanish children. *European Journal of Psychological Assessment*, 35(6), 842–854. <https://doi.org/10.1027/1015-5759/a000458>
- López, R., Poy, R., Patrick, C. J., & Moltó, J. (2013). Deficient fear conditioning and self-reported psychopathy: The role of fearless dominance. *Psychophysiology*, 50(2), 210–218. <https://doi.org/10.1111/j.1469-8986.2012.01493.x>
- MacDougall, E. A. M., Salekin, R. T., & Gillen, C. T. A. (2019). Adolescent psychopathy, heart rate, and skin conductance. *Psychophysiology*, 56(6), 1–11. <https://doi.org/10.1111/psyp.13344>
- Neumann, D. L., & Waters, A. M. (2006). The use of an unpleasant sound as an unconditional stimulus in a human aversive Pavlovian conditioning procedure. *Biological Psychology*, 73(2), 175–185. <https://doi.org/10.1016/j.biopsycho.2006.03.004>
- Neumann, D. L., Waters, A. M., Westbury, H. R., & Henry, J. (2008). The use of an unpleasant sound unconditional stimulus in an aversive conditioning procedure with 8- to 11-year-old children. *Biological Psychology*, 79(3), 337–342. <https://doi.org/10.1016/j.biopsycho.2008.08.005>
- Patrick, C. J. (2007). Getting to the heart of psychopathy. In H. Hervas & J. C. Yuille (Eds.), *The psychopath: Theory, research, and practice* (pp. 207–252). Erlbaum.
- Rothmund, Y., Ziegler, S., Hermann, C., Gruesser, S. M., Foell, J., Patrick, C. J., & Flor, H. (2012). Fear conditioning in psychopaths: Event-related potentials and peripheral measures. *Biological Psychology*, 90(1), 50–59. <https://doi.org/10.1016/j.biopsycho.2012.02.011>
- Salekin, R. (2016). Psychopathy in childhood: Why should we care about grandiose-manipulative and daring-impulsive traits? *The British Journal of Psychiatry*, 209(3), 189–191. <https://doi.org/10.1192/bjp.bp.115.179051>
- Salekin, R. (2017). Research review: What do we know about psychopathic traits in children? *Journal of Child Psychology and Psychiatry*, 11, 1180–1200. <https://doi.org/10.1111/jcpp.12738>
- Sheehan, D. V., Sheehan, K. H., Shytle, D. R., Janavs, J., Bannon, Y., Rogers, J. E., Wilkinson, B. (2010). Reliability and validity of the mini international neuropsychiatric interview for children and adolescents (MINI-KID). *The Journal of Clinical Psychiatry*, 71(3), 313–326. <https://doi.org/10.4088/JCP.09m05305whi>
- Somma, A., Andershed, H., Borroni, S., Salekin, R.T., & Fossati, A. (2018). Psychopathic Personality Traits in Relation to Self-report Delinquency in Adolescence: Should We Mind About Interaction Effects? *J Psychopathol Behav Assess*, 40, 69–78. <https://doi.org/10.1007/s10862-018-9658-6>
- Spruyt, A., Clarysse, J., Vansteenwegen, D., Baeyens, F., & Hermans, D. (2009). Affect 4.0: A free software package for implementing psychological and psychophysiological experiments. *Experimental Psychology*, 57(1), 36–45. <https://doi.org/10.1027/1618-3169/a000005>
- Steinberg, L., & Icenogle, G. (2019). Using developmental science to distinguish adolescents and adults under the law. *Annual Review of Developmental Psychology*, 1(1), 21–40. <https://doi.org/10.1146/annurev-devpsych-121318-085105>
- Van Goozen, S. H. M., Fairchild, G., Snoek, H., & Harold, G. T. (2007). The evidence for a neurobiological model of childhood antisocial behavior. *Psychological Bulletin*, 133(1), 149–182. <https://doi.org/10.1037/0033-2909.133.1.149>
- Veit, R., Konicar, L., Klinzing, J. G., Barth, B., Yilmaz, Ö., & Birbaumer, N. (2013). Deficient fear conditioning in psychopathy as a function of interpersonal and affective disturbances. *Frontiers in Human Neuroscience*, 7, 1–12. <https://doi.org/10.3389/fnhum.2013.00706>
- Wang, P., Baker, L. A., Gao, Y., Raine, A., & Isabel, D. (2012). Psychopathic traits and physiological responses to aversive stimuli in children aged 9–11 years. *Journal of Abnormal Child Psychology*, 40(5), 759–769. <https://doi.org/10.1007/s10802-011-9606-3>
- Wechsler, D. (2003). *Wechsler intelligence scale for children – Fourth edition (WISC-IV)*. The Psychological Corporation.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Authors and Affiliations

Anastasiya Ivanova-Serokhivostova¹  · Beatriz Molinuevo¹  · David Torrents-Rodas²  ·
 Albert Bonillo³  · Iris Pérez-Bonaventura^{4,5}  · Montserrat Corrales^{1,6,7,8}  · Montserrat Pamias^{4,5,7}  ·
 Josep Antoni Ramos-Quiroga^{1,6,7,8}  · Rafael Torrubia¹ 

Beatriz Molinuevo
Beatriz.Molinuevo@uab.cat

David Torrents-Rodas
torrents@uni-marburg.de

Albert Bonillo
Albert.Bonillo@uab.cat

Iris Pérez-Bonaventura
iperezb@tauli.cat

Montserrat Corrales
mcorrales@vhebron.net

Montserrat Pamias
mpamias@tauli.cat

Josep Antoni Ramos-Quiroga
jaramos@vhebron.net

Rafael Torrubia
Rafael.Torrubia@uab.cat

¹ Department of Psychiatry and Forensic Medicine, Institute of Neurosciences, Universitat Autònoma de Barcelona, 08193 Cerdanyola del Vallès, Spain

- ² Faculty of Psychology, Philipps-Universität Marburg, Marburg, Germany
- ³ Department of Psychobiology and Methodology of Health Sciences, Institute of Neurosciences, Universitat Autònoma de Barcelona, Cerdanyola del Vallès, Spain
- ⁴ Department of Mental Health, Corporació Sanitària Parc Taulí, Sabadell, Spain
- ⁵ Department of Clinical and Health Psychology, Universitat Autònoma de Barcelona, Cerdanyola del Vallès, Spain
- ⁶ Department of Psychiatry, Hospital Universitari Vall d'Hebron, Barcelona, Spain
- ⁷ Biomedical Network Research Centre on Mental Health (CIBERSAM), Barcelona, Catalonia, Spain
- ⁸ Group of Psychiatry, Mental Health and Addictions, Vall d'Hebron Research Institute (VHIR), Barcelona, Spain