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Is Callous Always Cold? A Critical Review of the Literature on Emotion and the Development of Callous–Unemotional Traits in Children

Jaimie C. Northam[1] · **Mark R. Dadds**[1]

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Abstract
Low emotional responsiveness is considered a core feature of callous–unemotional (CU) traits in childhood and, in the context of antisocial behavior, a precursor of psychopathic traits in adulthood. However, recent findings suggest that CU traits are not always characterized by low emotional responsiveness and the evidence base requires review. This review asks a fundamental question— 'Is callous always cold?'—with a specific focus on emotional responsiveness and CU traits in children with conduct problems (CPs). PRISMA review protocols were followed to identify literature reporting on emotional responsiveness for children 3–18 years with CPs and varying (high and low) CU traits. Results from eligible studies were contrasted by age (children 3–11 years, adolescents 12–18 years), emotional responsive measurement type (physiological, behavioral, self-report), emotion-eliciting stimuli type (interactive activities, static imagery, film) and socio-emotional context of the stimuli (other-orientated, self-orientated, neutral). This review highlights considerable variation in results across studies: reduced emotional responsiveness was not synonymous with participants demonstrating high CU traits. A more consistent picture of reduced emotional responsiveness in participants with high CU traits was found when studies used physiological measures, when stimuli were other-orientated in socio-emotional context, and in older, adolescent samples. In conclusion, this paper advocates for a more nuanced understanding of the relationship between high CU traits and the specific factors involved in emotional responsiveness, ultimately suggesting that callous is not always cold. Given that emotional responsiveness is central to theories of moral development, these findings may suggest innovative approaches to early intervention.

Keywords Callous–unemotional traits · Emotional responsiveness · Childhood psychopathology · Conduct problems · Psychopathy

Since the conception of the human sciences, philosophers and psychologists have attempted to understand what drives people to act antisocially. These attempts have yielded descriptive personality profiles, incorporating taxonomies of antisocial behaviors and interpersonal characteristics. One highly influential approach to this was Cleckley's (1941) seminal work into psychopathy. Those with psychopathic traits are known for their behavioral profiles, demonstrating both severe antisocial behaviors and affective deficits, such as a shallow affect, lack of empathy and remorse, and low emotional responsiveness to others' emotional cues (Frick and Marsee 2006; Hare 2003). These affective deficits are known as callous–unemotional (CU) traits and are thought to be a hallmark of psychopathy—present since birth and often genetically-influenced (e.g. Blair et al. 2006; Frick and Viding 2009; Viding and McCrory 2012). Accordingly, models attempting to forecast adult psychopathic traits propose dampened emotional responsiveness to be a persistent temperamental factor, theoretically observable in samples of children (as per Blair 2005; Herpers et al. 2014; Patrick 1994).

Surprisingly, to date, no exhaustive review of the empirical literature on dampened emotional responsiveness and CU traits in children and adolescents with conduct problems (CPs) exists. This review asks for the first time: what is the evidence that callousness is always associated with reduced emotional responsiveness? Or, is callous always cold? In what follows, we provide a brief background on CU traits in children before examining historical and contemporary

✉ Jaimie C. Northam
jaimie.northam@sydney.edu.au

[1] Child Behaviour Research Clinic, School of Psychology, The University of Sydney, 97 Church Street, Camperdown, NSW, Australia

methods for defining, eliciting and measuring emotional responsiveness as a context to the review.

Definitions of Key Terms and Constructs

Emotion-based literature is complex, relying on multiple constructs to describe related phenomena. However, with multiple constructs come multiple, sometimes contradictory, terminology. Prior to reviewing extant literature, it is important to operationalize the terms and constructs that will be used throughout this review. Henceforth, 'emotional responsiveness', 'emotionality' and 'emotional reactivity' will be used interchangeably when referring to a multi-systemic emotion-related response to an eliciting stimulus (Levenson 2007). Emotional responsiveness is operationalized as a responsive change from baseline homeostasis, reflected in physiological, neurological and behavioral systems (Levenson 2014; Mauss and Robinson 2009). Likewise, the term 'emotion processing' will refer to the higher order, 'top-down' processes which rely on the multi-systemic responses to an eliciting stimulus in order to interpret, make assumptions and appraisals of the evocative stimuli (Dalgleish 2004).

The Construct of Psychopathy and CU Traits in Children

Affective deficits, including reduced emotional responsiveness, have been well documented in psychopathy literature (Blonigen et al. 2006; Cleckley 1982; Herpertz et al. 2001; Patrick et al. 1993). People demonstrating antisocial behaviors and high psychopathic traits have shown dampened responsiveness to threat cues (e.g. Lykken 1957), reduced emotion-modulated startle response (e.g. Patrick et al. 1993), reduced autonomic arousal to distress cues (e.g. Blair et al. 1997) and reduced emotion-mediated attention and memory to emotional cues when compared to people demonstrating antisocial behaviors and low psychopathic traits (e.g. Kiehl et al. 1999). These affective deficits are thought to reliably predict psychopathy and indicate a specific temperament associated with fearlessness (Birbaumer et al. 2005; Hare and Neumann 2009; Lorenz and Newman 2002; van Honk and Schutter 2007). Although psychopathy is a construct only applied to adults, the emotional components of the personality profile (i.e. CU traits) can be reliably identified in children and adolescents, with such traits elevated in samples of those with CPs (Frick and Viding 2009). Research has demonstrated that developmental outcomes vary for children with CPs, with explanations for this variance often attributed to CU trait status (e.g. Blair et al. 2006; Fontaine et al. 2011; Frick et al. 2003; Frick and Viding 2009). Accordingly, research on heterogeneity within conduct-disordered children has often focused on the differences between those with high and low CU traits.

An emphasis has been placed on differentiating children with high and low CU traits based on their emotional responsiveness and potential errors in emotional processing (e.g. Ciucci et al. 2015; Fanti et al. 2017; Kimonis et al. 2017; Viding et al. 2012), which are suggested to occur on multiple components required for effective emotion processing (e.g. Woodworth and Waschbusch 2008). Specifically, children with CPs and high CU traits have been found to attend (Blair et al. 1999), recognize (Dadds et al. 2006; Leist and Dadds 2009) and react (Blair et al. 1999, 2001; Kimonis et al. 2017; Loney et al. 2003) to emotional stimuli differently to children with CPs and low CU traits. These differences have been proposed to result in cascading errors in components essential for accurate emotional processing (e.g. Shariff and Tracy 2011).

Several well known and frequently cited studies have shown that children with high CU traits show reduced emotional responsiveness when compared to children with low CU traits (e.g. Anastassiou-Hadjicharalambous and Warden 2008; Blair et al. 1999; Kimonis et al. 2017; Viding et al. 2012). Nonetheless, such findings are inconsistent across the literature. One explanation for this inconsistency may be methodological in nature, as the range of emotion elicitation methods and emotional reactivity measures used vary between studies. Recent review papers (e.g. Fanti 2018; Moul et al. 2018) have attempted to address this problem by further specifying deficits in emotional responsiveness with consideration of heterogeneity in CPs based on specific emotion processing systems. For example, Moul et al. (2018) provides a synthesis of the literature outlining a biobehavioral account of antisocial behaviour and CU traits, providing support for neurological measurement methods of emotional reactivity (e.g. fMRI measures). In this account, a neurocognitive model with an emphasis on hypoactivity in the amygdala to emotional cues of others is proposed as key. Impaired amygdala function is described to effect empathic processes and associative learning, specifically about associations between a person's own behaviors and consequential affective responses of others. Impairments (i.e. reduced reactivity) in neurocognitive processes are one example of physiological methods used measure emotional reactivity.

Another system of physiological measurement of emotional reactivity used in studies is that of autonomic nervous system (ANS) arousal. Fanti (2018) provides a review of the role emotional responsiveness on psychophysiological systems (e.g. skin conductance, electromyography, heart-rate and eye-blink startle response) in participants with CU traits. This review highlights the importance of this type of measurement strategy and the potential role that ANS hypoactivation plays on empathy and emotional responsiveness.

However, this review also highlights clear discrepancies in ANS responses based on CU trait subtype. Participants scored on opposite ends of responsiveness based on CU subtypes—those with primary variants of CU traits showing lower emotional reactivity while those with secondary variants demonstrated more.

Both of these recent and targeted reviews (i.e. Moul et al. 2018; Fanti 2018) indicate impairments in physiological components of emotional responsiveness in those with high CU traits. These papers provide an important synthesis of the evidence of emotional responsiveness in children with CU traits; however, they are limited to very specific emotional responsiveness measurement methods. This means that the generalizability of these findings is limited to these specific physiological systems and as yet, there are no reviews that consider the influence of varying emotional reactivity measurement strategies. Further synthesis of extant literature is needed to test whether, under all measurement conditions and contexts, callous is always cold. In order to do this, a brief foray into the emotion theory literature is needed to establish terms and provide rationale for the focus of this review.

Components and Contexts of Emotion

To help disentangle the role of emotional responsiveness in CU traits, some initial commentary on the definitions, function and controversies in the measurement of 'emotion' is needed. There is general consensus that an emotion is a psychological state that occurs as a multilayered process (Hockenbury and Hockenbury 2010). These layers are typically considered to include a subjective component (feelings), a cognitive component (appraisals), a physiological component (central and peripheral nervous system), a behavioral component (action tendencies) and an expressive component (Schröder et al. 2007). The extent to which each of these components interacts with each other, or is precipitated or activated in a sequence, is a much more contentious issue (for review, see Dalgleish 2004) and outside the scope of this review.

When discussing emotion literature, an apt metaphor is that of the blind men attempting to define an elephant. Each man defines 'an elephant' based on what they can 'see' with their hands and, as such, do not have a complete picture of its shape, size or nature. Emotion theory and literature as it pertains to CU traits is in a similar predicament. The science related to emotion measurement has progressed exponentially over the previous 15 years, with increased use of powerful physiological measures leading to greater scientific rigor and more sophisticated accounts of emotional processes (e.g. Lewis et al. 2010; Swan 2013). However, little evidence exists for an *integrated* account of emotion—or emotional deficits in the case of those with CU traits—across multiple sites involved in the experience and elicitation of emotion. This is particularly so for children and the potential influence of CU traits on emotional development.

As this review is interested in emotional responsiveness, as opposed to the more complex process of emotion processing, emotion responsiveness has been categorized into four measurable domains: (1) central nervous system responses, such as functional neuroimaging methods; (2) autonomic nervous system responses, such as peripheral physiological measurement; (3) behavioral responses, such as displayed emotion and reaction times; and (4) subjective responses (e.g. Kreibig 2010; Levenson 2007). As described by Mauss et al. (2005), there is important information to be gained from each of these domains and, when taken together, each contributes to a more comprehensive and integrated understanding of emotional responding.

In order to generate an emotional response, an evocative stimulus is needed. Levenson (2007, 2014) suggests that, under experimental conditions, emotion-eliciting stimuli typically fall into three categories: (1) participation in interactive activities (e.g. a disappointment task, as outlined in Cole et al. 1994); (2) exposure to imagery (e.g. International Affective Pictures System, see Lang et al. 1997); and (3) exposure to film (e.g. 6-min emotional scene from *The Lion King* [1994], as used in Dadds et al. 2016). Studies exploring emotional responsiveness tend to use a single emotion-eliciting stimuli type. While practical, given the many constraints of experimental lab-based experiments, methodologies incorporating singular emotion-eliciting stimuli types may lead to generalizations about the results—i.e. findings related to emotional responsiveness from a specific stimulus may be represented as more characteristic then they actually are. The same holds in the study of emotional responsiveness. The type of stimuli used to elicit an emotion (e.g. tasks, imagery, film) and the socio-emotional context of those stimuli are likely to influence emotional responsiveness. Thus, careful consideration is needed in constructing methodologies.

In regards to the socio-emotional context of stimuli, returning to the theoretical underpinnings of emotions is a useful exercise. Emotions hold a central place in the history of theories of human behavior. They motivate adaptive behavior and, through their expression, convey important social information (Abe and Izard 1999). As originally suggested by Darwin (1872) in his work 'The expression of the emotions in man and animals', human emotion can be considered to serve two specific functions: (1) preparation for adaptive responding to environmental threat; and (2) the communication of social information (Shariff and Tracy 2011). This concept, as it relates to research on emotional responsiveness in individuals with high CU traits, is an important one. The purpose of emotions may be

'self-oriented' (i.e. emotions that activate behaviors for self-preservation and meeting one's own needs) or 'other-orientated' (i.e. emotions that activate behaviors to meet the needs of others). Both types of emotional responsiveness trigger approach-avoidance behaviors motivated by self-welfare or preservation in the former, or approach-avoidance behaviors motivated by other-welfare in the latter (e.g. Elliot 2006). Both types of emotional responsiveness (self-orientated and other-orientated) play an undisputable role in healthy human functioning and emotional development. How CU traits influence emotional responsiveness under these different socio-emotional context is unknown.

Foundational to conceptualizations of CU traits is the 'unemotional' component that outlines an apparent disregard to the rights and welfare of others, in addition to empathy deficits and a lack of remorse (Frick and Marsee 2006). Accordingly, it is possible that those with high CU traits may demonstrate typical emotional responsiveness to stimuli that have a self-orientated socio-emotional context and lower emotional responsiveness to stimuli that are other-orientated. Consideration of past literature of emotional responsiveness in those with CU traits with this level of socio-emotional distinction in the stimuli may provide a more nuanced understanding of emotional deficits in these individuals.

Another complicating factor in the measurement of emotional responsiveness is the influence of age and developmental stage. How humans respond, experience and express emotion changes significantly throughout their lives (Labouvie-Vief et al. 2007). Healthy childhood development involves the acquisition of skills for theory of mind, emotion regulation and the ability to comprehend and label emotional experiences (Wellman and Liu 2004; Peterson et al. 2012). This learning typically results from children's interactions with their parents and more general observations of the environment, which help to inform a model of socially-appropriate emotional expression (Eisenberg 2000). Changes in emotional experience and expression between earlier childhood and puberty may be particularly evident (e.g. Pollak and Fries 2001). Thus, we argue that the study of emotional experience should not only consider the type of emotional stimuli used to elicit an emotional response and how it is measured, but the age of the participants as well.

The Current Study Aims

To help clarify etiological conceptualizations of childhood CPs, this paper aims to provide a systematic review of the literature assessing for evidence that the dampened emotional responsiveness associated with adult psychopathic traits is also present in samples of children and adolescents with CPs and high CU traits. In order to do so, this study had three specific aims.

The first aim was to explore whether reduced emotional responsiveness is more consistently demonstrated in children with CPs and high CU traits compared to those with CPs and low CU traits. It was expected that, like their adult counterparts, children with CPs and high CU traits would be more likely to demonstrate reduced emotional responsiveness when results were compared to those with CPs and low CU traits.

The second aim was to explore whether methodological variations across studies yielded differences in emotional responsiveness results. Based on previous work demonstrating that adults with psychopathic traits have reduced emotional responsiveness compared to other groups when measured physiologically (e.g. Levenston et al. 2000; Verona et al. 2004) and that responses demonstrating reduced emotionality are less predictable when measured behaviorally and by subjective experience (e.g. Ellis et al. 2017), a similar pattern of responding was expected when results were considered in studies examining children with CPs and high compared to low CU traits. Specifically, when results of studies were compared on the basis of emotional measurement type (fMRI, peripheral physiological, overt behavior, subjective experience), it was predicted that physiological measures of emotional responsiveness would be more robust than others in demonstrating reduced responsiveness for high CU trait groups. When emotion-eliciting stimuli types (i.e. interactive activities, imagery, film) were compared, it was predicted that no single stimulus type would be more robust in demonstrating reduced emotional responsiveness for those with high CU traits.

Given the differing socio-emotional context of emotion-eliciting stimuli (i.e. self-orientation vs. other-orientation) and the potential for these to affect emotional responsiveness in adults with psychopathic traits (i.e. Blair et al. 1997; Morrison and Gilbert 2001), the third aim was to explore the influence of the socio-emotional context of the emotion eliciting stimuli on emotional responsiveness results. Specifically, our aim was to explore whether emotional responsiveness differed in response to: a stimulus that affected the participant directly (i.e. inducing self-orientated emotions, such as a frustration induction task); a stimulus that affects someone else (i.e. inducing other-orientated emotions, such as watching a film in which the protagonist experiences distress); or a stimulus with little or neutral social context (such as exposure to a static image of an emotional expression). Based on the notion that reduced emotional responsiveness affects social learning processes related to 'other-orientated' stimuli, such as empathy and development of prosocial attitudes and behaviors, it was predicted that reduced emotional responsiveness would be demonstrated more often in children and adolescents with high CU traits in response to 'other-orientated' stimuli than 'self-orientated' or 'neutral' stimuli.

Method

This method used a systematic approach as described in Petticrew and Roberts (2008) to identify studies reporting on emotional responsiveness in children and adolescents with CPs and varying levels CU traits. The selection process was undertaken in accordance with PRISMA guidelines (see Moher et al. 2009).

Inclusion/Exclusion Criteria

The primary inclusion criterion was age, including children and adolescents aged 18 years and below who met criteria for clinically-significant CPs and were judged to have either high or low CU traits by use of an empirically-validated measure. As this paper aimed to assess the influence of children with CPs and either high or low CU traits, studies on CU traits in samples with no reported or evident CPs were excluded. Likewise, studies that measured psychopathic traits without specific measures of CU traits were excluded. Although the affective dimension of psychopathy is often represented by the inclusion of CU trait subscales, contributing to total psychopathy scores in measures such as the Youth Psychopathy Inventory (Andershed et al. 2002), it is possible for high total psychopathy scores to be reached based on the presence of antisocial behavior alone. For the purpose of this review, any article that provided only total scores for psychopathic traits and not a CU trait subscale, was deemed ineligible for inclusion.

Studies required the inclusion of discrete experimental emotion-eliciting stimuli and the measurement methods of emotional responsiveness. There were no restrictions on publication date. However, as the CU construct is a recent addition to the research literature, the oldest article found eligible for inclusion was published in 2003.

Information Sources

The following sources were searched:

(1) Electronic bibliographic databases (20–30/08/2017, 02/08/2019): MEDLINE, PsychINFO, Embase, Proquest International Dissertations and E-theses.
(2) Search Engines (02/09/2017, 02/08/2019): Google, Google Scholar.
(3) Reference list searching: the reference lists of all papers considered suitable for inclusion were hand searched to identify further suitable studies.

Search Terms

Keyword searches of the following electronic databases were undertaken on MEDLINE, PsychINFO and Embase. There were three groups of search terms used to identify studies. Terms were set broadly, with the aim of initially identifying as many relevant studies as possible. The first group related to emotional responsiveness and included the terms 'emotion', 'affect', 'emotional reactivity', 'emotion processing', 'emotional response' and 'emotion elicitation'. The second group related to CU traits and included 'callous unemotional traits', 'limited prosocial emotions', 'fearlessness', 'psychopathic', 'psychopathy', 'meanness' and 'proactive aggression'. The third group related to emotional measurement and included the terms 'facial expression', 'heart rate', 'pupil dilation', 'gaze aversion', 'attention', 'respiration', 'galvanic skin response', 'self report', 'behavior observation', 'behavior', 'behavior', 'autonomic nervous system', 'electrodermal activity', 'electromyography', 'startle', 'eye blink', 'emotional language', 'fMRI', 'ERP' and 'event-related potential'. Due to the large number of studies initially identified, a fourth search group of child and adolescent terms was identified and used with the 'AND' function, meaning that the above search terms were valid if they included one of the child/adolescent terms. These included 'childhood', 'children', 'early onset', 'adolescent', 'adolescence', 'youth', 'young person' and 'teenager'.

Study Selection and Data Extraction

Figure 1 describes the study selection process following PRISMA protocol, starting with an initial 849 studies identified, which, after duplicates were removed, titles screened and abstracts reviewed, left 69 articles for full-text review. A secondary coder reviewed a random sample of 50 titles (15%) and 89 abstracts (50%) based on inclusion and exclusion criteria, with an agreement of 100% with the primary coder at both title and abstract levels. As many of the abstracts did not include information about whether CU traits were included as an independent measure and did not provide specific information about the nature of the methodologies employed, a full-text review was deemed necessary for a total of 69 articles. Both primary and secondary coders reviewed the 69 articles independently, with 21 meeting inclusion criteria. Agreement about study inclusion was 100% and agreement about exclusion reasons was 98%. Figure 1 shows a flow chart of article selection, including reasons for exclusion at the full-text level.

From the 21 studies deem eligible information was abstracted on study sample size, recruitment, age, CU trait measurement method, type of emotion-eliciting stimulus, method used to measure emotion and difference testing results between high and low CU trait groups. Tables 1, 2, 3

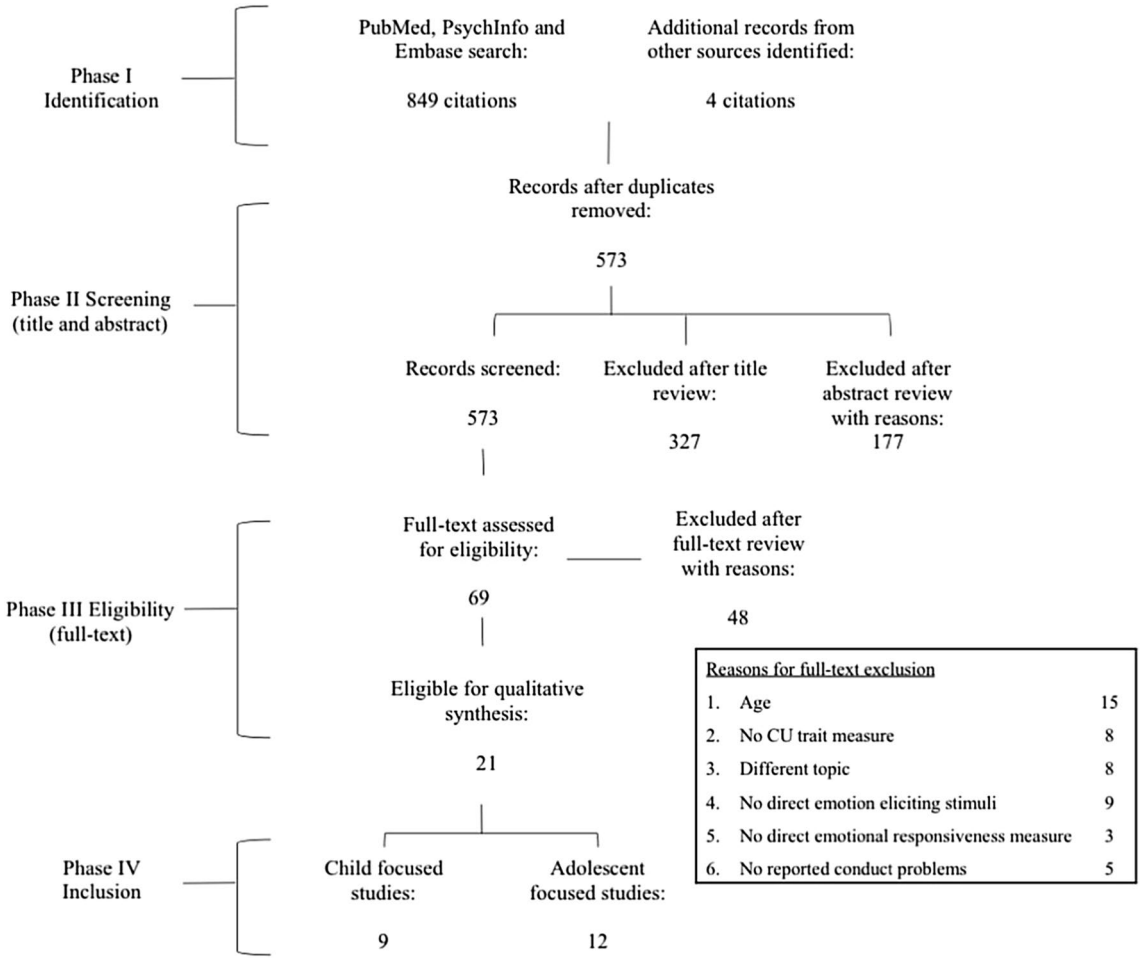

Fig. 1 The selection process following PRISMA protocol (Moher et al. 2009)

Table 1 Demographic information of child studies (9)

Study	Sample size	Sample type	% Female	Age range (M)	Conduct problem measure	CU traits measure
Anastassiou-Hadjicharalambous and Warden (2008)	95	Clinical	4	7–11	Revised Rutter Teacher Scales for School-age Children	APSD–CU subscale
Dadds et al. (2016)	76	Clinical	26	4–14 (7.1)	DISCAP	UNSW System
Ezpeleta et al. (2017)	320	Clinical	48	8	SDQ	ICU
Fanti et al. (2016)	73	Clinical	45	(11.2)	Child Symptom Inventory for Parents-4	ICU
Helseth et al. (2015)	60	Clinical	30	6–12 (9.04)	DBDRS and DISC-IV	APSD–CU subscale
Ragbeer (2015)	73	Clinical	100	9–13 (10.7)	APSD	APSD–CU subscale
Sharp et al. (2006)	659	Community	52	7–11	SDQ	APSD–CU subscale
Souroulla et al. (2019)	87	Community	48	10.1–12.8 (11.2)	CBCL	ICU
Yoder et al. (2016)	106	Clinical and community	49	9–11 (10.55)	DISC Predictive Scale for CD	ICU

Age range and means are both reported when possible

ICU Inventory of Callous–Unemotional Traits, *APSD* Antisocial Process Screening Device, *CD* Conduct Disorder, *CBCL* Child Behaviour Check List, *SDQ* Strengths and Difficulties Questionnaire, *DBDRS* Disruptive Behaviour Disorder Rating Scale, *DISC-IV* Diagnostic Interview Schedule for Children, *DISCAP* Diagnostics Interview Schedule for Children, Adolescents and Parents

Table 2 Demographic information of adolescent studies (12)

Study	Sample size	Sample type	% Female	Age (M)	CPs measure	CU traits measure
Cardinale et al. (2018)	48	Clinical	31	10–17 (14)	SDQ and CBCL	ICU
De Wied et al. (2012)	44	High risk/clinical	0	12–15 (13.63)	CBCL	APSD–CU subscale
Hwang et al. (2016)	67	Community	38	(14.35)	K-SADS	ICU
Kimonis et al. (2017)	238	Forensic	0	(16.8)	DSM-IV criteria	ICU
Lozier et al. (2014)	46	Community	43	10–17	SDQ and CBCL	ICU
Loney et al. (2003)	65	Forensic	0	12–18 (16.01)	CASI-4R	APSD–CU subscale
Martin-Key et al. (2017)	77	Forensic and school	0	13–18	K-SADS	ICU
Masi et al. (2014)	62	Clinical	18	8–16 (11.3)	CBCL	ICU
Sakai et al. (2016)	72	Clinical	0	15–18 (16.7)	DISC-IV	ICU
Schwenck et al. (2012)	92	Clinical	0	6–17 (12.3)	DSM-IV TR	ICU
Schwenck et al. (2017)	43	Clinical	0	11–17 (14.34)	Kinder-DIPS	ICU
Sebastian et al. (2014)	55	Community	0	10–16 (14)	CASI-4R	ICU

Age range and means are both reported when possible

ICU Inventory of Callous–Unemotional Traits, *APSD* Antisocial Process Screening Device, *CASI-4R* Child and Adolescent Symptom Inventory-4R (Lavigne et al. 2009), *K-SADS* Kiddie Schedule for Affective Disorders, *DISC-IV* Diagnostic Interview Schedule for Children

and 4 summarize the abstracted information from the 21 articles. Only the outcomes relevant to this review are reported in the tables. Due to the small number of papers identified and significant variation in emotion reactivity measurement type, a meta-analysis was not deemed appropriate and the decision to conduct a theoretical qualitative narrative was made.

Eligible studies were separated into groups by mean age, with the 'child' group consisting of studies with a mean age under 12 years (9 studies), and the 'adolescent' group with a mean age between 12 and 18 years of age (12 studies). Studies were systematically categorized based on: (1) methodology in relation to category of emotion-eliciting stimuli (interactive activities, imagery, film) and emotional measurement method (subjective experience, observed behavior, peripheral psychophysiological arousal, fMRI); and (2) socio-emotional context of the emotion-eliciting stimuli (neutral, e.g. static images displaying a single facial affect with no other contextual information; 'self-orientated', e.g. frustration induced by losing a game; 'other-orientated', e.g. watching a film of someone else in distress).

Results

Participant and Study Characteristics

As shown in Table 1, the 21 studies yielded a total of 2458 participants, of which 1549 were children (9 studies) and 909 were adolescents (12 studies). Participants were predominantly male, which was consistent with previous research published on children with CPs. All studies included established measures of CU traits (e.g. Dadds et al. 2005; Frick and Hare 2001; Kimonis et al. 2008).

The first aim of this review was to explore whether the emotional responsiveness observed in samples of adults with high psychopathic traits was also observable in samples of children and adolescents with CPs and high CU traits. Of the 21 studies meeting eligibility criteria, 13 (62%) showed that either children or adolescents with high CU traits demonstrated reduced emotional responsiveness on at least one measure compared to those with low CU traits. One study (Dadds et al. 2016) found the opposite effect, with the high CU group demonstrating greater emotional responsiveness compared to the low CU group. Children with high CU traits demonstrated reduced emotional responsiveness in comparison to those with low CU traits in three out of 9 studies (33%), while adolescents showed this effect for 10 out of 12 studies (83%).

The Effect of Methodological Differences on Emotionality

The second aim of the review was to explore whether methodological differences between studies influenced emotional responsiveness in CU trait groups. First, the effect of different types of emotion eliciting stimuli were considered. As demonstrated in Tables 3 and 4, studies using imagery as the emotion-eliciting stimulus most frequently demonstrated reduced reactivity for high compared to low CU trait groups (6 out of 8 studies, 75%), followed by task-based stimuli (5 out of 8 studies, 62%) and film (2 out of 5 studies, 40%). No effect was evident for emotion-eliciting stimuli type when results were considered by age.

Table 3 Results of child studies organized by stimuli type (9)

Stimuli type (*N*)	ER measurement	Study	Study results specific to CU group difference	Type of stimuli
Task (3)	Behavior (2)	Ezpeleta et al. (2017)	No difference was found between HCU and LCU groups in reaction times for identifying different emotions (happy, fear or neutral) in a go, no-go task	Neutral
		Ragbeer (2015)	No differences between HCU and LCU groups in observed behaviors (emotional expressions and intensity of negative valence emotions) during a disappointment task	Self
	Subjective experience (2)	Ragbeer (2015)	No differences between groups of girls with varying levels of CU traits in self-reports of their affect after a disappointment task	Self
		Helseth et al. (2015)	No difference was found between HCU and LCU groups in self-reports of valence on a 5-point Likert scale, which responses ranged from 0 (very happy) to 4 (very angry), which were anchored by drawing of happy, neutral and angry faces	Self
Images (4)	Subjective experience (3)	Sharp et al. (2006)	No significant differences were found between HCU and LCU groups in self-reports of arousal and valence for pleasant, neutral and aversive images	Neutral
		Yoder et al. (2016)	A significant difference was found between HCU and LCU trait groups—HCU trait groups less likely to report feeling distressed than others	Other
		Souroulla et al. (2019)	No significant differences were found on self-report measures of valence and arousal, between HCU and LCU groups in response to images depicting joy, fear, sadness or neutrality	Neutral
Images (4)	Peripheral physiological (2)	Fanti et al. (2016)	A significant difference was found between HCU and LCU trait groups in fear potentiated startle—HCU showed diminished startle potentiation when compared to LCU	Self
		Souroulla et al. (2019)	No significant differences were found on measures of heart-rate, skin conductance and EMG measures, between HCU and LCU groups in response to images depicting joy, fear, sadness or neutrality	Neutral
	fMRI (1)	Yoder et al. (2016)	HCU children showed less functional connectivity seeded in the anterior cingulate with left amygdala and anterior insula in response to viewing images of other people being harmed, when compared to LCU children	Other
Film (2)	Behavior (1)	Dadds et al. (2016)	Children with HCU traits expressed similar emotional responses and emotion regulation strategies (observed behaviours) to LCU children	Other
	Subjective experience (1)	Anastassiou-Hadjicharalambous and Warden (2008)	No significant difference found for children with HCU and LCU traits in self-reports of vicarious response to film	Other
	Peripheral physiological (1)	Anastassiou-Hadjicharalambous and Warden (2008)	Those with HCU traits demonstrated significantly lower baseline heart-rate and magnitude of HR change from baseline, than those with LCU	Other

Next, the effect of emotional measurement methods was explored. As shown in Tables 3 and 4, physiological measures of responsiveness were more likely to demonstrate reduced emotionality in groups with high CU traits than observational and self-report measures. Studies using fMRI-based emotional responsiveness measurement showed the highest predictability of demonstrating reduced responsiveness in groups with high CU traits (6 out of 6 studies, 100%), closely followed by studies using peripheral physiological measures (4 out of 5 studies, 80%). Subjective experience (4 out of 10 studies, 40%) and behavioral measures (1 out of 6 studies, 17%) were less predictable. There was little difference between age groups on these measures.

Table 4 Results of adolescent studies organized by stimuli type (11)

Stimuli type (*N*)	ER measurement	Study	Study results specific to CU group difference	Type of stimuli
Task (5)	Behavior (2)	Loney et al. (2003)	A significant difference was found between HCU and LCU in reaction times to an affective Stroop task. HCU group demonstrated slower reaction times to negative valenced words	Neutral
		Hwang et al. (2016)	A significant difference was found between HCU and LCU groups for accuracy in affect mediated cognitive task—those with HCU traits provided more accurate responses compared to those with LCU traits, suggestive of reduced emotionality in response to positive and negatively valenced images	Neutral
	Subjective experience (1)	Sakai et al. (2016)	A significant difference was found between HCU and LCU trait groups—HCU adolescents self-reported reduced ER after observing another person conduct a prosocial action	Other
	fMRI (3)	Hwang et al. (2016)	A significant difference was found between HCU and LCU groups in response to an affective Stroop task—HCU demonstrated decreased activation of ventromedial prefrontal cortex (vmPFC) and amygdala for negative valenced stimuli	Neutral
		Schwenck et al. (2017)	Decreased amygdala and TPJ activation were found to be significantly correlated with HCU traits	Self
		Cardinale et al. (2018)	HCU adolescents exhibited left amygdala hypoactivation relative to healthy controls and LCU adolescents during evaluations of causing others fear. CU traits moderated the relationship between externalizing behavior and both amygdala activity and patterns of functional connectivity	Other
Images (4)	Subjective experience (1)	Masi et al. (2014)	A significant difference between groups was found in self-report measure of valence—HCU predicted a pleasant judgment to negative images. No group differences were found for self-reported arousal to the images and for positive valenced images	Neutral
	Peripheral physiological (1)	Kimonis et al. (2017)	A significant difference was found between adolescents with HCU and LCU, in which HCU group demonstrated a reduced startle potentiation to aversive images. No difference was found between groups in response to pleasant images	Self
	fMRI (2)	Lozier et al. (2014)	No differences were found between HCU and LCU in right amygdala responses to fear expressions. However, multiple regression analysis found amygdala responses to fearful expression to be negatively associated with CU traits and positively associated with externalizing behavior when both variables were modeled simultaneously. Reduced amygdala responses mediated the relationship between CU traits and proactive aggression	Neutral
		Sebastian et al. (2014)	No difference was found between HCU and LCU group in bilateral amygdala response when exposed to fearful and calm faces. HCU group demonstrated a significantly reduced response compared to LCU group in the middle temporal gyrus (MTG)	Neutral
Film (3)	Behavior (1)	De Wied et al. (2012)	No differences in verbal or facial reactions to sadness in a film between HCU and LCU groups	
	Subjective experience (3)	De Wied et al. (2012)	No significant difference between HCU and LCU groups for self-reports of emotional experience	Other

Table 4 (continued)

Stimuli type (*N*)	ER measurement	Study	Study results specific to CU group difference	Type of stimuli
Film (3)	Subjective experience (3)	Martin-Key et al. (2017)	No difference between HCU and LCU groups in self-reports of emotional experience in response to watching an actor talk about emotional memories (happy, surprised, sad, angry, disgusted, fearful)	Other
		Schwenck et al. (2012)	No difference between HCU and LCU groups in self-reports of how emotionally affected they were on a 10 point Likert scale in response to watching video scenes in which a character experienced varying events	Other
	Peripheral physiological (1)	De Wied et al. (2012)	A significant difference was found between HCU and LCU groups at the autonomic level (HCU showed less HR change from baseline) in response to a sad scene shown on film	Other

Studies Using Multi-systemic Measures of Emotional Responsiveness

The results of studies that adopted multiple measures of emotional responsiveness were also considered. Four studies with child samples used multiple measures (Anastassiou-Hadjicharalambous and Warden 2008; Ragbeer 2015; Souroulla et al. 2019; Yoder et al. 2016). Of these, all demonstrated consistency *within* their studies: that is, multiple measures of responsiveness demonstrated the same effect. However, the direction of the effect was not consistent. Two studies (Anastassiou-Hadjicharalambous and Warden 2008; Yoder et al. 2016) showed reduced responsiveness for the high compared to low CU trait group in both measures [physiological measures (fMRI and peripheral physiological) and subjective experience], while two studies (Ragbeer 2015; Souroulla et al. 2019) found the high CU trait groups to be as emotionally reactive as the low CU trait groups (peripheral physiological, behavior and subjective experience measures).

Only two studies with adolescent samples used multiple measurements (Hwang et al. 2016; De Wied et al. 2012). Hwang et al. found that groups with high CU traits demonstrated results in fMRI and behavioral measures consistent with reduced emotional responsiveness compared to results from groups with low CU traits. However, De Wied et al. (2012) demonstrated inconsistent results within their study: while groups with high CU traits demonstrated reduced responsiveness on physiological measures, there were no differences on measures of subjective experience and behavioral responses.

The Effect of Social Context on Emotional Responsiveness

Next, we considered the effect of the social context embedded in the emotion-eliciting stimuli. As shown in Tables 3 and 4, 8 of the 21 studies used 'neutral' socially-orientated stimuli, 8 used 'other-orientated' emotional stimuli, and 5 used 'self-orientated' stimuli.

Neutral Social Stimuli

Of the 8 studies using 'neutral' socially orientated stimuli, 4 (50%) demonstrated dampened emotional responsiveness for high compared to low CU trait groups. Three studies (Ezpeleta et al. 2017; Sharp et al. 2006; Souroulla et al. 2019) included child samples, with each finding that high and low CU trait groups had similar levels of responsiveness. The opposite effect was seen in the five studies with adolescent samples. Four (Loney et al. 2003; Hwang et al. 2016; Masi et al. 2014; Lozier et al. 2014) showed reduced responsiveness for those with high CU traits, while one with an fMRI-based measurement (Sebastian et al. 2014) found no difference for the primary region of interest—the bilateral amygdala—but a significant group effect for the middle temporal gyrus.

Other-Orientated Stimuli

Of the 8 studies using 'other-orientated' emotional stimuli, 5 (62%) showed those with high CU traits demonstrated less emotional responsiveness than those with low CU traits. Three studies included child samples, 2 (67%) of which found significantly reduced responsiveness in the high CU traits groups for at least one measure (Anastassiou-Hadjicharalambous and Warden 2008; Yoder et al. 2016). The remaining study (Dadds et al. 2016) found similar emotional responsiveness in the high and low CU trait groups. There were 5 studies that included adolescent samples, 3 (60%) of which demonstrated reduced emotional responsiveness for the high compared to low CU trait groups on at least one measure of responsiveness. Two (50%) of these studies used multiple measures of emotional responsiveness (De Wied

et al. 2012; Hwang et al. 2016), with both finding reduced emotionality for high CU traits in physiological measures, with mixed results in reports of subjective experience and behavioural measures.

Self-Orientated Stimuli

Of the 5 studies using 'self-orientated' emotional stimuli, 2 (40%; Fanti et al. 2016; Schwenck et al. 2017) showed reduced emotional responsiveness for high compared to low CU traits, while 3 (60%) (Helseth et al. 2015; Kimonis et al. 2017; Ragbeer 2015) found the opposite.

Discussion

Accurate etiological conceptualizations of how antisocial behaviors develop are essential for clinical researchers to develop effective early interventions and treatment. Recently, such attempts have focused on children with CPs and high CU traits—a group thought to show similar affective deficits demonstrated by adults with psychopathic traits. However, the evidence for this association is mixed, and yet no reviews have been conducted with consideration made to the influence of varying experimental methods. This paper aimed to systematically review literature reporting on emotional responsiveness for children with high vs. low CU traits to test claims that high CU traits are synonymous with dampened emotional responsiveness.

The first specific aim was broad, with a focus on exploring whether dampened emotional responsiveness would be more likely observed in samples of children with CPs and high, rather than low, CU traits. Findings from this review did not support this supposition; rather, inconsistency was shown between studies reporting on emotional responsiveness for children with CPs and varying CU traits. When child and adolescent studies were considered together, groups with high CU traits demonstrated reduced emotional responsiveness in 13 of the 21 studies (62%) that met eligibility criteria. When results were compared by age, children with high CU traits demonstrated dampened emotional responsiveness compared to those with low CU traits in 3 out of 9 studies (33%), while adolescents showed this effect for 10 out of 12 studies (83%). This finding indicates that low emotional responsiveness is not consistent across studies measuring this broad construct, which supports this review's decision to provide a more nuanced, structured review of the literature. Further, the differences in results based on age indicate a need to consider developmental stage and its contribution to varying results.

In order to better understand the effect of emotional components for children and adolescents with high compared to low CU traits, we considered the effects of different measures of emotional responsiveness across the studies. First, the results were assessed to determine whether methodological variations correlated with different results in emotional responsiveness for high and low CU trait groups. Physiological measures (i.e. peripheral physiological, fMRI) were expected to demonstrate dampened emotional responsiveness in high CU groups more frequently than more overt measures (i.e. behavioural and self-report). This effect was supported and it was concluded that physiological measures were more robust predictors of reduced emotional responsiveness for high CU traits groups than others.

Peripheral physiological measures were particularly robust, with reduced emotional responsiveness for high CU trait groups found in 4 out of 5 studies (80%) including these measures. This finding aligns with previous literature, suggesting that reduced physiological responding to emotional stimuli represents a specific biomarker of CU traits and psychopathic traits (e.g. Blair 2013; Moul et al. 2018). Developmental theories of antisocial behavior suggest that this reduced physiological response to others' emotional cues is fundamental to the development of antisocial behaviors and attitudes (e.g. Moffitt and Caspi 2001; Raine and Yang 2006). The underlying theory is that, without aversive physiological responding (i.e. stress and distress), the classical conditioning processes associated with those feelings of seeing an individual in distress do not develop. This is believed to impair the development of internalized social norms and, more broadly, the development of prosocial behaviors (Hoffman 2001).

In line with such theories, decreased neural activation in core areas associated with emotional responsiveness, particularly the amygdala, was expected. This was also supported, with all 6 (100%) of the studies that used fMRI measures of emotional responsiveness testing amygdala reactivity specifically. Five (83%) of these six studies showed that high CU traits were associated with reduced amygdala responsiveness when compared to children and adolescents with low CU traits. This finding is consistent with biological explanations of high CU traits and psychopathy (e.g. Fanti et al. 2016; Viding and McCrory 2012). As the amygdala is involved with multiple stages of information processing and processing of affective information, reduced activity in children and adolescents with high CU traits has been used to partly explain the emotion-processing deficits commonly seen (Blair 2013).

In addition to the amygdala, several other areas of the brain were investigated in eligible studies. Three studies explored additional neural areas, with 2 (67%; Hwang et al. 2016; Schwenck et al. 2017) demonstrating reduced emotional responsiveness in high compared to low CU trait groups. They found that high CU trait groups demonstrated lower reactivity in the ventromedial prefrontal cortex (Hwang et al. 2016) and the temporoparietal junction

(Schwenck et al. 2017): regions thought to regulate and suppress amygdala activity, and influence reinforcement learning (e.g. Koenigs and Grafman 2009; Milad and Quirk 2012). These findings further confirm theories of physiologically-based impairments affecting how children and adolescents with CU traits process emotions.

The next step of the methodological based aims was to consider results based on the emotion-eliciting stimuli used. Based on the notion that emotional responsiveness should be stable across contexts (e.g. Blair 2005; Frick and Marsee 2006), it was predicted that dampened emotional responsiveness in high CU trait groups would be similarly predicted by all emotional stimuli types. This effect was supported. All emotion-eliciting stimuli types demonstrated similar emotional responsiveness for participants with high and low CU traits. Imagery and interactive activities were equally likely to demonstrate reduced emotional responsiveness in the high CU trait group, with both demonstrating the effect in 5 out of 8 studies (62% each), and film with 2 out of 5 studies (40%). As none of the emotion-eliciting stimuli demonstrated a clear dominance in showing reduced reactivity for high CU trait groups, each stimuli type was viewed as similarly salient.

Next, emotional responsiveness was explored according to the socio-emotional context of the emotion-eliciting stimuli. Based on the plethora of work demonstrating low empathy in children with high CU traits (e.g. Blair 2013; de Wied et al. 2012; Decety and Svetlova 2012), it was predicted that other-orientated stimuli (e.g. stimuli that involved witnessing another person in distress) would more consistently demonstrate diminished emotional responsiveness for those with high compared to low CU traits. Emotion-eliciting stimuli related to 'self' (e.g. participation in a frustration-inducing task) and stimuli that contained limited (neutral) information about social context (e.g. images of facial expressions with varying affect) were expected to demonstrate less predictable results. This effect was also supported.

Studies using self-orientated social stimuli were least likely to predict reduced emotional responsiveness for those with high CU traits compared to low, showing this effect in 2 out of 5 studies (40%). One explanation for these results is that self-orientated stimuli may have more personal salience than other types, which might increase the chances of greater emotional responsiveness. Perhaps a potential threat to 'self' (e.g. through a frustration-induction task or removal of a desired toy) is sufficiently salient to trigger an emotional response of similar magnitude to those with low CU traits, which may support previous notions of the role of narcissistic distress in these populations (e.g. Lau and Marsee 2013).

Neutrally-orientated social stimuli were more likely to predict reduced emotional responsiveness in high compared to low CU trait groups, with 4 out of 8 studies (50%) demonstrating this effect. Three of the 8 studies (38%) focused on child samples, all of which showed similar emotional responsiveness for CU trait groups. The remaining 5 studies (62%) were focused on adolescent samples and all found the opposite effect: reduced emotional responsiveness in high CU compared to low CU groups. When comparing results of child- and adolescent-focused studies, an age effect is also indicated: adolescents show reduced emotional responsiveness in high compared to low CU traits more frequently than children. High CU traits have been associated with problems orientating to areas that convey emotional information, such as the eye region on static images of faces (e.g. Dadds et al. 2006), a commonly-used stimuli with neutral or limited social context. These attention/orientation issues have been suggested as an explanation for reduced emotional responsiveness in those with high CU traits in previous studies (Marsh and Blair 2008; Szabó et al. 2017). However, this effect was also found to be inconsistent across studies in samples with high vs. low CU traits, particularly with child groups, providing further evidence of a complex association between CU traits and elements of emotional responsiveness.

Other-orientated social stimuli were most likely to predict reduced emotional responsiveness in high CU trait groups, with a total of 5 out of 8 studies (62%) demonstrating this effect. Three were conducted with child samples. Two of these three studies (Anastassiou-Hadjicharalambous and Warden 2008; Yoder et al. 2016) demonstrated reduced emotional responsiveness in those children with high CU traits compared to those with low CU traits. However, the study conducted by Dadds et al. (2016) found the opposite. Specifically, children with high CU traits were observed to be equally emotionally responsive as those with low CU traits and healthy controls.

At the time of publication, this was an unexpected finding, contrasting with the conclusions of previous studies (e.g. Blair et al. 1999; Blair et al. 2001; Dadds et al. 2008). Measurement issues were raised as a potential explanation for this usual outcome. Only behavioural measures of emotional responsiveness were used, raising the possibility that children only appeared to be emotionally responsive. Additionally, CU traits were measured using the UNSW System (Dadds et al. 2005), which while a validated measure of CU traits—found to be particularly reliable for young children—controversially does not include a specific item about whether the child 'shows their feelings'. It is possible that exclusion of this item has unduly influenced the results in Dadds et al (2016). Another explanation for the results was stimuli-based: the other-orientated stimulus used in the study was primarily 'attachment-relationship' related. Attachment relationships, maternal warmth in particular (see Wright et al. 2018), have received increasing attention in literature as a potential protective factor for the development of

psychopathic traits into adulthood. They have also been suggested to be more salient for eliciting emotions (e.g. Pasalich et al. 2012). It is possible that young children with high CU traits are more likely to demonstrate emotional responsiveness under attachment-related conditions, though further studies with multiple validated measures of CU traits are needed to confirm this speculation.

When other-orientated responses in adolescent samples are examined, all studies—with exception to those using self-report measures (i.e. Martin-Key et al. 2017; Schwenck et al. 2012)— demonstrate reduced responsiveness for those with high compared to low CU traits. One study that adopted multiple measurement methods did not show consistency *between* those methods. De Wied et al. (2012) showed that adolescents with high CU traits reported similar affective experiences and demonstrated similar behavioral responses compared to those with low CU traits, but with diminished physiological responses. In this sense, those with high CU traits may appear, through observations and self-reports, to be just as emotionally responsive as those with low CU traits but still experience reduced physiological reactivity. This may also explain the discrepant findings of Martin-Key et al. (2017) and Schwenck et al. (2012). An important question is whether this emotional expression represents a genuine emotional experience or whether these expressions are fabricated, presumably for a self-orientated motivation.

As referred to throughout, results also suggest differences in CU trait emotional responsiveness based on age. Children with high CU traits demonstrated reduced emotional responsiveness compared to those with low CU traits in 3 out of 9 studies (33%), while adolescents showed this effect for 10 out of 12 studies (83%), suggesting that emotional responsiveness may become more limited as children with these personality traits grow older. These findings held when results were considered by the socio-emotional context of the stimuli, with neutral, self-orientated and other-orientated stimuli showing a trend in which adolescents with high CU traits were more likely than children with high CU traits to demonstrate low emotional responsiveness.

Perhaps of greatest significance were the inconsistent findings in multiple measures of emotional responsiveness in the adolescent samples to other-orientated socio-emotional stimuli. They may indicate that adolescents can learn to respond in socially appropriate ways, while manifesting a limited physiological response. This explanation is consistent with developmental models of adolescence that emphasize social development and the acquisition of socially-acceptable behaviors, which may extend to the expression of emotion (e.g. Eisenberg 2000). While the link between low emotional responsiveness and high CU traits appears less consistent in children compared to adolescents, further exploration of age effects is needed to better understand the etiology of these traits.

In summary, the results from this review indicate a need to reconsider how emotionality and emotional responsiveness is conceptualized within children and adolescents with high CU traits. Our main findings can be summarized in four points. The first is that dampened emotional responsiveness in groups with high compared to low CU traits was not consistently reported across studies. The second is that methodological variations, particularly how emotional responsiveness was measured, influenced the likelihood of dampened emotional responsiveness in high CU trait groups, with physiological measures the most robust predictors. The third is that the socio-emotional context of the emotion-eliciting stimuli appeared to influence whether low emotional responsiveness would be demonstrated for high CU trait groups, which was most likely with other-orientated contexts. The fourth is that children with high CU traits appear to be more emotionally-responsive than their adolescent counterparts. Overall, the results became more homogenous with increased specificity: that is, when socio-emotional context of the emotion-eliciting stimuli, emotional measurement type and participant age are also considered. Accordingly, we propose several recommendations for future work.

Firstly, studies documenting emotional responsiveness in samples with CU traits should consider the socio-emotional context of the emotion-eliciting stimuli used. Other-orientated stimuli are the most robust for predicting reduced emotional responsiveness in groups with high CU traits, which we believe speaks to a specific type of emotion-processing deficit. Deficits in the experience of other-orientated emotions likely signal a developmental trajectory marked by interpersonal problems and an increase in self-motivated behaviors (Fairchild et al. 2013; Frick and White 2008), consistent with conceptualizations of empathy deficits in these groups (e.g. Lui et al. 2016). Further exploration into emotional responsiveness dependent on specific socio-emotional contexts would help to further delineate affective deficits in high CU trait groups.

Secondly, the current review indicates that developmental influences on emotional responsiveness warrant further consideration. Future studies should explore for age effects, especially using longitudinal designs to detail differences between younger children and adolescents, and also gender effects. The majority of participants included in this review were male. Previous work has suggested that CU traits may present differently dependent on the gender of the child (e.g. Essau et al. 2006; Raschle et al. 2018), indicating a need for further attention in this area. Our findings suggest an interesting age effect across studies: low emotionality was less likely to be demonstrated in child compared to adolescent groups. These findings could reflect a genuine difference between ages and correlation with low emotionality, but further empirical studies are needed to test this tentative

theory. A delayed onset of reduced emotional responsiveness could identify a critical period for intervention. Conversely, when results from other-orientated emotional stimuli are considered, both child and adolescent samples demonstrate consistently reduced responsiveness. In fact, the adolescent samples appear to lose some of the emotional deficits by demonstrating no affective differences in some studies using self-reported experiences of emotion (e.g. De Wied et al. 2012). This is especially interesting, as it may indicate learning processes reflecting acquisition of complex theory of mind skills and learnt use of socially-appropriate emotion-motivated behavior. It is believed that adults with psychopathic traits display emotion-based behaviors (such as providing self-reports of emotional experience) despite reduced emotional arousal (e.g. Carmen Pastor et al. 2003), assumed to be for manipulation and personal gain (e.g. Frick and Hare 2001; Frick and Moffitt 2010). Therefore, it is possible that as children with early CU traits grow older, they are more likely to show socially-appropriate behaviours in response to other-orientated emotional cues, but may not experience responsiveness on the other measures of emotionality. Further research is needed to test such theories and may provide further evidence for the necessity of inclusion of physiological measures of emotion.

Thirdly, we propose that multiple measures of emotional responsiveness should be used to operationalize the construct more comprehensively. We found that physiological measures (i.e. fMRI and peripheral physiological arousal) were most robust in predicting reduced emotional responsiveness in high CU trait groups. However, measures of emotional behavior and self-reports of subjective emotional experience provide important insights into a more complete understanding of emotional experience and should not be discounted. The fundamental goal of researchers in this area should be to understand how children with high CU traits experience emotion and how this influences social learning processes, including the internalization of prosocial rules and values. This can only be achieved when emotion-motivated behavior and self-reported experience is also considered (Fanti et al. 2016). Therefore, we recommend that future studies incorporate multiple measures of emotional responsiveness, with at least one physiological measure.

Strengths, Limitations and Recommendations

To our knowledge, this paper is the first to systematically review the empirical literature with the purpose of testing whether the low emotionality demonstrated in adults with psychopathic traits (e.g. Levenston et al. 2000; Verona et al. 2004) is also seen in youth with high CU traits. We believe we are the first to do so according to the effect of emotional measurement, type of emotion-eliciting stimuli and social context of stimuli. The eligibility criteria are both a strength and weakness of this paper. This is a strength as we have been able to provide a very specific review of emotional responsiveness based on the construct of CPs and varying CU trait status only. Literature exploring emotional responsiveness in populations with CPs have frequently conflated CU traits with the broader construct of psychopathic traits. As it is possible to attain a high score for overall psychopathic traits while achieving a low score on measures of CU traits, we excluded papers that did not report on CU traits specifically. Such literature has also explored emotional responsiveness in populations with demonstrated high proactive vs reactive aggression. Proactive aggression is associated with high CU traits (Bozsik et al. 2013; Lozier et al. 2014) but it is not necessarily mutually inclusive (Eisenbarth et al. 2016; Yoder et al. 2016). Therefore, a range of studies that may have provided relevant information were excluded, due to ambiguity in reference to CU traits specifically.

This paper did not explore the influence of specific emotions or impact of stimulus valence on emotional responsiveness. Due to the limited number of studies that aimed to elicit a specific emotional response in participants, a review exploring emotional responsiveness by affect or valence was not possible. Past research demonstrates that individuals with high CU traits have problems recognizing fear and sadness (e.g. Dadds et al. 2006; White et al. 2016) and possibly other emotional states (Dawel et al. 2012), which indicates that further research into the influence of specific emotional states and emotional responsiveness would make an important contribution.

Further, the findings of this paper must be taken within the confines of a qualitative review. This paper aims to provide a synthesis of current literature reporting on specific dimensions of emotional responsiveness and children with high CU traits, with the goal of raising questions and refocussing future research questions left unanswered about the developmental trajectories of early CU traits. Limited numbers of studies published in this area meant that a quantitative review is not yet possible to answer the questions posed in this review. Therefore, the generalizability of our findings are limited and must be observed within the context of the findings from few studies.

Conclusion

Individuals with psychopathic traits have long been associated with notions of low emotionality, operationalized in this review as emotional responsiveness. Children with CPs and high CU traits are considered at higher risk of developing psychopathic traits in adulthood, with patterns of dampened emotional responsiveness deemed a key predictor for this developmental trajectory. While there are some notable studies that support this thesis, some recent studies contradict this

association and a critical review of this literature had not been undertaken. This review aimed to address this gap.

The findings from this review suggest complex interactions between CU traits and low emotionality, with low levels of emotional responsiveness in high CU traits best predicted under conditions by which stimuli are embedded in 'other-orientated' socio-emotional contexts. The stability of reduced emotional responsiveness over development was brought into question and the influence of other-orientated socio-emotional stimuli that were other-orientated in context. In response to other-orientated stimuli, physiological measures were most likely to predict reduced emotionality in high CU trait child and adolescent samples, but varied responses were found in other measures. Notable differences in behavioral and self-report measures between child and adolescent samples for other-orientated stimuli were found: children were more likely to show reduced reactivity across all measures for other-orientated stimuli and adolescents demonstrated reduced reactivity on physiological measures but not on others. These findings raise questions about the experience of emotions in children and adolescents with high CU traits. Do they experience a genuine emotional response as indicated in their self-reports and observed behaviors? Or have they learnt to correctly interpret others' emotional cues and respond with socially-appropriate behaviors?

This paper initially attempted to answer a single question: 'Is callous cold?' It was found that it is, but only consistently under specific, other-orientated social contexts. These results have potential clinical implications. Future research is recommended to test whether there are critical periods of development for learning socially-appropriate emotional responding and to test emotional responsiveness in a range of social contexts, with multiple measurement methods. As emotional responsiveness is key to many theories of moral development and the internalization of prosocial attitudes and values, this research may provide the basis of new directions in innovative approaches to early interventions for young children with CU traits.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval This type of study contains no data from human participants collected by the authors.

Informed consent For this type of study formal consent is not required.

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