Face emotion processing and attention to eye-gaze: Typical development and associations with psychopathic traits and callous unemotional (CU) traits

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Declaration

This thesis contains original research undertaken during the Doctor of Philosophy (Clinical Psychology) in the Research School of Psychology at The Australian National University. Chapters 1, 2 and 7 are my own work, apart from the usual contributions of my supervisors, Prof. Elinor McKone, A/Prof. Romina Palermo, and A/Prof. Richard O'Kearney. Chapters 3–6 are published journal articles or manuscripts prepared for submission of which I am the first author; the contributions of co-authors are detailed at the start of each chapter. All ideas that are not my own have been properly acknowledged and referenced.

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I also wish to acknowledge some more specific contributions. In Chapter 3, statistical advice was provided by Prof. Mike Smithson, and the second coder for the meta-analysis was Dr Jessica Irons, who also provided valuable input into the design of experiments in Chapters 4, 5 and 6. In Chapters 4 and 5, Dr Andrew Bayliss provided advice regarding the eye-gaze cueing paradigm, and some of the participants were tested by Emma Cummings. In Chapter 6, FACS coding of the face stimuli from news photographs was provided by Dr Chiara Fiorentini and Dr Susan Schmidt, and Melissa Freire tested some of the participants. Thank you to Dr Tracey McLellan for sharing her stimuli. For administrative and technical support, I thank Shane Pozzi, Mary Dalton, Petrina Daniels, and Linda Barbour. I also thank the Director of The Research School of Psychology, Prof. Don Byrne, for practical support. More broadly, I wish to thank the ANU 'Cog Group' community for their guidance and contribution to my intellectual development.

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Abstract

There is widespread agreement that the affective features of psychopathy – namely callousness, lack of empathy and remorse, and shallow affect – are core to this disorder. This thesis investigates both global psychopathy and, at times, focuses more specifically on its affective features in the form of callous-unemotional (CU) traits. The starting motivation for the thesis was to investigate three competing etiological models that include, as part of their theory, proposals about the mechanisms underlying the affective features of psychopathy. The three theories alternatively propose: a deficit in processing others' emotions that is specific to expressions signaling distress (e.g., fear; Blair, 1995, 2006); a deficit in attending to the eyes of faces (Dadds et al., 2006); or differences in general attention that produce an abnormally enhanced ability to tune out peripheral information (Newman et al., 2010). In testing these proposals, I examined several aspects of face processing that are potentially impaired in individuals with high levels of psychopathic or CU traits, specifically recognition of others' facial emotions, arousal to those facial emotions, and shifting of attention to follow others' eye-gaze.

Results relevant to psychopathic or CU traits were as follows. A meta-analysis of 29 published experiments found global psychopathy was associated with impaired recognition of several expressions, including the positive, non-distress emotion of happiness. My empirical studies found: (1) decreased arousal to happy expressions with higher psychopathic/CU traits; and (2) increased ability to suppress following of attentional cues with higher CU traits, for non-social arrow cues as well as eye-gaze cues, in fearful, happy and neutral expression faces alike. Together, these results favour the Newman model, and argue against Blair's proposal of deficits only for distress emotions.

The empirical studies also produced two results with important implications for the broader facial expression literature. First, in establishing the attention cueing paradigm, I investigated typical development facial expression-context interactions to drive social attention and threat bias in 8-12 year olds. Interactions emerged from 8 years, but were not fully mature even in the oldest children tested. Second, to select the stimuli used in the arousal rating experiment, I examined perceived

authenticity of currently available stimulus sets that show posed expressions (e.g., Ekman and Friesens' Pictures of Facial Affect), and found they were perceived as showing faked emotion for many expressions. I then found that using genuinely-felt compared to posed expressions can lead to starkly different conclusions: higher levels of psychopathic/CU traits were associated with decreased arousal to genuinely-felt happy expressions, but not posed happy expressions. These results highlight the importance of using ecologically valid stimuli that show faces as they would occur in real world interactions, with relevant contextual information and often signaling genuine emotion.

Overall, results of this thesis argue that psychopathy-related deficits in processing social information are not specific to emotional expressions that signal distress, or to the eyes of faces. Instead, results support the proposal that higher psychopathic/CU traits are associated with enhanced selective attention which suppresses processing of peripheral information, irrespective of the emotional nature of that information.

Word count: 498 words (max. 500)

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Chapter 1: Introduction

1.1 Rationale for thesis and aims

The ability to accurately perceive, interpret and respond to social information is critical to interpersonal behavior. Individuals who are somehow abnormal in these abilities will necessarily have social difficulties. One case where abnormalities in affective processing occur is that of psychopathy. Higher psychopathic traits have been associated with impaired recognition of facial expressions (Marsh & Blair, 2008) and vocal tones (Blair et al., 2002, 2005), and decreased arousal to crying faces (Blair et al., 1997; Blair, 1999). Moreover, these deficits in affective processing have been theorized (e.g., Blair, 2006) to underlie the affective characteristics of this disorder, namely callousness, lack of empathy and remorse, and shallow affect. This thesis investigates both global psychopathy and, at times, focuses more specifically on the affective features of psychopathy in the form of callous unemotional (CU) traits.

This thesis addresses questions about typical processing of social stimuli (facial expressions and eye-gaze) and investigates associations with psychopathic traits and with CU traits as examples of when social information processing goes awry. Key aims are to: (1) test possible limitations of the types of facial expression stimuli currently used in the literature, specifically the influence of context and expression genuineness; (2) investigate aspects of typical development; (3) establish whether, as predicted by one theory, abnormalities in emotion processing in high psychopathic traits or high CU are specific to expressions of distress (i.e., fear and sadness), or whether they extend to other emotions, including the positive emotion of happiness; and (4) investigate alternative theoretical mechanisms underlying apparent impairments in facial emotion recognition in psychopathy and high CU.

Regarding methodology, the results presented in this thesis are derived from meta-analysis in one study, and from behavioral tasks in all other studies, although reference is made to previous results from brain imaging where relevant. All participants were typically developing children and adults. Empirical tests of psychopathic traits and CU made use of individual differences in the general population, consistent with evidence that these traits are dimensional (Edens, Marcus, Lilienfeld, & Poythress, 2006; Marcus, John, & Edens, 2004).

1.2 Thesis structure

There are seven chapters in this thesis. Chapter 2 reviews general background material that is relevant to the understanding and interpretation of the empirical work presented in later chapters. The chapter is divided into two main sections. The first section provides an overview of the clinical aspects of psychopathy and CU, and explains how psychopathy and CU are related. The second section presents three alternative theoretical models, which each include proposals about the etiology of the affective features of psychopathy, which are tested by this thesis.

Chapter 3 presents a meta-analysis that investigates whether impaired recognition of emotions in psychopathy is specific to distress emotions (i.e., fear and sadness), or whether impairments extend to other emotions as indicated by some recent individual studies. Most of the studies reviewed used facial expressions. This chapter also extends previous work by testing whether impairments are cross-modal (i.e., for facial, vocal and postural cues), analyzing results for children and adults separately, and for the primary factor of psychopathy alone.

Chapter 4 investigates the typical development of interactions between facial expressions and contextual information in 8-12 year olds compared to adults. It is the first of two chapters (the other being Chapter 6) that explores limitations on facial expression stimuli in the literature. The limitation addressed here is that findings for facial expressions tested in isolation, as is typical in the literature, can differ from findings for expressions presented with relevant contextual information, as they would appear in the real world. The investigation is by way of a Posner-style eye-gaze cueing paradigm that tests two types of expression-context interactions that can be observed in adults. This study extends previous work by being the first study to test context effects in facial expression processing in children in this way.

Chapter 5 uses the eye-gaze cueing paradigm from Chapter 4 to test three different theoretical explanations of the affective features of psychopathy, which each make different predictions about what will happen in the paradigm. This study has a broader aim to commence bridging the gap between the child literature on CU and adult literature on psychopathy, by testing theories that have emerged separately from these literatures against one another for the first time.

Chapter 6, the second chapter to examine stimulus-related issues, addresses the topic of expression authenticity. Studies of facial expression processing have used mostly posed or faked expressions, which show acted, unfelt emotions (e.g., smiling as though for a driver's license photograph). Yet in real life facial expressions often reflect genuinely felt emotions (e.g., smiling when winning or watching something funny), which convey different meanings and invite different responses. The first section of this chapter tests whether commonly used facial expression stimuli sets are perceived as posed and whether it is possible to generate genuinely-felt facial expressions that are perceived as genuine. To this end, two types of genuinely-felt stimuli are tested: expressions elicited in the lab, and expressions elicited at sporting events captured in news photography. The second section investigates whether using genuinely-felt versus posed facial expression stimuli can lead to different theoretical conclusions in psychopathic traits or CU traits.

Chapter 7 presents a summary of the discoveries of this thesis and integrates them in relation to current theorizing about psychopathy and CU. General implications of the findings that are not considered in earlier chapters are discussed. Finally, I propose some open questions for future research that are raised by the findings of this thesis.

1.3 Thesis format and publication details

The meta-analysis (Chapter 3) and empirical chapters (Chapters 4-6) of this thesis were prepared as individual manuscripts for journal publication. The text in these chapters is identical to the published or to-be-submitted manuscripts, except that numbering has been altered to integrate the thesis.

At the time of writing, Chapters 3 and 4 have been published, Chapter 5 is currently being revised for publication following a recommendation for ‘Major Revisions’, and 6 is to be submitted. I am the first author for the meta-analysis and the three empirical chapters. The contributions of other authors are detailed at the start of each chapter. Publication status details for each chapter are as follows:

Chapter 3

Dawel, A., O'Kearney, R., McKone, E., & Palermo, R. (2012). Not just fear and sadness: Meta-analytic evidence of pervasive emotion recognition deficits for facial and vocal expressions in psychopathy. *Neuroscience and Biobehavioral Reviews*, 36, 2288-2304. doi: 10.1016/j.neubiorev.2012.08.006

Chapter 4

Dawel, A., Palermo, R., Irons, J., O'Kearney, R., & McKone, E. (2014). Fearful faces drive gaze-cueing and threat bias effects in children on the look out for danger. *Developmental Science,* epub ahead of print. doi: 10.1111/desc.12203

Chapter 5

Dawel, A., Palermo, R., Irons, J., O'Kearney, R., & McKone, E. ('Major revisions' decision received 17/07/14 from *Personality Disorders: Theory, Research, and Treatment*; manuscript currently undergoing revisions). Attention abnormalities in callous unemotional traits are not specific to eye-gaze or fear.

Chapter 6

Dawel, A., Palermo, R., Irons, J., O'Kearney, R., & McKone, E. (to be submitted). Are you for real? Why faking it isn't good enough for facial expression stimuli.

1.4 References

Blair, R. J. R. (1999). Responsiveness to distress cues in the child with psychopathic tendencies. *Personality and Individual Differences, 27*(1), 135–145. doi:10.1016/S0191-8869(98)00231-1

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Blair, R. J. R., Budhani, S., Colledge, E., & Scott, S. (2005). Deafness to fear in boys with psychopathic tendencies. *Journal of Child Psychology and Psychiatry, 46*(3), 327–336. doi:10.1111/j.1469-7610.2004.00356.x

Blair, R. J. R., Jones, L., Clark, F., & Smith, M. (1997). The psychopathic individual: A lack of responsiveness to distress cues? *Psychophysiology, 34*, 192–198.

Blair, R. J. R., Mitchell, D. G. V, Richell, R. A., Kelly, S., Leonard, A., Newman, C., & Scott, S. K. (2002). Turning a deaf ear to fear: Impaired recognition of vocal affect in psychopathic individuals. *Journal of Abnormal Psychology, 111*(4), 682– 686. doi:10.1037//0021-843X.111.4.682

Edens, J. F., Marcus, D. K., Lilienfeld, S. O., & Poythress, N. G. (2006). Psychopathic, not psychopath: taxometric evidence for the dimensional structure of psychopathy. *Journal of Abnormal Psychology*, *115*(1), 131–144. doi:10.1037/0021-843X.115.1.131

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Marsh, A. A., & Blair, R. J. R. (2008). Deficits in facial affect recognition among antisocial populations: A meta-analysis. *Neuroscience and Biobehavioral Reviews, 32*(3), 454–465. doi:10.1016/j.neubiorev.2007.08.003

Chapter 2: Literature review: Clinical and theoretical overview of psychopathic and CU traits

2.1 Chapter overview

This chapter provides brief clinical profiles of psychopathy and CU (Section 2.2) and outlines the three theories that are most relevant to the questions addressed within this thesis (Section 2.3). My main aim is to provide broader background material that gives context to the specific questions and literature addressed in the meta-analysis and empirical chapters. It is not my intention to provide an exhaustive review, but rather to focus on that literature which is most pertinent for integrating the thesis as a whole. Later chapters contain additional review of the literature specific to the questions addressed in each chapter.

2.2 Clinical profiles of psychopathy and high CU

In this section I will briefly describe psychopathy and CU traits, and then explain how they relate to one another. I then outline the clinical, cognitive and biological profiles of psychopathy and high CU. Finally, I discuss their measurement, with a particular focus on the questionnaires used in the empirical chapters of this thesis.

2.2.1 Psychopathy

Hervey Cleckley's book 'The Mask of Sanity' (1941/1988) is credited with being the first clear clinical description of psychopathy (see Table 2.2.1 for criteria). Cleckley emphasized affective deficits, and particularly emotionally impoverished responding, as core to psychopathy. Building on Cleckley's work, Robert Hare and his colleagues developed a two-factor model of psychopathy (see Table 2.2.1 for criteria; Hare et al., 1990), in which the first, primary factor – characterized by impairments in affective and interpersonal functioning – is closely aligned with Cleckley's (1941/1988) criteria:

"On the interpersonal level, individuals with this disorder typically present as grandiose, arrogant, ***callous****, dominant, superficial, deceptive, and manipulative. Affectively, they are short-tempered, unable to form strong emotional bonds with others, and* ***lacking in empathy, guilt, remorse, or deep-seated emotions****." (Hare, Clark, Grann, & Thornton, 2000, p. 624).*

In comparison, the additional, secondary factor proposed by Hare and colleagues (Hare et al., 1990) focuses on antisocial and disinhibited behavior:

"…a socially deviant lifestyle that includes irresponsible and impulsive behavior, and a tendency to ignore or violate social conventions and morals." (Hare, Clark, Grann, & Thornton, 2000, p. 624).

The present thesis addresses psychopathy in its entirety, but also at times focuses on the primary affective/interpersonal factor of psychopathy, particularly as the affective facet relates to the construct of CU traits. Bolded symptoms in the above quote are of particular interest because of their alliance with high CU (addressed in Section 2.2.2).

There are several reasons to focus on the primary affective/interpersonal factor. First, the affective and interpersonal features of psychopathy are unique to this disorder, and are not always accompanied by criminality. Some psychopaths are 'successful' and achieve their goals via legitimate means (e.g., in the business world; Babiak, Neumann, & Hare, 2010), rather than by antisocial or criminal means. Thus it is debatable whether antisocial behavior and particularly criminal behavior is an *essential* feature of psychopathy (see Andrade, 2008 for a review of this issue). Some researchers have argued that, where criminality does accompany the primary factor, it may be better understood as a *consequence* of the affective deficits in psychopathy rather than as core to the disorder (Cooke & Michie, 2001). Second, the antisocial behavior factor has limited clinical utility because it is *not unique* to psychopathy. Antisocial behavior often occurs without the primary factor (Poythress et al., 2010), can arise from other causes (e.g., early adversity; Hawes, Brennan, & Dadds, 2009; negative parenting strategies; Leschied, Chiodo, Nowicki, & Rodger, 2008), and shows substantial overlap with other clinical disorders, such as Antisocial Personality Disorder (APSD; American Psychiatric Association, 2013). Finally, the two factors – affective/interpersonal and antisocial/disinhibited behavior – show distinct clinical profiles (Gao & Raine, 2010; Harpur, Hare, & Hakstian, 1989) and may follow different causal pathways. Specifically, the affective/interpersonal factor of psychopathy in adults may represent the continuation of a pattern of symptoms or features that uniquely characterize a subgroup of children with conduct problems who are at risk for ongoing and severe antisocial behavior (Frick, Ray, Thornton, & Kahn, 2013b), namely children with high CU.

Table 2.2.1

Criteria for psychopathy proposed by Cleckley in 'The Mask of Sanity' (1941/1988) and Hare's Psychopathy Checklist Revised (PCL-R; Hare et al., 1990)

Cleckley's criteria	Hare et al.'s Psychopathy Checklist Revised (PCL-R)
1. Superficial charm and good 'intelligence'.	*Factor 1: Affective/interpersonal deficits*
2. Absence of delusions and other signs of irrational thinking.	1. Glibness/superficial charm.
3. Absence of 'nervousness' or psychoneurotic manifestations.	2. Grandiose sense of self worth.
4. Unreliability.	3. Pathological lying.
5. Untruthfulness and insincerity.	4. Conning/manipulative.
6. Lack of remorse or shame.	5. Lack of remorse or guilt.
7. Inadequately motivated antisocial behavior.	6. Shallow affect.
8. Poor judgment and failure to learn by experience.	7. Callous/lack of empathy.
9. Pathologic egocentricity and incapacity for love.	8. Failure to accept responsibility for own actions.
10. General poverty in major affective reactions.	*Factor 2: Antisocial/disinhibited behavior*
11. Specific loss of insight.	9. Parasitic lifestyle.
12. Unresponsiveness in general interpersonal relations.	10. Need for stimulation/proneness to boredom.
13. Fantastic and uninviting behavior with drink and sometimes without.	11. Impulsivity.
14. Suicide rarely carried out.	12. Irresponsibility.
15. Sex life impersonal, trivial, and poorly integrated.	13. Lack of realistic, long-term goals.
16. Failure to follow any life plan.	14. Poor behavioral controls.
	15. Early behavioral problems.
	16. Juvenile delinquency.
	17. Revocation of conditional release.
	Items that do not load
	18. Criminal versatility.
	19. Promiscuous sexual behavior.
	20. Many short-term marital relationships.

2.2.2 Callous unemotional (CU) traits

Psychopathy as a disorder is diagnosable only in adults. In line with the affective/interpersonal factor of adult psychopathy, high CU– which can be assessed in both adults and children – refer to a cold and unempathic interpersonal style, which is lacking in warmth, guilt and remorse, and is marked by shallow affect. Figure 2.2.2 shows that children with high CU represent a distinct subgroup of those with conduct problems (taken from Blair, 2013b), just as adults with psychopathy represent a distinct subgroup of people with criminal behavior. Figure 2.2.2 also illustrates the theorized pathway from childhood CU to adulthood psychopathy. CU traits, like psychopathy, show stability across time, and are uniquely predictive of the stability and severity of antisocial behavior (Frick, Ray, Thornton, & Kahn, 2013a; Frick et al., 2013b). CU traits also have a distinct cognitive/affective and biological profile, which parallels that for adulthood psychopathy and differs from other antisocial behavior (Frick et al., 2013a, 2013b). As a consequence of their unique predictive value and etiological profile, CU traits have been added as a specifier to the diagnosis of childhood Conduct Disorder in the DSM-V (American Psychiatric Association, 2013), entitled 'with limited prosocial emotions'.

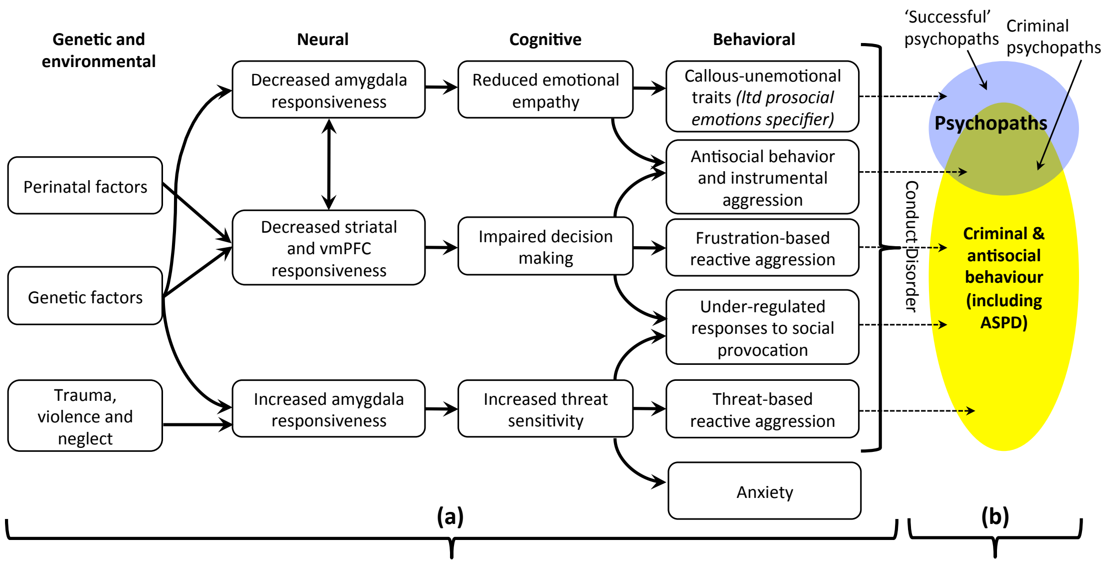

Figure 2.2.2 (a) 'A framework for understanding conduct disorder' from (Blair, 2013b, Figure 2, p. 794). Conduct Disorder is a heterogeneous construct, with several distinct etiological pathways – including the CU traits pathway – that result in different types of antisocial behaviour. (b) Illustration of how the etiological pathways to Conduct Disorder might map onto psychopathic and non-psychopathic antisocial behavior. It is theorized that the CU traits pathway in particular maps onto adulthood psychopathy. 'Successful' psychopaths (Gao & Raine, 2010) are those who do not engage in criminal behavior (or at least are not caught), but still exhibit the core affective and interpersonal features of psychopathy (i.e., shallow affect, lack of guilt and remorse, poor empathy). ASPD = Antisocial Personality Disorder.

Because of their analogous relationship with the affective and interpersonal features of adulthood psychopathy, CU traits are potentially useful for investigating the development of this disorder. CU traits can be measured across the lifespan, from as young as 3 years (Ezpeleta, de la Osa, Granero, Penelo, & Domènech, 2013; Willoughby, Waschbusch, Moore, & Propper, 2011) through to adulthood (Kimonis, Branch, Hagman, Graham, & Miller, 2013). Thus, CU traits may also be useful for bridging the current gap between theories about childhood CU traits (e.g., Dadds, Allen, et al., 2012) and those that more specifically address adulthood psychopathy (e.g., Wallace, Vitale, & Newman, 1999). This is one of the broader aims of this thesis (Chapter 5).

2.2.3 Prevalence, course and outcomes of psychopathic and CU traits

Clinically high levels of psychopathic traits (Coid, Yang, Ullrich, Roberts, & Hare, 2009) and CU traits (Fontaine, McCrory, Boivin, Moffitt, & Viding, 2011) are exhibited by about 1-5% of the general population, and about a fifth of adult forensic populations are diagnosable as 'psychopaths' (Hare, 1996). Both psychopathic traits (Lynam, Caspi, Moffitt, Loeber, & Stouthamer-Loeber, 2007) and CU traits (Fontaine et al., 2011) show stability over time, and high levels of these traits are associated with a particularly severe pattern of antisociality (CU traits: Frick, Ray, Thornton, & Kahn, 2013a; psychopathy: Hare & Neumann, 2008), and poor response to treatment (CU traits: Frick et al., 2013a; psychopathy: Salekin, Worley, & Grimes, 2010).

In relation to stability, a recent article (Frick et al., 2013a) reviewed 18 studies from early childhood to adulthood and concluded that stability of CU traits "appears to be higher than found for many forms of psychopathology and comparable to what is found for other personality traits"(p. 10). Studies of adolescents and adults also show psychopathic traits are stable across time (Harpur & Hare, 1994; Lynam et al., 2007), with decreases in older adulthood potentially explained by changes in antisocial behavior rather than any reduction in the core, affective component (Harpur & Hare, 1994). Altogether there is good evidence that both psychopathic traits and CU traits are relatively stable across the lifespan.

In relation to severity, psychopathy (Cornell et al., 1996) and high CU (Frick, Ray, Thornton, & Kahn, 2013a) are associated with increased aggression, and particularly increased instrumental aggression (i.e., goal-directed as opposed to reactive violence. In high-risk youths, CU traits predict later criminal and other antisocial behavior (McMahon, Witkiewitz, & Kotler, 2010). In adult forensic samples, psychopaths are at increased risk of reoffending – particularly violent reoffending – compared to non-psychopaths (Hemphill, Hare, & Wong, 1998). In the general adult population, psychopathic traits are associated with increased suicide attempts, homelessness, and drug dependence (Coid et al., 2009). Thus overall the evidence is strong that both psychopathy and CU traits increase the likelihood of antisocial behavior.

In relation to treatment, it is doubtful whether adult psychopathy can be treated effectively (Salekin et al., 2010). Further, children with behavioral problems and high CU are not as responsive to traditional treatments that are highly effective for children with disruptive behavioral disorder with low CU (Hawes, Dadds, Brennan, Rhodes, & Cauchi, 2013). For example, Hawes and Dadds (2005) found punishment strategies like time-out were less effective for children high on CU traits than for children low on CU traits. It is possible, however, that high CU children might respond better to other kinds of treatment that emphasize positive parent-child interactions. The study by Hawes and Dadds (2005) found that positive parenting was effective in treating antisocial behavior irrespective of CU status, although high CU children still did not improve as much as those with low CU. Also, in one recent study children with high CU showed *more* improvement in behavior problems than those with low CU when the treatment was emotion recognition training, which involved quality interactions with parents (Dadds, Cauchi, Wimalaweera, Hawes, & Brennan, 2012). Thus there is some preliminary evidence that treatment can be effective for children with high CU.

2.2.4 Cognitive and affective profile

There are many similarities in the cognitive and affective profiles that have been established for psychopathy and high CU. Both are associated with cognitive abnormalities in three main areas: processing of emotional stimuli (including facial expressions), autonomic responding to threat, and behavioral learning (particularly punishment-based learning). Table 2.2.4 lists the specific cognitive profiles proposed by several recent reviews that address findings from psychopathy and CU together (Blair, 2013b; Frick et al., 2013a; Moul, Killcross, & Dadds, 2012). The table shows that impairments are widely agreed upon by different authors and by profiles from adults and children.

This thesis is primarily concerned with associations of emotional processing with psychopathic traits and CU traits, and does not address learning impairments. Of relevance to this thesis, all review articles in Table 2.2.4 agree that there are problems with recognizing and responding to others' facial expressions of distress (i.e., fear and sadness). However, several recent *individual studies* have failed to find deficits for fear (Book, Quinsey, & Langford, 2007; Eisenbarth, Alpers, Segrè, Calogero, & Angrilli, 2008; Fairchild, Stobbe, van Goozen, Calder, & Goodyer, 2010; Glass & Newman, 2006; Hansen, Johnsen, Hart, Waage, & Thayer, 2008; Hastings, Tangney, & Stuewig, 2008) and/or sadness (Del Gaizo & Falkenbach, 2008; Glass & Newman, 2006; Hansen et al., 2008; Leist & Dadds, 2009; Muñoz, 2009) and some have instead found deficits for non-distress emotions, including happiness (Hastings et al., 2008). This evidence regarding emotion recognition deficits is reviewed in detail in Chapter 3, which is a meta-analysis of emotion recognition in psychopathy.

Also relevant to this thesis, all review articles in Table 2.2.4 agree psychopathic traits and/or CU traits are associated with impaired emotional *responsiveness*. Both Blair (2013b) and Frick et al., (2013a) note this includes reduced responsiveness to others' expressions of distress. Reduced emotional responsiveness is consistent with clinical descriptions of psychopathy and high CU that emphasize shallow affect and poor *affective* empathy. Affective empathy refers specifically to having some kind of emotional reaction to others' feelings. Research on emotional responsiveness in psychopathy and in high CU has focused almost exclusively on reactions to threatening and distressing stimuli. One aim of the present thesis, addressed in Chapter 6, is to investigate whether emotional responsiveness might also be reduced for pleasant experiences, such as being smiled at.

A final point – not included in the review article profiles – is that high CU traits in children and adolescents have recently been associated with lack of attention to the eyes of faces (Dadds et al., 2006; Dadds, El Masry, Wimalaweera, & Guastella, 2008).This finding has lead to theorizing that poor attention to the eyes may have some important etiological role in the development of CU traits and later psychopathy (Dadds, Allen, et al., 2012; see Section 2.3.2).

Table 2.2.4

Cognitive and affective profile of psychopathy/high CU from recent review articles

Article	Population focus	Cognitive and affective profile
Moul, Kilcross and Dadds (2012, p. 790)	Psychopathy (mostly in adults, some reference to psychopathic traits and CU traits in youths)	• Deficits in fear-recognition • Lower conditioned fear responses • Poor performance in stimulus-reinforcement tasks (passive avoidance and response-reversal learning)
Blair (2013b, p. 795)	Psychopathic traits (youths and adults, some reference to CU traits in youths)	• Reduced psychophysiological responsiveness to the distress of others • Impaired facial expression recognition • Impaired aversive condition (for adults, unclear for youths) • Impaired extinction • Impaired reversal learning • Impaired care-based moral judgment
Frick et al., (2013a, p. 11)	Focus on CU traits, but also addresses psychopathic traits more broadly where applicable (youths)	• Impaired responsiveness to and recognition of cues to fear and sadness in others • Deficits in affective empathy • Abnormalities in processing of punishment cues • Endorse more deviant social goals

2.2.5 Biological basis

Consistent with the cognitive profile outlined above, psychopathy and high CU have been associated with structural and functional abnormalities in specific brain regions that are involved in processing emotional stimuli, responding to threat, and learning. Abnormalities are found primarily in the amygdala and ventromedial prefrontal cortex (vmPFC; Blair, 2013a, 2013b). There is also evidence of abnormalities in various associated neurotransmitter and endocrine systems (Yildirim & Derksen, 2013). Although genetic research is in its infancy, it seems that these abnormalities may arise largely from genetic influences (Blair, 2013b), and be less influenced by environmental factors than other antisocial behavior ((Larsson, Viding, & Plomin, 2008); but cf. Fontaine et al., 2011 for evidence of environmental influence). The evidence summarized below is reviewed in detail by several recent articles (Blair, 2013a, 2013b; Frick et al., 2013b).

Amygdala abnormalities are believed to have a critical contribution to both psychopathy and high CU. There is strong evidence of structural and functional abnormalities in the amygdala in psychopathy in particular (Blair, 2013a, 2013b). There is also evidence of decreased connectivity with other regions, such as the ventromedial prefrontal cortex (vmPFC; Blair, 2013a, 2013b). Abnormalities in the amygdala make sense in terms of the cognitive profile associated with psychopathy and high CU. Amygdala lesion patients show many parallels with psychopaths and high CU, including deficits in recognizing fearful expressions (Adolphs et al., 1999), lack of attention to the eyes of faces (Adolphs et al., 2005), and problems with stimulus-reinforcement learning (Everitt, Cardinal, Parkinson, & Robbins, 2003). The amygdala, however, is not wholly disrupted in psychopathy and high CU, as it is in lesion patients. One recent theoretical perspective (Moul et al., 2012) suggests that only some parts of the amygdala function abnormally in psychopathy. In particular, that the basolateral amygdala is under-functioning but the central amygdala maintains normal or above-average levels of functioning. Overall, the evidence for some degree of abnormality in the amygdala in psychopathy and high CU is strong and undisputed in the literature.

Abnormalities in amygdala functioning may also impact over time on other connected, interacting regions. One such region is the vmPFC. There is good evidence that structural volume is reduced in the vmPFC in psychopathic adults, but findings from youths are unclear (Blair, 2013b). Functionally, there is evidence of reduced responsiveness to rewards in the vmPFC in youths, but in this case findings from adults are ambiguous (Blair, 2013b). The vmPFC has a role in making moral judgments and emotional processing (van den Bos & Güroglu, 2009), and some authors have argued that it is dysfunctions in the vmPFC in psychopathy that leads to impaired decision making when it comes to actions that hurt others (Blair, 2007). At this stage, we still need more investigation of developmental changes in the vmPFC as they relate to moral decision making in psychopathy and high CU to establish whether there is any relationship.

More recently, there have been increasing claims that neurochemical systems, in addition to specific neural structures, may be abnormal in psychopathy and high CU (Blair, 2006; Moul et al., 2012). Suggestions include serotonin (Moul, Dobson-Stone, Brennan, Hawes, & Dadds, 2013; Yildirim & Derksen, 2013), oxytocin

(Beitchman et al., 2012; Dadds et al., 2014; Moul et al., 2012) and testosterone (Yildirim & Derksen, 2012). Research into the precise genetic origins of these abnormalities is still in its infancy (Blair, 2013b; Frick et al., 2013b), but there is reasonable evidence that psychopathic traits and CU traits are highly heritable (e.g., Blair, 2013b).

Biological abnormalities in high CU children may be different from those in high CU or psychopathic adults, the reason being that abnormalities early in development that are genetically initiated may have propagative effects on other neural regions and systems. It also follows that the cognitive profiles of psychopathy and high CU are likely to change with development. Thus, taking a lifespan approach to understanding the development of the psychopathy is essential if we wish to understand how to best intercede at different stages.

2.2.6 Measurement of psychopathic traits and CU traits

The use of the term 'psychopath' implies that this is a categorical construct. However psychopathic traits, like CU, are *dimensional* and show natural variation within the general population (Edens, Marcus, Lilienfeld, & Poythress, 2006; Marcus, John, & Edens, 2004). Psychopathy is a label applied to adults at the extreme high end of this spectrum, who show a level of dysfunction that is considered disordered. The vast majority of studies have used the types of forensic or clinical samples in which psychopathic traits and CU traits are concentrated. This thesis instead harnesses individual differences in the general population. This approach is more consistent with the dimensional nature of these constructs. Also, it may be useful for developmental comparisons, which are an important avenue for future work. For example, adult forensic samples often have histories of substance abuse, which confounds the study of psychopathic traits with substance effects. Measuring CU in community adult samples may serve as a better comparison for children with high CU.

This thesis uses two self-report measures. To measure psychopathic traits, I use the Levenson Self Report Psychopathy Scale (LSRPS; Levenson, Kiehl, & Fitzpatrick, 1995). To measure CU, I use the Inventory of Callous Unemotional Traits (ICU; Frick, 2003), and also the callous factor of the LSRPS (Brinkley, Diamond, Magaletta, & Heigel, 2008). These self-report measures have been designed for use in the general population and thus have good range for testing individual differences in trait-levels in community samples, where psychopathic traits and CU traits are mostly well below pathological levels but still show variance between individuals. The ICU also has the advantage that it can be used across a wide range of ages, from three years until adulthood (Kimonis et al., 2013). I next describe the LSRPS and ICU in more detail.

Table 2.2.6a

Items for the Levenson Self Report Psychopathy Scale (LSRPS; Levenson, Kiehl, & Fitzpatrick, 1995)

Factor 1	*Factor 2*
2. In today's world, I feel justified in doing anything I can get away with to succeed. 4. My main purpose in life is getting as many goodies as I can. 7. Even if I were trying very hard to sell something, I wouldn't lie about it. 9. I enjoy manipulating other people's feelings. 11. Looking out for myself is my top priority. 12. I tell other people what they want to hear so that they will do what I want them to do. 13. Cheating is not justifiable because it is unfair to others. 15. I would be upset if my success came at someone else's expense. 17. For me, what's right is whatever I can get away with. 19. Success is based on survival of the fittest; I am not concerned about the losers. 21. I feel bad if my words or actions cause someone else to feel emotional pain. 22. Making a lot of money is my most important goal. 23. I let others worry about higher values; my main concern is with the bottom line. 24. I often admire a really clever scam. 25. People who are stupid enough to get ripped off usually deserve it. 26. I make of point of trying not to hurt others in pursuit of my goals.	1. I am often bored. 3. Before I do anything, I carefully consider the possible consequences. 5. I quickly lose interest in tasks I start. 6. I have been in a lot of shouting matches with other people. 8. I find myself in the same kinds of trouble, time after time. 10. I find that I am able to pursue one goal for a long time. 14. Love is overrated. 16. When I get frustrated, I often 'let off steam' by blowing my top. 18. Most of my problems are due to the fact that other people just don't understand me. 20. I don't plan anything very far in advance.

The LSRPS is a 26-item scale (see Table 2.2.6a) that is completed by self-report and is only used in adults. Although the LSRPS was originally put forward as having two factors that are aligned with those proposed by Hare et al., (1990; i.e., primary factor = affective and interpersonal deficits; secondary factor = antisocial and disinhibited behavior), others (Brinkley, Diamond, Magaletta, & Heigel, 2008) have argued a three-factor solution is more appropriate (callous-unemotional, egocentric/manipulative interpersonal style, and antisocial approach to life). Items are scored from 1 'disagree strongly' to 4 'agree strongly'. The LSRPS correlates with other psychopathy measures in forensic (e.g., the PCL-R; Brinkley, Schmitt, Smith, & Newman, 2001) and community samples (Levenson et al., 1995), demonstrating good validity. The total LSRPS scale also shows good reliability (e.g., Cronbach's $\alpha = .85$; Brinkley, Schmitt, Smith, & Newman, 2001). However, the CU subscale (used in Chapter 5) from the 3-factor solution shows only modest reliability ($\alpha = .63$; Brinkley, Diamond, Magaletta, & Heigel, 2008). Because of the LSRPS-CU subscale's limited reliability, it is used only in conjunction with the ICU in this thesis.

Table 2.2.6b

Items for the Inventory of Callous Unemotional Traits (ICU; Frick, 2003)

1. I express my feelings openly.	13. I easily admit to being wrong.
2. What I think is 'right' and 'wrong' is different from what other people think.	14. It is easy for others to tell how I am feeling.
3. I care about how well I do at school or work.	15. I always try my best.
4. I do not care who I hurt to get what I want.	16. I apologize ('say I am sorry') to persons I hurt.
5. I feel bad or guilty when I do something wrong.	17. I try not to hurt others' feelings.
6. I do not show my emotions to others.	18. I do not feel remorseful when I do something wrong.
7. I do not care about being on time.	19. I am very expressive and emotional.
8. I am concerned about the feelings of others.	20. I do not like to put the time into doing things well.
9. I do not care if I get into trouble.	21. The feelings of others are unimportant to me.
10. I do not let my feelings control me.	22. I hide my feelings from others.
11. I do not care about doing things well.	23. I work hard on everything I do.
12. I seem very cold and uncaring to others.	24. I do things to make others feel good.

The ICU (Frick, 2003) is a 24-item scale (see Table 2.2.6b) that can be completed by parent-, teacher- or self-report. The scale was developed to overcome limitations of the CU subscale of the Antisocial Process Screening Device (APSD; Frick & Hare, 2001). Items are based on the APSD and include an equal number of positively and negatively worded items. Scoring is from 0 'not at all true' to 3 'definitely true'. Although the scale can be divided into three factors (callousness, unemotional and uncaring), we deal here only with total ICU scores because total CU traits are of primary theoretical relevance. The total ICU scale shows good reliability (e.g., Cronbach's $\alpha = .81$; Kimonis et al., 2008). The ICU has also demonstrated validity. In forensic samples, the ICU is correlated with increased aggression and decreased emotional reactivity (Kimonis et al., 2008). In community samples, the ICU shows reasonable correlations with self-report measures of psychopathy, including the LSRPS (Kimonis et al., 2013). One particular advantage of the ICU is that it has been used in samples from as young as 3 years (Ezpeleta et al., 2013) until early adulthood (Kimonis et al., 2013), which is important for investigating the developmental trajectory of CU traits. It has also been used with both general population (Kimonis et al., 2013) and forensic (Kimonis et al., 2008) samples.

2.3 Theoretical explanations of affective deficits in psychopathy

This section outlines three different theoretical accounts that include proposals about the nature of affective processing deficits in psychopathy that are relevant to the evidence presented in the later chapters of this thesis. Theory 1 proposes specific difficulties in processing others' distress (Blair, 1995, 2006). Theory 2 argues for lack of attention to the eyes of faces (Dadds et al., 2006). Theory 3 proposes more general abnormalities in attention that also encompass non-social stimuli (Baskin-Sommers, Curtin, & Newman, 2011; Newman, Curtin, Bertsch, & Baskin-Sommers, 2010).

2.3.1 Blair's distress-specific theory of psychopathy

Over the past two decades, Blair (1995, 2006) has argued that impaired processing of others' emotions in psychopathy is limited to emotions that signal distress (e.g., fear or sadness), and that this is a key etiological factor in the development of the affective features of psychopathy. Specifically, Blair contends that the affective features of psychopathy are caused by abnormalities in encoding the emotional valence (i.e., punishment or reward value) of stimuli, specifically for those stimuli that normally invoke a distress response or anxiety (i.e., are punishing or aversive). In typical, non-psychopathic individuals, people typically find others' distress to be inherently aversive (Bandura & Rosenthal, 1966). This means that actions that cause distress are 'punished' and consequently the behavior is stopped (Perry & Perry, 1974). Blair (1995, 2006) argues that in high psychopathic traits signals of distress are not encoded properly and are therefore not recognized nor experienced as aversive, and thus antisocial behavior continues unchecked by guilt or remorse.

Blair's (1995, 2006) theory has been highly influential (his original 1995 article has been cited 399 times according to Scopus March 7, 2014) but, while much evidence has appeared to support it, other evidence has not. That is, there are reasons to think deficits in emotional processing associated with psychopathic traits might not be specific to distress.

First, from a clinical perspective, Cleckley (1941/1988) was clear that the experience of *positive* as well as negative emotions is impaired in psychopathy:

> "…the psychopath always shows general poverty of affect ... mature, wholehearted anger, true or consistent indignation, honest, solid grief, **sustaining pride, deep joy,** and genuine despair are reactions not likely to be found…" (Cleckley, 1941/1988, p. 348).

Second, the distress-*specific* theory implies that impairments in emotion processing should be limited to emotions like fear and sadness. Although some findings are consistent with this idea, several are not. This evidence can be divided into that pertaining to the *recognition* of others' emotions and that pertaining to the *experience* of emotion.

Concerning emotion *recognition* – for example, labeling a fearful expression as 'fear, or a happy expressions as 'happy' – an influential meta-analysis (Marsh & Blair, 2008) found evidence of impaired recognition in psychopathy for fearful and sad facial expressions, and not for other emotions. Since the publication of this meta-analysis however, there have been several individual studies have failed to find deficits for fear (Book et al., 2007; Eisenbarth et al., 2008; Fairchild et al., 2010; Glass & Newman, 2006; Hansen et al., 2008; Hastings et al., 2008) and/or sadness (Del Gaizo & Falkenbach, 2008; Glass & Newman, 2006; Hansen et al., 2008; Leist & Dadds, 2009; Muñoz, 2009) and some have instead found deficits for non-distress emotions, including happiness (Hastings et al., 2008). Also in line with the idea that emotion recognition might not be impaired just for distress, Marsh and Cardinale (2012) showed psychopathic traits were related to problems identifying statements that would cause others to feel others to feel happiness (e.g., "I bought you a present) as well as fear (e.g., "I could easily hurt you"). These new findings argue that deficits in emotion recognition may not be specific to distress. A re-evaluation of this issue is the specific topic addressed by the meta-analysis presented in Chapter 3.

Concerning the *experience* of emotion, a long-held view is that there is low temperamental fearfulness in psychopathy. For example, Cleckley's original criteria (1941/1988) state there is an 'absence of nervousness'. Empirically, psychopathy has been associated with decreased autonomic responding to threat (e.g., electric shocks; Lykken, 1957) and reduced fear conditioning (Moul et al., 2012). However, a recent review of emotion processing in psychopathy by Brook, Brieman, & Kosson (2013) found that in fact the evidence is equivocal as to whether these deficits in experience are *specific* to one type of emotion – as predicted by Blair's theory – or more general. One reason for this is that many individual studies have focused specifically on threatening or fearful stimuli, and have not included rewarding stimuli. For example, reduced autonomic responding to crying faces has been demonstrated in both adults (Blair, Jones, Clark, & Smith, 1997) and children (Blair, 1999) with high psychopathic traits, but most comparison stimuli were either threatening non-face stimuli (e.g., sharks) or neutral household objects (e.g., a hairdryer) (note one control stimulus in Blair et al., 1997 and Blair, 1999 was an angry face but results were not reported for this stimulus separately). Thus it is difficult to draw any inference about the distress-specificity of these results. It is also interesting that in these studies autonomic responding was not reduced for the threatening stimuli as would be expected by the distress-specific account. Still, one recent study that did test the full range of 'basic' emotions (i.e., anger, disgust, fear, happy, sad, surprise; Ekman, 1992) found that adolescents with high psychopathic traits report reduced experiences of fear in everyday life, but were no significant differences in their experiences of other emotions when compared to control participants (Marsh et al., 2011). The question of whether psychopathic and CU traits are related to decreased experience of emotion in response to non-distress stimuli is a specific topic of empirical work presented in Chapter 6 of this thesis.

In summary, although there is strong evidence that impaired processing of distress stimuli is related to psychopathic and CU traits, it is unclear whether this applies *only* to distress stimuli; that is, whether impairments are distress-specific as argued by Blair's theory. One of the key aims of this thesis is to examine this issue by investigating recognition (Chapter 3) and experience (Chapter 6) of the positive emotion of happiness, which clearly does not signal distress.

Another key aspect of Blair's (1995, 2006) theory is his proposal that the encoding of punishment value associated with distress stimuli is fundamentally disrupted in high psychopathic traits. This suggests that getting them to apply more attention to distress stimuli should *not* improve their ability to recognize or respond to them in any way. However, at least two labs have established that attention manipulations can ameliorate some of the affective processing deficits in psychopathy (Newman et al., 2010) and high CU (Dadds et al., 2006, 2008).

2.3.2 Dadds' lack of attention-to-the-eyes theory of high CU

The first of these is Dadds and colleagues, who have shown that deficits in fearful expression recognition can be ameliorated by instructing high-CU youths to attend to the eyes of faces (Dadds et al., 2006, 2008). This finding has led Dadds to propose that deficits in fear recognition in psychopathy are a secondary consequence of lack of attention to the eyes, because fear is an emotion where the eyes carry much of the information (unlike, say, happiness where the mouth is critically important). Consistent with this, youths with high CU traits show less attention to the eyes of all faces. This includes an eye-tracking study in which high CU adolescents showed fewer first fixations, shorter duration of fixations, and fewer fixations overall to the eyes of faces, irrespective of the emotional expression being displayed (Dadds et al., 2008). It also includes naturalistic interactions between children and their parents, in which case high CU children made less eye-contact with their caregiver than low CU children (Dadds et al., 2013; Dadds, Jambrak, Pasalich, Hawes, & Brennan, 2011; Dadds, Allen, et al., 2012). These findings for high CU youths parallel results for amygdala lesion patients, who also show less attention to the eyes of faces, together with fear recognition deficits, and amelioration of fear recognition deficits when instructed to attend to the eyes (Adolphs, 2008; Adolphs et al., 1999, 2005). This is important because amygdala dysfunction has been implicated in psychopathy and high CU traits. Also relevant, the amygdala has a critical role in directing attention to biologically salient aspects of stimuli, including the eyes (Adolphs, 2010). Interestingly, however, a recent fMRI study (Sebastian et al., 2014) found no corresponding increase in amygdala activation when the attention of high-CU participants was directed to the eyes of fearful faces.

How might lack of attention play a role in the etiology of psychopathy? Dadds has proposed that poor eye contact with attachment figures could "drive cascading errors in the development of empathy and conscience" (Dadds, Allen, et al., 2012, p. 195), thus explaining the core affective deficits in childhood CU and the later development of psychopathy. Eye contact is a critical means of communication, which plays an important role in social development (Baron-Cohen, Wheelwright, & Jolliffe, 1997; Blakemore, 2008; Skuse, 2003). If children with high CU are failing to make normal levels of eye contact with their care-givers, as suggested by Dadds' research (Dadds et al., 2013, 2011; Dadds, Allen, et al., 2012), then this could divert the normal course of empathic socialization and interrupt normal attachment processes. Consistent with disrupted attachment, there is some evidence that high CU traits cause negative changes in parenting methods over time (Hawes, Dadds, Frost, & Hasking, 2011).

Dadds' lack-of-attention-to-the-eyes theory makes different predictions about the nature of abnormalities for processing face stimuli in psychopathy to Blair's distress-specific account. For one, it predicts that there should be some degree of impairment for processing other emotional expressions (as investigated in Chapter 3), given that the eye region provides important clues as to the identity of many emotions, not only fear. I note, however, that Dadds' theory does suggest that emotion recognition impairments may be less for some emotions than for other emotions: for example, the eyes are *especially* important for identifying fear, because the information necessary for identifying fear is carried mostly by the eyes (compared to, say, happy, which can often be identified from the mouth alone).

Second, Dadds' theory suggests there could be problems with processing more subtle emotion signals, such as discriminating whether an expression is displaying an emotion that is *genuinely-felt* or not. Studies of facial expression processing have used mostly posed expressions, which show acted, unfelt emotions (e.g., smiling as for a driver's license photograph). Yet in real life facial expressions often reflect genuinely-felt emotions (e.g., smiling when winning a medal), which convey different meanings and invite different responses. For happy, the eye region is particularly important in determining genuineness of emotion. Genuinely-felt happy expressions are distinguished from posed happiness by small wrinkles or 'crow's feet' around the eyes (Ekman, 2003). Poor attention to the eyes could mean that people with high psychopathic and CU traits fail to detect, or fail respond to, the genuineness of happy expressions. This possibility is addressed in Chapter 6 of this thesis.

A third broad prediction of Dadds' theory is that CU traits (and possibly psychopathy) should be associated with abnormalities in other experimental tasks that involve attention to the eyes, not just emotion recognition. For example, it predicts that high CU traits should be associated with reduced following of others' direction of social attention, using an eye-gaze-direction cueing paradigm. Previous literature has not investigated this prediction, and it is the topic of Chapter 5 of this thesis.

The testing of eye-gaze cueing in Chapter 5 also allows me to address a significant limitation of previous empirical tests of Dadds' lack-of-attention-to-the-eyes theory. To date, the theory has only been investigated in relation to childhood and adolescent CU traits (Dadds et al., 2006, 2013, 2008, 2011; Dadds, Allen, et al., 2012). Chapter 5 tests adults, and thus provides the first test of whether adults with high CU traits show the same problems as children and adolescents with attending the eyes of faces.

2.3.3 Newman's general attention abnormalities theory of psychopathy

The second lab that has demonstrated that attention manipulations can ameliorate some of the affective processing deficits associated with psychopathic traits is that of Newman and colleagues (Baskin-Sommers et al., 2011; Newman et al., 2010; Wallace et al., 1999). In this case, the researchers have shown that, in adult forensic psychopaths, focusing attention on cues that predict when an electric shock will occur ameliorates deficits in fear-potentiated startle (paradigm illustrated in Figure 2.3.3; Baskin-Sommers et al., 2011; Newman et al., 2010). Results such as these have led Newman to suggest that high psychopathic traits are related to abnormalities in general attention mechanisms, which include processing of non-social stimuli. More specifically, Newman and colleagues have proposed the *response modulation hypothesis* (e.g., Wallace, Vitale, & Newman, 1999). The response modulation hypothesis implies that psychopaths have *superior* ability to focus their attention on goal-directed tasks, to the exclusion of peripheral information that would typically capture attention, such as emotional or threatening stimuli. To illustrate, most people find it difficult to ignore the distress they cause another by stealing from them. Someone with high psychopathic traits, however, might be able to focus on their goal (stealing, getting money) to the exclusion of others' distress.

Empirical evidence for the response modulation hypothesis is from the paradigm presented in Figure 2.3.3. Figure 2.3.3a shows a threat-relevant condition, in which participants decided whether a square was red or green, with red boxes signaling that an electric shock may be administered. Figure 2.3.3b shows a threat-irrelevant condition, in which participants decided whether a letter contained within the box was uppercase or lowercase, which was unrelated to being shocked. Electric shocks were only ever paired with red squares. Startle-probes were administered for both coloured squares. Psychopaths only showed reduced fear-potentiated startle in the threat-irrelevant condition, and only when the threat-irrelevant information was presented prior to the coloured square (i.e., in the early other focus condition). The idea here is that because psychopaths had already set their attention to focus on the goal-relevant information (i.e., the letter) the threat-relevant information (i.e., the colour of the square), which typically captures attention, was effectively ignored. The response modulation hypothesis is also supported by the results of a recent fMRI study using the same paradigm (Larson et al., 2013), in which psychopaths showed increased activation in neural regions involved in selective attention in the threat-irrelevant condition (as in Figure 2.3.3b), consistent with exerting greater top-down control to ignore peripheral information.

A more subtle component of the Newman's theory, proposed on the basis of the finding that the deficit in FPS was only present in the early other focus condition, is that there is an 'early attention bottleneck' (Baskin-Sommers et al., 2011) in which peripheral information is *only* ignored when attention is already focused elsewhere. However, arguing against the idea of an 'early attention bottleneck', fear recognition deficits are observed even when the primary goal of the task is to identify the expression being shown (Marsh & Blair, 2008), and thus there is no 'other focus'. So far then, the evidence for an 'early attention bottleneck' is unconvincing.

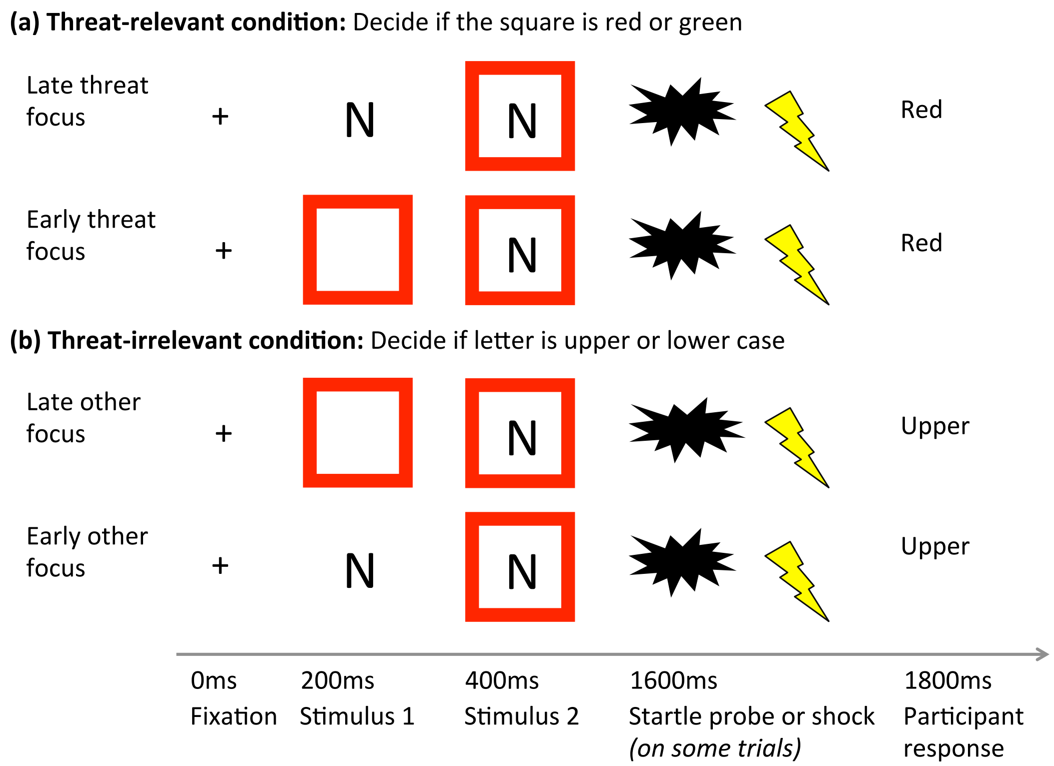

Figure 2.3.3 Startle-probe paradigm as used by Baskin-Sommers et al. (2011; adapted from their Figure 1).

To summarize, there is some support for Newman and colleagues' general idea of a response modulation hypothesis. However, this idea has only been tested in forensic psychopathic adult samples. It remains to be seen whether findings hold for high CU traits in adults, and whether they extend to CU traits in youths.

Importantly, while both Newman's theory and Dadds' theory reference the idea of attention, they make quite different predictions regarding the effects of psychopathic traits or CU traits on attentional cueing from different types of stimuli. Dadds' theory predicts attention shifting should be reduced only when eyes are cueing the attentional shift. Newman's theory predicts any method of cueing direction, including without eyes (e.g., via arrows pointing left or right) should show equal deficits. Chapter 5 provides the first test of these hypotheses. Chapter 5 also provides evidence that is of some relevance to the idea of an early attention bottleneck.

2.4 Summary and links to the present thesis

CU traits are in many ways analogous with the affective and interpersonal deficits characteristic of psychopathic traits. High CU and psychopathy have in common many behavioral, cognitive and biological correspondents, including a particularly severe and stable pattern of antisocial behavior, deficits in recognizing others' emotional facial expressions, and abnormalities in the amygdala. CU traits have mostly been measured in youths, and have demonstrated a developmental trajectory that corresponds with adulthood psychopathic traits. Thus psychopathic traits are best understood as developmental in origin, with a strong link to CU traits. Despite this, theorizing and empirical research has often investigated youth CU traits (Dadds et al., 2006, 2013, 2008, 2011; Dadds, Allen, et al., 2012) and adulthood psychopathic traits apart (Baskin-Sommers et al., 2011; Newman et al., 2010; Wallace et al., 1999). Other researchers have gone some way to span this gap by testing both adults and youths (e.g., Blair et al., 2004; Blair, Colledge, Murray, & Mitchell, 2001; Stevens, Charman, & Blair, 2001), but they have not tested very young children in which treatment might be most effective. One of the broader aims of this thesis (addressed in Chapter 5) is to contribute to bridging this gap, by testing these theories against one another for the first time. In doing so, this thesis focuses on CU traits in adults, and thus paves the way for future investigations of CU traits in children.

The more specific aim of this thesis regarding psychopathic traits and CU traits (addressed in Chapters 3, 5 and 6) is to contrast the three theoretical accounts – from Blair, Dadds, and Newman – on two core types of predictions.

The first concerns whether facial emotion processing deficits associated with psychopathic traits and/or CU traits are specific to signals of distress, or whether they are also evident for non-distress emotions, the clearest example being happiness. If it were the case that there are impairments for happiness, this would argue against Blair's (1995, 2006) distress-specific account of psychopathy. It would however potentially be consistent with attentional accounts of the affective deficits in psychopathy (Dadds et al., 2006; Wallace et al., 1999). From a clinical perspective, it then would imply problems in reward processing, with potential for an etiological role in the development of the affective features of psychopathy.

The second concerns attentional processing, particularly whether psychopathic traits and/or CU traits are associated with the shifting of attention in response to various types of cues. Blair's (1995, 2006) theory predicts reduced cueing from eye-gaze direction specifically for eyes that are in faces displaying *distress*, but not for, say, eyes that are in faces showing happiness. Dadds' (2006, 2008) theory predicts reduced cueing from eye-gaze direction regardless of the emotional expression of the face, due to *eyes* being unattended in any expression. Newman's theory predicts reduced attentional cueing from *any* stimuli, including non-social stimuli such as arrows (Baskin-Sommers et al., 2011; Newman et al., 2010; Wallace et al., 1999).

Overall, results of several chapters of this thesis will be relevant to the evaluation of current theories of the etiology of psychopathy.

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Chapter 3: Not just fear and sadness: Meta-analytic evidence of pervasive emotion recognition deficits for facial and vocal expressions in psychopathy

3.1 Chapter overview

This chapter investigates for what emotions and modalities there are recognition deficits in psychopathy, by quantitatively evaluating the literature via meta-analysis. Of particular theoretical interest is whether deficits in emotion recognition are limited to fear and sadness, as argued by the distress-specific account of psychopathy (Blair, 1995, 2006), or whether they might be more pervasive and include other emotions – perhaps even the positive emotion of happiness.

3.2 Publication status

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3.3 Author contributions

- **Dawel** proposed the project.
- **Dawel** established the meta-analysis protocol, with advice from Palermo, O'Kearney, and McKone.
- **Dawel** searched and screened the literature.
- **Dawel** coded the data. Reliability of coding was verified by a Research Assistant (Dr Jessica Irons).
- **Dawel** analyzed the data, with advice from O'Kearney.

- **Dawel** produced the figures.

- **Dawel** drafted the manuscript.

- **Dawel** and Palermo together refined the paper, with detailed editing provided by Palermo. O'Kearney and McKone provided general content comments and suggestions, and some editing.

- After reviews were received from *Neuroscience and Biobehavioral Reviews*, all authors contributed to discussion of the reviewers' comments.

- **Dawel** and McKone together refined the paper in response to the reviewer's comments, with detailed editing provided by McKone. Palermo and O'Kearney also contributed to editing.

3.4 Published manuscript: Not just fear and sadness: Meta-analytic evidence of pervasive emotion recognition deficits for facial and vocal expressions in psychopathy

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Review

Not just fear and sadness: Meta-analytic evidence of pervasive emotion recognition deficits for facial and vocal expressions in psychopathy

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ABSTRACT

The present meta-analysis aimed to clarify whether deficits in emotion recognition in psychopathy are restricted to certain emotions and modalities or whether they are more pervasive. We also attempted to assess the influence of other important variables: age, and the affective factor of psychopathy. A systematic search of electronic databases and a subsequent manual search identified 26 studies that included 29 experiments ($N = 1376$) involving six emotion categories (anger, disgust, fear, happiness, sadness, surprise) across three modalities (facial, vocal, postural). Meta-analyses found evidence of pervasive impairments across modalities (facial and vocal) with significant deficits evident for several emotions (i.e., not only fear and sadness) in both adults and children/adolescents. These results are consistent with recent theorizing that the amygdala, which is believed to be dysfunctional in psychopathy, has a broad role in emotion processing. We discuss limitations of the available data that restrict the ability of meta-analysis to consider the influence of age and separate the sub-factors of psychopathy, highlighting important directions for future research.

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1. Introduction

Psychopathy is a severe and chronic personality disorder, characterized by poor empathy, with a prevalence of approximately 1% of the general population (Hare, 2003). Psychopathic traits are associated with increased criminality within antisocial populations (Leistico et al., 2008), and increased rates of violent behaviour, suicide attempts and homelessness within the general population (Coid et al., 2009). Thus psychopathy has considerable social and economic costs for the individual and society. Unfortunately, however, there is limited evidence of effective treatment of psychopathy (Salekin et al., 2010). Improving our understanding of the aetiology of this disorder is vital for developing more effective treatments.

Developmental models of psychopathy implicate abnormal cognitive and neurological functioning in the affective impairments associated with this disorder (e.g., Frick and White, 2008). Psychopathy has, for example, been linked with deficits in recognizing emotions from nonverbal cues, including facial (e.g., Blair et al., 2001a, 2004) and vocal cues (e.g., Stevens et al., 2001; Blair et al., 2002). Yet the literature is currently unclear as to whether deficits are specific to some emotions and whether they are pervasive across modalities. This has important theoretical implications, as at least one prominent theory (Blair, 1995, 2006) argues that a *specific* deficit in recognizing others' distress (expressions of fear and sadness) contributes to the development of psychopathy. The main purpose of this review therefore was to quantitatively evaluate impairments in emotion recognition in psychopathy.

1.1. Factor structure of psychopathy

A complicating issue relevant to this review is that psychopathy is generally accepted to be comprised of two main factors, which in all likelihood have different aetiologies (e.g., Harpur et al., 1989). The first factor is characterized by impaired affective and interpersonal functioning (e.g., poor empathy, lack of guilt and remorse, callousness), whilst the second factor consists of antisocial behaviour. It is the first, affective factor that uniquely distinguishes psychopathy from other antisocial behaviour. The affective factor has been measured as a component of psychopathy scales in adults (e.g., PCL-R; Hare, 2003) and children/adolescents (e.g., APSD; Frick and Hare, 2001), and in isolation as callous unemotional (CU) traits (e.g., ICU; Essau et al., 2006), which is arguably the key component of the affective psychopathy factor (e.g., Frick and White, 2008; although others argue impulsivity is also critical to psychopathy e.g., Hart and Dempster, 1997).

Two previous meta-analyses of emotion recognition in psychopathy (Marsh and Blair, 2008; Wilson et al., 2011) have considered both dimensions of psychopathy together. Given the likely differences in aetiology, however, it is possible the two factors may be associated with different impairments in emotion recognition. Thus in the current meta-analysis we attempted to separate out the affective factor of psychopathy and investigate its relationship to emotion recognition.

1.2. Psychopathic traits in children

Around half of the studies investigating emotion recognition deficits associated with psychopathic traits have used child/adolescent samples. In older children/adolescents, measures of adult psychopathy that are adapted for use with children are frequently used (Lynam and Gudonis, 2005). Alternatively, CU traits have been measured as a proxy for the affective factor of psychopathy from as early as 3 years of age (Hawes et al., 2011). CU traits have a strong genetic basis (e.g., Viding et al., 2005), uniquely predict a more severe and long-lasting pattern of antisocial behaviour (Essau et al., 2006; Frick et al., 2005), and longitudinal studies show that higher levels of CU traits are associated with later psychopathy in adulthood (e.g., Burke et al., 2007).

There are likely to be important differences in psychopathic traits between adults and children, which mean that considering both populations together may not be appropriate. One example is that psychopathic adults are likely to have engaged in more severe antisocial behaviour, including substance abuse, which may impact on neurobehavioural functioning. Some evidence already indicates that behavioural (e.g., Weber et al., 2008) and physiological (e.g., Blair, 1999) response abnormalities differ between adults and children with psychopathic traits. However, the question of whether there are age-related differences in emotion recognition deficits has not been explored by the previous meta-analyses (Marsh and Blair, 2008; Wilson et al., 2011). Here we examined children and adolescents separately to adults.

1.3. Neurological basis of emotion recognition deficits

The neurological basis for the observed problems with emotion recognition in psychopathy is frequently argued to be amygdala dysfunction (e.g., Blair, 2003). There is strong evidence the amygdala is involved in emotional processing (Phelps and LeDoux, 2005), and that psychopathic traits are associated with abnormal amygdala function (e.g., Blair, 2010) and structure (e.g., Weber et al., 2008) in both adults and children (for a review see DeLisi et al., 2009). Also, there is growing evidence the long allele of the serotonin transporter gene, which is a key neurotransmitter involved in amygdala functioning, is a genetic risk factor for psychopathy (e.g., Glenn, 2011).

1.4. Theoretical implications of emotion recognition deficits

There are two prominent theories of psychopathy that implicate amygdala dysfunction (see discussion for more detail), but which differ markedly on the underlying role of emotion recognition deficits. Arguably the most influential theorist, Blair (1995, 2006) proposes that *specific* deficits in fear and sadness recognition contribute to the development of psychopathy. More recently though, other researchers (e.g., Dadds et al., 2011b) have conjectured that psychopathy is associated with abnormal attention to socially relevant cues (i.e., the eyes), and that dysfunction in attentional mechanisms underlies emotion recognition deficits (Dadds et al., 2006, 2008), rather than a specific deficit for fear or sadness per se. Determining whether emotion recognition deficits are specific to certain emotions and modalities or pervasive will help distinguish between these two theories.

How might specific versus pervasive deficits contribute to the development of psychopathy? The core idea of Blair's theorizing (Blair, 1995, 2006) is that people typically find others' fear and sadness to be inherently aversive, so that when an antisocial action results in an expression of fear or sadness the action itself becomes aversive (and is inhibited) via classical conditioning. It follows that if an individual has a specific deficit in recognizing fear and sadness there is no aversion, allowing them to behave in a self-gratifying manner without the negative consequence of 'feeling bad'. This explanation is highly consistent with the cold and unremorseful behaviour associated with psychopathy.

If, however, deficits in processing emotion cues are more pervasive, which would be consistent with the idea that poor attention to the eyes would impair processing of emotions other than just fear, then they are likely to contribute to more widespread difficulties in empathic and emotional behaviour. Misreading emotion cues, for example, is likely to make it more difficult to understand the subtleties of others' perspectives, which is a key component of empathy. This would mean that, although recognizing others' distress cues may be important (Blair, 1995, 2006), additional, perhaps more subtle deficits in socio-emotional functioning are being overlooked.

1.5. Emotion recognition deficits: facial expressions

Most research investigating emotion recognition impairments associated with psychopathic traits has focused on facial expressions, particularly that of so called 'basic' or universal expressions (anger, fear, disgust, surprise happiness and sadness; Ekman, 1992). A previous meta-analysis of papers published until 2006 (Marsh and Blair, 2008) found that antisocial behaviour, of which psychopathy is one type, but which also included aggressive, criminal, delinquent or externalizing individuals, was associated with *specific* deficits in recognizing fear and, to a lesser extent, sadness from facial expressions (i.e., only for those expressions). Expression recognition deficits were not moderated by whether the sample was psychopathic (10 of the 20 studies) or not.

Since this initial meta-analysis, some studies have replicated the findings of impaired recognition in psychopathy of fear (Fairchild et al., 2009) and/or sadness (Eisenbarth et al., 2008; Hastings et al., 2008; Woodworth and Waschbusch, 2008; Fairchild et al., 2009, 2010) from facial expressions. Others have also found deficits in recognizing fear when measuring CU traits (Dadds et al., 2008; Leist and Dadds, 2009; Muñoz, 2009). There are, however, also numerous studies that have not found deficits for recognizing these emotions. Nine studies did not find that psychopathic traits were associated with deficits in recognizing facial expressions of fear (Glass and Newman, 2006; Book et al., 2007; Eisenbarth et al., 2008; Hansen et al., 2008; Hastings et al., 2008; Fairchild et al., 2010) and/or sadness (Del Gaizo and Falkenbach, 2008; Glass and Newman, 2006; Hansen et al., 2008; [in relation to CU traits] Leist and Dadds, 2009; [in relation to CU traits] Muñoz, 2009). Moreover, Del Gaizo and Falkenbach (2008) found psychopathy was associated with *better* recognition of fear, and a trend in this direction was observed by Woodworth and Waschbusch (2008). Also, some of the studies found evidence psychopathic traits are associated with deficits in recognizing other emotions as well (disgust; Hansen et al., 2008; anger [in relation to CU traits]; Muñoz, 2009; happiness; Hastings et al., 2008; surprise; Fairchild et al., 2009), bringing into question whether deficits really are specific to fear and sadness.

These mixed findings raise the possibility that the deficits in facial expression recognition associated with psychopathic traits may be more pervasive than previously believed. A more recent meta-analysis of facial expression recognition by Wilson et al. (2011; 23 independent effect sizes) that includes papers (and unpublished theses) until 2009, found that psychopathy was significantly associated with deficits for multiple emotions, although these effects were numerically small (N-weighted r = .06–.12) and trended towards being largest for fear and sadness. The significant deficits suggest that impairments are more pervasive than those evidenced by Marsh and Blairs' (2008) meta-analysis. There are, however, some methodological differences that might also explain the finding of more pervasive deficits. Specifically, Wilson et al. (2011) used a fixed-effects model for meta-analysis and an alpha level of .10. Fixed-effects models are problematic because they make assumptions that are often not met in social science data and can result in elevated Type I error rates (Field and Gillett, 2010). Coupled with the higher alpha threshold used, there is an increased likelihood of Type I errors in Wilson et al.'s (2011) meta-analyses. Also, important methodological information was not reported, including how control samples were selected and estimates of publication bias.

1.6. Emotion recognition deficits: other modalities

Both previous meta-analyses (Marsh and Blair, 2008; Wilson et al., 2011) have focused solely on facial expression recognition. Yet several studies have now investigated recognition of emotion from nonverbal vocal cues (i.e., sentences with non-affective semantic content [e.g., "I am a carpenter"] spoken with emotional prosody or tone; e.g., Stevens et al., 2001; Blair et al., 2002, 2005) and at least one study has investigated recognition of emotions from body posture (e.g., slouching to indicate sadness; Muñoz, 2009). It is commonly cited in the literature that, consistent with Blair's (1995, 2006) theory, psychopathy is associated with a specific deficit in recognizing fear from vocal cues, but this is based on the individual findings of a small number of studies. The advantages of meta-analysis include increased statistical power and more reliable estimates of effect size (Lipsey and Wilson, 2001). Thus meta-analysis can better reveal those findings upon which studies agree and divest findings that are spurious.

1.7. The current meta-analysis

The main aim of the present meta-analysis was to quantitatively evaluate emotion recognition deficits in psychopathy across emotions and modalities. The reason for this is that the literature is currently unclear as to whether deficits are pervasive or specific to some emotions and modalities, which has important implications for our theoretical and aetiological understanding of psychopathy. A second aim was to attempt to distinguish whether results differed for the critical, affective factor of psychopathy or by age group, and to comment on the extent to which available studies allow meta-analysis to evaluate the influence of these two potentially important variables.

2. Methods

2.1. Inclusion and exclusion criteria

This review aimed to include all published English-language studies that investigated the association between psychopathic traits and recognition of nonverbal emotion cues (facial, vocal, postural), where data were available for one or more individual emotions. Both between groups and correlational designs were included.

Specific inclusion criteria for studies in this meta-analysis were:

1. Studies must include a validated measure of psychopathy or CU traits.
2. Samples may be forensic, clinical, or community, or any combination thereof. Forensic samples are defined as populations selected primarily on the basis that they have been charged with or convicted of criminal offences. Clinical samples are defined as populations selected primarily on the basis of diagnosable mental disorder. Community samples are those populations that do not meet the criteria for forensic or clinical samples.
3. Studies that used a dichotomous measure of psychopathic traits must include a control group. The control group may be a community or matched forensic or clinical sample. Where multiple groups were included, the best-matched group was used in analyses (e.g., for studies that compared a psychopathic forensic sample with both non-psychopathic forensic and community samples, the non-psychopathic forensic sample was used for comparison).
4. Studies must include a recognition measure (i.e., label the emotion expressed) of nonverbal cues (facial expression, vocal prosody/tone, body posture) for one or more 'basic' emotions (anger, disgust, fear, happiness, sadness, surprise; Ekman, 1992). These emotions were chosen for consistency with past reviews and because few studies have investigated other emotions. Nonverbal vocal cues are defined as those for which emotion is conveyed solely by prosody or tone (i.e., any semantic content was non-affective).
5. Stimuli must be normed or validated appropriately.
6. Data for individual expressions must be available.
7. Studies were excluded if they explicitly included participants with known cognitive impairments that are likely to influence recognition of nonverbal cues, including brain injuries, pervasive developmental disorders (e.g., autism), psychotic disorders (e.g., schizophrenia), current substance abuse, or evidence of below normal intelligence ($-2SD$).
8. Articles must be full-text published peer-reviewed journal articles that are available in English. Only peer-reviewed articles were included to ensure a minimum threshold for quality. Non-English studies were excluded because we did not have the language capacity to extract data.

2.2. Search strategy

The search strategy and number of titles retained at each level is outlined in Fig. 1. First, all years of PsycINFO, PubMed and ISI Web of Science were searched on 10 November 2010 by combining all terms from a list of nonverbal emotion terms (affect, body, cues, distress, emotion*, expression*, face perception, face recognition, facial*, fear, fearful, gesture, nonverbal*, posture, sad, sadness, tone, vocal, voice) with a list of psychopathy terms (aggression, aggressive, amygdala, antisocial*, callous, Conduct Disorder, criminal*, delinquen*, empathy, Oppositional Defiant Disorder, psychopath, psychopathic, psychopathy, sympathy, trait, traits, unemotional, violence, violent).

Titles, abstracts, and full-text articles were then screened progressively by the first author and excluded at each level if they violated inclusion criteria. The reason for exclusion was recorded for full-text articles. The reference lists of retained full-text articles were also hand-searched for additional studies. If articles met other inclusion criteria but sufficient data were not available, data were requested from the authors (at least two attempts were made in each instance).

2.3. Data extraction and management

Data were extracted by the first author and a second coder independently, and coded using a standardized format in SPSS. Effect sizes were calculated in Excel independently by both coders, and then entered in SPSS. Excel was also used to calculate other data required by the standardized form when necessary. For example, the standardized form required age data for the total sample, so if demographics were reported by subgroups, means and standard deviations for the total sample were calculated in Excel as the n-weighted average. For studies that reported results for multiple measures of nonverbal cue recognition in the same domain (i.e., multiple facial, vocal, or postural) for the same sample, average recognition across measures was calculated. To illustrate, Eisenbarth et al. (2008) reported results for two presentation durations (multiple measures) for facial expression recognition (same domain), so results were averaged across presentation durations. Following data extraction and coding, the two SPSS files (one per coder) were cross-checked by the first author, and any discrepancies between the files were investigated and resolved.

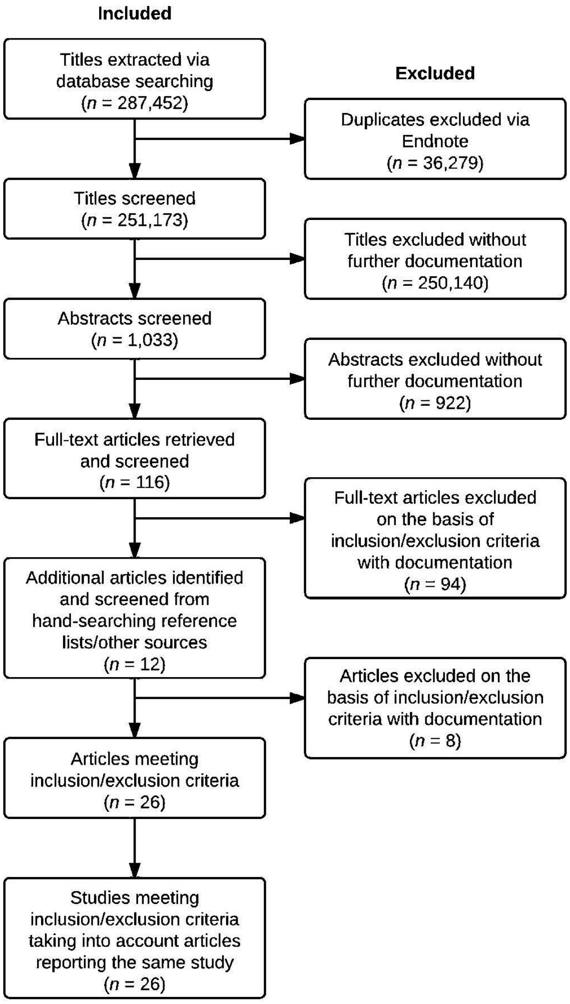

Fig. 1. Flow chart of search strategy indicating number of titles retained at each stage of the search process.

2.4. *Data analysis*

2.4.1. *Effect sizes*

For studies ($k = 19$) that provided means and standard deviations for accuracy or errors for two groups, effect size was calculated as *r* for independent samples with equal variance and unequal sample size. For correlational design studies ($k = 6$), *r* was used as reported, which was typically raw correlations between psychopathy and emotion recognition except for Dadds et al. (2006) and Muñoz (2009), who reported partial correlations controlling for violent and antisocial behaviour. *r* was the most appropriate effect size because it is flexible (can be used for both dichotomous and continuous variables, both of which were reported by different studies) and gives a readily-interpretable measure of the strength of the relationship between two variables. In the context of each study, *r* represents the strength of the relationship between emotion recognition accuracy and (1) group membership (between-groups studies) or (2) level of psychopathic/CU traits (correlational studies).

2.4.2. *General procedure for meta-analyses*

Meta-analyses were performed using Field and Gilletts' (2010) syntax Meta_Basic_r.sps. Results reported here are from Hedges and Veveas' (1998) random-effects models. The I^2 heterogeneity index was calculated as described by Higgins et al. (2003), who define low heterogeneity as less than 25%.

2.4.3. *Meta-analysis of emotions*

Meta-analysis using *r* as the effect size (calculated for each emotion for each study) was conducted using (1) the mean *r* for all emotions for each study, (2) the mean *r* for all emotions excluding fear and sadness for each study, and (3) separately for each emotion (anger, disgust, fear, happiness, sadness, surprise), for each nonverbal cue type (facial, vocal) for which there were sufficient studies. To illustrate, if *r* could be calculated for anger, fear, happiness and sadness for a given study, then for (1) the mean *r* was calculated by averaging the individual *r*s for anger, fear, happiness and sadness and for (2) the mean *r* was calculated by averaging the individual *r*s for anger and happiness.

2.4.4. *Meta-analysis of effect size differences*

Because previous studies have found greater deficits for fear and sadness than other emotions, we also used meta-analysis to test whether there were significant differences in the effect sizes for (1) fear versus other emotions, (2) sadness versus other emotions, and (3) fear and sadness versus other emotions. To do this, we calculated for each study the absolute difference in effect sizes by subtracting the mean *r* for other emotions from (1) *r* for fear, (2) *r* for sadness, and (3) mean *r* for fear and sadness. The mean *r* for other emotions was calculated separately for each analysis, depending on what the 'other' emotions were (i.e., for fear versus other emotions, the mean *r* for other emotions was calculated as the mean *r* for all other emotions tested by each study except fear).

2.4.5. *Moderator analysis*

Moderator analyses were conducted using Field and Gilletts' (2010) syntax launch_meta_mod_r.sps and Meta_Mod_r.sps to investigate whether effect size for facial cues (but not vocal or postural cues because of small *k*) for individual emotions was moderated by task difficulty (continuous; *M* accuracy for control group; between-groups studies only). These analyses were performed because it has been debated as to whether findings of specific deficits in fear recognition may simply reflect that this is the most difficult emotion to recognize (e.g., Blair et al., 2001b; see Marsh and Blair, 2008 for further discussion).

2.4.6. *Publication bias*

Publication bias was investigated using Begg and Mazumdars' (1994) rank correlation, which is a statistical analogue of funnel plots, and Rosenthal's fail-safe *N* (Rosenthal, 1979) in SPSS (syntax: Meta_Basic_r.sps; Field and Gillett, 2010). Additionally, funnel plots and Vevea and Woods' (2005) sensitivity analysis were produced using R (syntax: pub_bias_r.R; Field and Gillett, 2010).

2.4.7. *Alpha level*

An alpha level of .05 was set for statistical significance for all analyses.

3. Results

3.1. *Description of studies*

3.1.1. *Included studies*

Twenty-six studies involving 29 experiments met the inclusion criteria for this review (facial = 22 experiments; vocal = 6 experiments; postural = 1 experiment). Two studies tested both facial and

Table 2
Sample characteristics for correlational studies for facial and postural cues.

Authors	Year	Total *N*	*M* age	Age range	% Male	Sample	Psychopathy measure	% Caucasian	Location
Facial cues									
Adult studies									
Book et al.	2007	59	32.1	19–58	100	Forensic	PCL-R	100	Canada
Hansen et al.[a]	2008	43	31.58	18–53	100	Forensic	PCL-R	100	Norway
Hastings et al.	2008	145	30.94	18–60	100	Forensic	PCL:SV	32	USA
Del Gaizo and Falkenbach	2008	175	19.74	17–45	32	Community	PPI	26	USA
Child/adolescent studies									
Dadds et al.	2006	33	12.07	8–15	100	Community	APSD and SDQ combined	NR	Australia
Munoz	2009	55	11.8	8–16	100	Community	ICU	NR	UK
Postural cues									
Child/adolescent studies									
Munoz	2009	55	11.8	8–16	100	Community	ICU	NR	UK

Note. NR = not reported. PCL-R = Psychopathy Checklist Revised (Hare, 2003). PCL:SV = Psychopathy Checklist Screening Version (Hart et al., 1995). PPI = Psychopathic Personality Inventory (Lilienfeld, 1990). APSD = Antisocial Process Screening Device (Frick and Hare, 2001); formerly known as the Psychopathy Screening Device (PSD; Murrie and Cornell, 2002). SDQ = Strengths and Difficulties Questionnaire (Goodman, 1997). ICU = Inventory of Callous Unemotional Traits (Essau et al., 2006).

[a] Additional data for this study was provided by the authors.

vocal cue recognition (Stevens et al., 2001; Suchy et al., 2009) and one study tested both facial and postural cue recognition (Muñoz, 2009). All studies were published between 2000 and 2010 (no earlier studies were identified).

3.1.2. Population characteristics

Population characteristics for between-groups studies are reported in Table 1 and for correlational studies in Table 2. Total sample size ranged from 10 to 175 (*Mdn N* = 44). Sixteen experiments tested adult samples (facial cues = 12; vocal cues = 4) and 13 experiments tested child or adolescent samples (facial cues = 10; vocal cues = 2; postural cues = 1). Adult samples ranged from 17 to 60 years (*M* = 33.02, *SD* = 7.22) and child/adolescent samples from 8 to 18 years (*M* = 13.07, *SD* = 2.06). Four studies of facial cue recognition used mixed sex samples and two used female-only samples. All other studies used male-only samples. All but two studies of adults used forensic samples. Studies of children and adolescents used a mix of clinical and community samples. Two of the child samples classified as ‘community’ (because no formal clinical diagnoses were reported) were not from the general population. Blair et al. (2001a) sampled from “schools for boys with emotional and behavioural difficulties” (p. 493), and Muñoz (2009) sampled from a holiday program in what was described as a ‘highly deprived’ area. All studies included control samples that were from the same source population (i.e., if the psychopathy group was forensic or clinical the control group was also forensic or clinical respectively) except for Leist and Dadds (2009) who used a clinical psychopathy group and a community control group. Thus all other studies matched samples for *presence* of criminal behaviour or clinical diagnosis. This does not however necessarily mean that samples were matched for *level* of criminal behaviour or clinical severity. The seven studies that reported means for the affective and antisocial factors of psychopathy reported that the psychopathic group scored higher on both factors, suggesting that higher levels of affective psychopathic traits were confounded with increased antisocial behaviour.

3.1.3. Measurement of psychopathy

In total, eight different measures of psychopathic traits were used. The most common measure for adults was the Psychopathy Checklist Revised (PCL-R; Hare, 2003), which was used in 10 of 15 adult studies. The most common measure for children/adolescents was the Antisocial Process Screening Device (APSD; Frick and Hare, 2001; formerly known as the Psychopathy Screening Device or PSD; Murrie and Cornell, 2002), which was used either alone or in combination with the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) in 8 of 11 child studies. See Tables 1 and 2 for other measures used.

3.1.4. Measurement of the affective factor of psychopathy

Fourteen experiments from 13 studies (noted in Table 3) reported results for the affective factor of a psychopathy measure (facial = 6; vocal = 2) or for CU traits alone (facial = 5; postural = 1). The affective factor was measured using factor 1 of the PCL-R (Hare, 2003; three studies), factor 1 of the PCL:SV (Hart et al., 1995; two studies), the CU subscale of the APSD (Frick and Hare, 2001; three studies), combined items from the APSD & SDQ (Dadds et al., 2005; three studies), and factor 1 of the PPI (Lilienfeld, 1990; one study). Only six of these studies also reported results for the antisocial factor.

3.1.5. Stimuli and task variables

Stimuli and task variables are reported in Table 3. Studies reported results for one to all six emotions included in this review. Eight studies also tested recognition for neutral facial expressions (Kosson et al., 2002; Montagne et al., 2005; Dadds et al., 2006, 2008; Eisenbarth et al., 2008; Hansen et al., 2008; Bagley et al., 2009; Leist and Dadds, 2009), one tested recognition for shame (facial; Hastings et al., 2008) and another for interest (vocal; Suchy et al., 2009). Eight face and four vocal stimuli sets were used. Stimulus duration for faces ranged from 100 ms to unlimited, although only one study showed images for less than 1 s. Stimulus duration was unlimited for the single postural study and was not reported for any of the six vocal studies. Of the six vocal studies, emotion was conveyed by ‘tone’ in four studies, and by ‘prosody’ in two studies. Twenty-six experiments reported using a forced-choice response format where participants selected the label that best reflected the emotion, while three experiments that also required participants to label emotions did not report response format.

3.2. Meta-analysis of emotions for total psychopathy

3.2.1. Facial cue deficits in total psychopathy

This section deals with all studies that tested facial expression recognition and included a measure of psychopathic traits (psychopathy or CU measure). The results of meta-analyses are shown in Table 4. Forest plots for individual emotions showing effect sizes for each study weighted by *N* are shown in Fig. 2.

Table 1
Sample characteristics for between-groups studies for facial and vocal cues.

Authors	Year	Total *N*	*M* age	Age range	% Male	Sample	Psychopathy measure	Psychopathy group	Psychopathy group *n*	Control group	Control group *n*	% Caucasian	Location
Facial cues													
Adult studies													
Blair and Cipolotti	2000	10	48.5	NR	100	Forensic	PCL-R	PCL-R ≥30	5	PCL-R ≤20	5	NR	UK
Kosson et al.	2002	67	27	NR–44	100	Forensic	PCL-R	PCLR ≥30	34	PCLR ≤20	33	NR	USA
Blair et al.	2004	38	32.11	22–50	100	Forensic	PCL-R	PCL-R ≥30	19	PCL-R <20	19	95	UK
Montagne et al.	2005	32	NR	19–25	53	Community	BIS/BAS	Low BIS/high BAS	16	High BIS/low BAS	16	NR	Netherlands
Dolan and Fullam	2006	49	35.18	NR	100	Forensic	PCL:SV	PCL:SV ≥17	22	PCL:SV <17	27	NR	UK
Glass and Newman	2006	111	32.27	NR–45	100	Forensic	PCL-R	PCL-R ≥30	50	PCL-R ≤20	61	100	USA
Eisenbarth et al.	2008	28	40.32	NR	0	Forensic	PCL-R	PCL-R ≥30	13	PCL-R <30	15	NR	Italy
Suchy et al.[a]	2009	41	32.37	NR	100	Forensic	PPI	Non-pedophilic child molesters	23	Pedophilic child molesters	18	90.24	USA
Child/adolescent studies													
Blair and Coles	2000	21	12.4	11–14	71	Community	APSD	Highest APSD	11	Lowest APSD	10	58	UK
Blair et al.	2001	51	12.88	9–17	100	Community	APSD	APSD >28	20	APSD <20	31	NR	UK
Stevens et al.	2001	18	11.5	9–15	100	Clinical	APSD	APSD >25	9	APSD <20	9	NR	UK
Woodworth and Waschbusch	2007	56	9.81	7–13	81	Clinical	APSD	APSD-CU t-score ≥67	24	APSD-CU t-score ≤63	32	84	Canada
Dadds et al.	2008	50	12.4	8–15	100	Community	APSD and SDQ combined	CU >75th percentile	25	CU <25th percentile	25	NR	Australia
Leist and Dadds	2009	45	16.61	16–18	74	Clinical	APSD and SDQ combined	Clinical	23	General population	22	61	Australia
Fairchild et al.[a]	2009	77	15.66	14–18	100	Clinical	YPI	YPI ≥2.5	31	YPI <2.5	46	90	UK
Fairchild et al.[a]	2010	25	15.6	14-18	0	Clinical	YPI	YPI ≥2.5	11	YPI <2.5	14	92	UK
Vocal cues													
Adult studies													
Blair et al.	2002	39	32.92	21–52	100	Forensic	PCL-R	PCL-R ≥30	19	PCL-R <20	20	82	UK
Mitchell et al.	2006	10	42.5	37–53	100	Forensic	PCL-R	Psychopathic inmates	5	PCL-R ≤20	5	NR	USA
Suchy et al.[a]	2009	41	32.37	NR	100	Forensic	PPI	Non-pedophilic child molesters	23	Pedophilic child molesters	18	90.24	USA
Bagley et al.	2009	68	24.7	18–45	100	Forensic	PCL-R	PCL-R ≥30	34	PCLR ≤20	34	44	USA
Child/adolescent studies													
Stevens et al.	2001	18	11.5	9–15	100	Clinical	APSD	APSD >25	9	APSD <20	9	NR	UK
Blair et al.	2005	43	13.01	11–15	100	Community	APSD	APSD ≥25	22	APSD ≤15	21	98	UK

Note. NR = not reported. PCL-R = Psychopathy Checklist Revised (Hare, 2003). BIS/BAS = Behavioural Inhibition System/Behavioural Activation System (Carver and White, 1994). APSD = Antisocial Process Screening Device (Frick and Hare, 2001); formerly known as the Psychopathy Screening Device (PSD; Murrie and Cornell, 2002). APSD-CU = callous unemotional subscale of the APSD. SDQ = Strengths and Difficulties Questionnaire (Goodman, 1997). YPI = Youth Psychopathic Inventory (Andershed et al., 2002). PPI = Psychopathic Personality Inventory (Lilienfeld, 1990).

[a] Additional data for these studies was provided by the authors.

Table 3
Stimuli and task variables for all studies.

Study	Stimuli	Exposure duration	Response format	Number of trials					
				AN	DI	FE	HA	SA	SU
Facial cues (between-groups design)									
Adult studies									
Blair and Cipolotti (2000)	Emotion hexagon	3 s	AFC key/BB	20	20	20	20[c]	20	20
Kosson et al. (2002)	PFA	1 s	AFC key/BB	5	5	5	5[c]	5	5
Blair et al. (2004)[a]	PFA	69 s	AFC verbal	3	3	3	3[c]	3	3
Montagne et al. (2005)	PFA	Unlimited	AFC key/BB	16	16	16	16[c]	16	16
Dolan and Fullam (2006)[a]	PFA	Unlimited	AFC key/BB	16	16	16	16	16	16
Glass and Newman (2006)	MacBrain NimStim	2.75 s	AFC key/BB	40	–	40	40	40	–
Eisenbarth et al. (2008)	KDEF	Unlimited	AFC key/BB	12	12	12	12	12	12
Suchy et al. (2009)	PFA	1.5 s	AFC key/BB	NR	NR	NR	NR[c]	NR	NR
Child/adolescent studies									
Blair and Coles (2000)[a]	Emotion hexagon	3 s	AFC key/BB	20	20	20	20	20	20
Blair et al. (2001b)	PFA	69 s	AFC verbal	3	3	3	3[c]	3	3
Stevens et al. (2001)	DANVA	2 s	AFC unspecified	12	–	12	12	12	–
Woodworth and Waschbusch (2008)[a]	PFA	NR	NR	3[b]	3[b]	3[b]	3[b,c]	3[b,c]	3[b]
Dadds et al. (2008)[a]	UNSW FACES	2 s	AFC written	6[b]	6[b]	6	6[b]	6[b]	–
Leist and Dadds (2009)[a]	UNSW FACES	2 s	AFC written	6[c]	6	6	6[c]	6	–
Fairchild et al. (2009)	Emotion hexagon	5 s	AFC key/BB	20	20	20	20[c]	20	20
Fairchild et al. (2010)	Emotion hexagon	5 s	AFC key/BB	20	20	20	20[c]	20[c]	20
Facial cues (correlational design)									
Adult studies									
Book et al. (2007)[a]	JACFEE	0.1 s	AFC unspecified	4[b]	4[b]	4	4[b]	4[b]	–
Hansen et al. (2008)	PFA	Unlimited	AFC key/BB	16	16	16	16	16	16
Hastings et al. (2008)[a]	JACFEE	Unlimited	AFC key/BB	12	–	12	12	12	–
Del Gaizo and Falkenbach (2008)[a]	DANVA-2-AF	2 s	AFC unspecified	6	–	6	6	6	–
Child/adolescent studies									
Dadds et al. (2006)[a]	UNSW FACES	2 s	AFC written	4	4	4	4	4	–
Muñoz (2009)[a]	Based on Ekman criteria; validated	Unlimited	AFC unspecified	4	4	4	4[c]	4	4
Vocal cues (between-groups design)									
Adult studies									
Blair et al. (2002)	Scott et al. (1997)	NR	AFC unspecified	12	12	12	12	12	–
Mitchell et al. (2006)	Scott et al. (1997)	NR	NR	12	12	12	12	12	–
Suchy et al. (2009)	NYEB	NR	NR	3	3	3	3	3	3
Bagley et al. (2009)[a]	Not specified	NR	AFC unspecified	6	–	–	6	6	6
Child/adolescent studies									
Stevens et al. (2001)	DANVA	NR	AFC key/BB	12	–	12	12	12	–
Blair et al. (2005)[a]	Scott et al. (1997)	NR	AFC unspecified	12	12	12	12	12	–
Postural cues (correlational design)									
Child/adolescent studies									
Muñoz (2009)[a]	Atkinson et al. (2007)	Unlimited	AFC written	4	–	4	4	4	2

Note. NR = not reported. AN = anger. DI = disgust. FE = fear. HA = happy. SA = sad. SU = surprise. AFC = alternative forced choice. key/BB = keyboard/button box. Emotion hexagon (Calder et al., 1996). PFA = Pictures of Facial Affect (Ekman and Friesen, 1975). MacBrain NimStim (Tottenham et al., 2009). KDEF = Karolinska Directed Emotional Faces (Lundqvist et al., 1998). DANVA = Diagnostic Analysis of Nonverbal Accuracy (Nowicki and Duke, 1994). JACFEE = Japanese and Caucasian Facial Expressions of Emotion (Matsumoto and Ekman, 1988). DANVA-2-AF = DANVA version 2 adult faces subtest (Nowicki and Carton, 1993). UNSW FACES (Dadds et al., 2004). NYEB = New York Emotion Battery (Borod et al., 1992).

[a] Studies provided data for the affective factor of psychopathy.
[b] Individual data necessary for calculating effect sizes were not available.
[c] Accuracy was at ceiling (i.e., >95%) for the control group (between-groups studies) or the total sample (correlational studies).

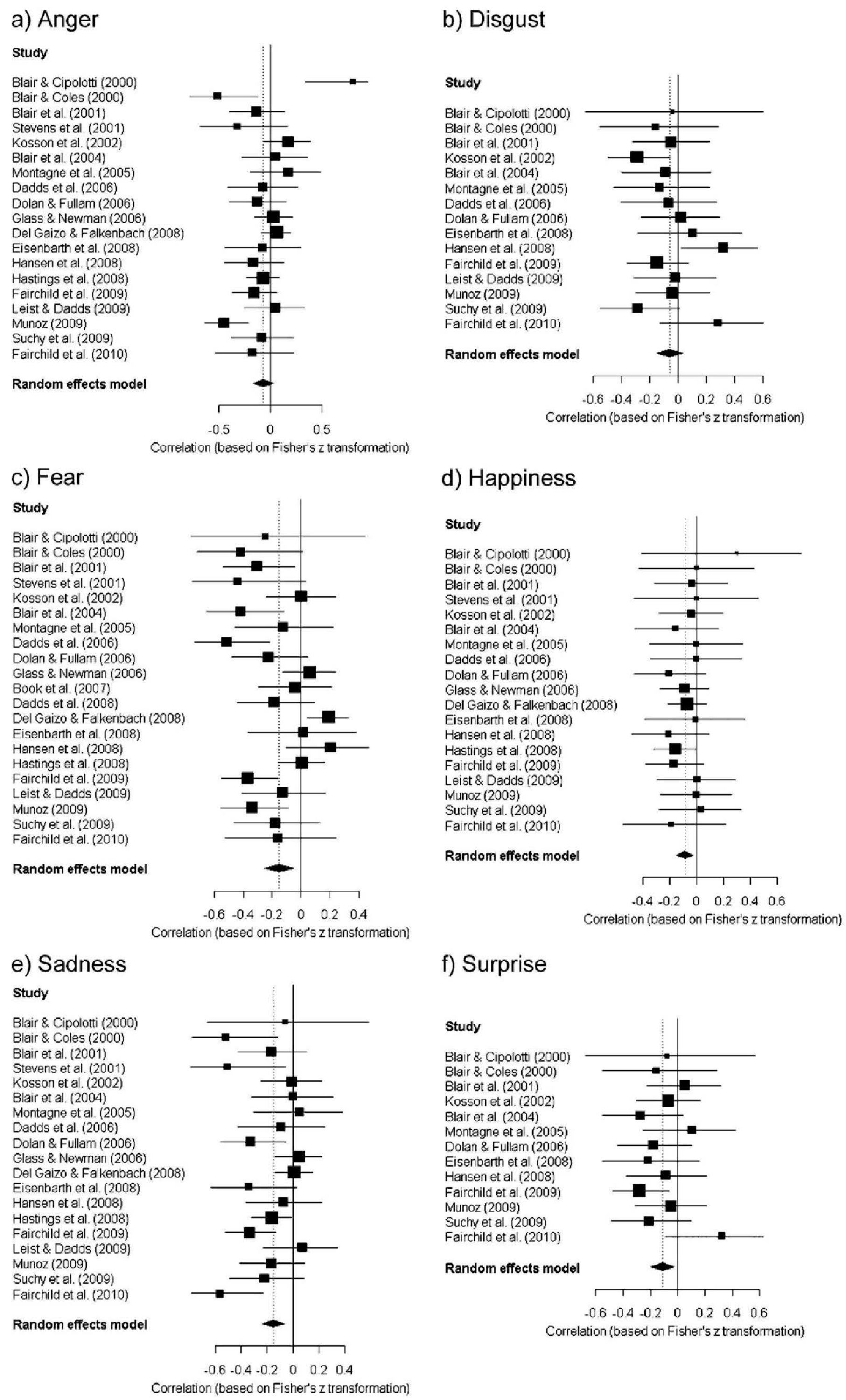

Fig. 2. Forest plots of study and random-effects model (weighted) mean effect sizes (correlations based on Fisher's z transformation) for facial cues for the six emotions. Vertical dotted lines indicate the mean effect size for random-effects models, indicating that psychopathic traits were associated with poorer recognition for all emotions. Error bars and width of diamonds indicate 95% confidence intervals.

Table 4
Random-effects models for facial and vocal cues by emotion for total psychopathy[a].

	Hedges–Vevea random-effects model						Homogeneity test (Q-statistic)			I^2	Rosenthal fail-safe *N*
Emotion	Mean *r*	Lower *r*	Upper *r*	*z*	*p*	*k*	χ^2	*df*	*p*		
Facial cues											
Mean all emotions	−.084	−.142	−.025	2.808	**.005****	21	12.091	20	.913	0%	53
Mean excluding FEA and SAD	−.077	−.138	−.016	2.455	**.014***	19	7.572	18	.984	0%	17
FEA minus other[b]	−.071	−.063	.022	1.492	.136	19	15.881	18	.601	0%	–
SAD minus other[c]	−.004	−.084	.077	.095	.925	19	19.944	18	.336	10%	–
FEA and SAD minus other[d]	−.045	−.111	.020	1.355	.176	19	17.618	18	.481	0%	–
Anger	−.068	−.161	.026	1.420	.156	19	22.267	18	.220	19%	–
Disgust	−.059	−.149	.032	1.274	.203	15	13.764	14	.467	0%	–
Fear	−.153	−.251	−.052	2.968	**.003****	21	17.244	20	.637	0%	**133**[e]
Happy	−.087	−.147	−.025	2.753	**.006****	19	6.641	18	.993	0%	15
Sad	−.153	−.237	−.066	3.449	**.001****	19	18.757	19	.407	0%	**137**[e]
Surprise	−.110	−.196	−.023	2.464	**.014***	13	11.569	12	.481	0%	9
Vocal cues											
Mean all emotions	−.141	−.273	−.004	2.014	**.044***	6	2.134	5	.830	0%	4
Mean excluding FEA and SAD	−.130	−.263	.007	1.854	.064	6	1.411	5	.923	0%	–
FEA minus other[b]	−.160	−.414	.118	1.129	.259	5	5.119	4	.275	22%	–
SAD minus other[c]	.074	−.157	.297	.624	.533	6	5.719	5	.334	13%	–
FEA and SAD minus other[d]	−.127	−.287	.041	1.484	.138	5	3.238	4	.519	0%	–
Anger	−.042	−.178	.096	.595	.552	6	4.155	5	.527	0%	–
Disgust	−.101	−.277	.081	1.092	.275	4	2.967	3	.397	0%	–
Fear	−.333	−.551	−.073	2.485	**.013***	5	4.882	4	.300	18%	24
Happy	−.163	−.294	−.026	2.330	**.020***	6	3.106	5	.684	0%	4
Sad	−.165	−.395	.086	1.291	.197	6	5.705	5	.336	12%	–
Surprise	−.202	−.378	−.012	2.080	**.038***	2	.659	1	.417	0%	1

Note. FEA = fear. SAD = sad.
[a] All results shown in this table were calculated using Field and Gilletts' (2010) syntax Meta_Basic_r.sps.
[b] *r* for fear minus mean *r* for all other emotions for each study.
[c] *r* for sadness minus mean *r* for all other emotions for each study.
[d] Mean *r* for fear and sadness minus mean *r* for all other emotions for each study.
[e] Fail-safe *N* exceeds the criterion of 5*k* + 10 proposed by Rosenthal (1979).
* $p < .05$.
** $p < .01$.

For the mean of all emotions model, psychopathy was associated with significantly poorer recognition. Indicating a deficit pervasive across emotions, the model remained significant even when fear and sadness were excluded, and the differences between effect sizes for all models (fear minus other emotions, sadness minus other emotions, fear and sadness minus other emotions) were non-significant. It is however noted that the effect sizes for fear and sadness trended towards being larger than for those other emotions. For individual emotions, psychopathy was associated with significantly poorer recognition of fear, happiness, sadness and surprise, but not of anger or disgust.

Perhaps the most surprising of these individual emotion deficits is that for happiness. In previous studies, only one individual study (Hastings et al., 2008) and the later of the two meta-analyses (Marsh and Blair, 2008; Wilson et al., 2011) have reported significant deficits for happiness. Present results suggest previous non-significant findings may be due to the presence of ceiling effects in many studies. Ten of the 19 studies included in the meta-analysis for happiness reported accuracy at ceiling (i.e., >95%); the other nine studies either reported accuracy below ceiling ($k = 5$ studies) or did not report accuracy ($k = 4$ studies). Meta-analysis of those studies that reported accuracy at ceiling found a reduced and non-significant effect size, $r = -.058$, $CI_{95}[-.153, .039]$, $k = 10$, $p = .241$, compared to the original analysis, $r = -.087$, $CI_{95}[-.147, -.025]$, $k = 19$, $p = .006$, and to meta-analysis of the studies that reported accuracy below ceiling/did not report accuracy, $r = -.106$, $CI_{95}[-.185, -.026]$, $k = 9$, $p = .009$.

3.2.2. *Can fixed-effects modeling explain differences between our results and those of Wilson et al. (2011) for facial cues?*

Wilson et al. (2011) found psychopathy was associated with significant deficits in recognizing facial expressions of anger and disgust (as well as the other emotions for which the present results show deficits) using a fixed-effects model and alpha level of .10. Using the same procedure, we found psychopathy was associated with a significant deficit in recognizing anger, $r = -.053$, $CI_{95}[-.115, .008]$, $k = 19$, $p = .091$, but not disgust, $r = -.063$, $CI_{95}[-.145, .019]$, $k = 15$, $p = .130$, from facial expressions. We also ran fixed-effects models for the other individual emotions (fear, happiness, sadness, and surprise) for facial expressions, to see how they compared with our random-effects models, and found they were all significant at $p < .05$.

3.2.3. *Vocal cue deficits in total psychopathy*

This section deals with all studies that tested vocal cue recognition and included a measure of psychopathic traits (psychopathy or CU measure). The results of meta-analyses are shown in Table 4. Forest plots for individual emotions showing effect sizes for each study weighted by *N* are shown in Fig. 3. The number of vocal cue studies was low overall (maximum $k = 6$ studies), and for some analyses the number of studies was particularly small (e.g., for surprise $k = 2$ studies); thus these results should be interpreted with additional caution.

For the mean of all emotions model, psychopathy was associated with significantly poorer recognition. The model was no longer significant when fear and sadness were excluded, though it was approaching significance ($p = .064$). The differences between effect sizes for all models (fear minus other emotions, sadness minus other emotions, fear and sadness minus other emotions) were non-significant. It is however noted that the effect size for fear trended towards being larger than those for other emotions. For individual emotions, psychopathy was associated with significantly poorer

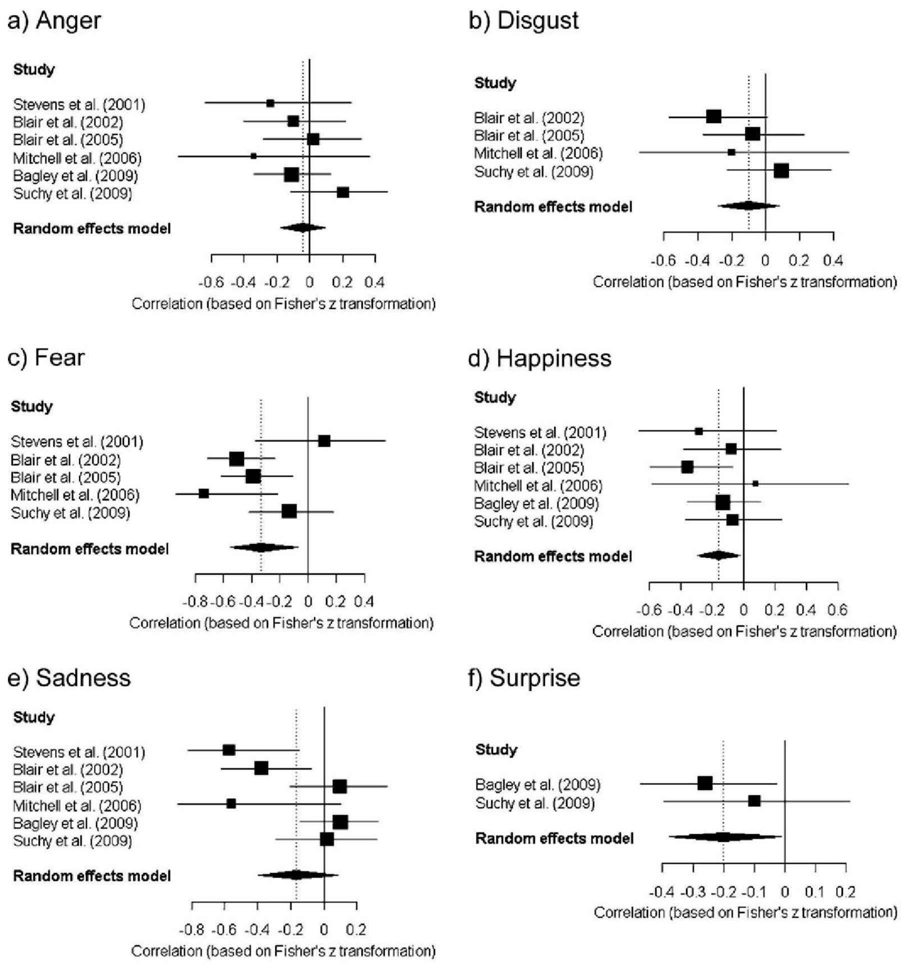

Fig. 3. Forest plots of study and random-effects model (weighted) mean effect sizes (correlations based on Fisher's *z* transformation) for vocal cues for the six emotions. Vertical dotted lines indicate the mean effect size for random-effects models, indicating that psychopathic traits were associated with poorer recognition for all emotions. Error bars and width of diamonds indicate 95% confidence intervals.

recognition of fear, happiness, and surprise, but not of anger, disgust, or sadness.

3.3. Single-studies not included in meta-analysis for total psychopathy

3.3.1. Facial cue deficits in CU traits

One study of facial cue recognition, by Woodworth and Waschbusch (2008), did not provide sufficient information for calculating effect sizes (i.e., no measure of variance). This study found CU traits were associated with significantly poorer recognition of sadness from facial expressions, $\beta = -.81$, OR = 0.44, $p < .05$, but with a trend towards being *more* accurate at recognizing fear, $\beta = .28$, OR = 1.32, $p = .080$.

3.3.2. Postural cue deficits in CU traits

Meta-analysis for postural cues could not be conducted because only one relevant study was identified (Muñoz, 2009). This single study found that CU traits were significantly negatively associated with recognition of fear from postures ($r = -.30$, $p < .05$), but showed no significant associations with recognition of anger ($r = -.11$), happiness ($r = .05$), sadness ($r = -.00$ [*sic*]), or surprise ($r = .05$).

3.4. Meta-analysis for the affective factor of psychopathy

3.4.1. Multi-modal deficits in the affective factor of psychopathy

This section deals with the subset of studies ($k = 12$; 13 experiments) that included a measure of the affective factor of psychopathy (i.e., factor 1 of the PCL-R or a pure CU measure). To maximise power, and because results were very similar for earlier facial and vocal meta-analyses, all modalities were combined (N.B. effect sizes were averaged across modalities prior to meta-analysis for the one study that reported results for more than one modality). Results for meta-analyses are shown in Table 5.

Consistent with our analyses for undifferentiated psychopathy, all effects were negative (fear > sadness > surprise > happiness > anger > disgust), though the effect for disgust was negligible. The affective factor was associated with a significant deficit when effects for all emotions were averaged, however, unlike the previous model for psychopathy as a whole, this model was no longer significant when fear and sadness were excluded. For individual emotions, a significant deficit was only observed for fear. Thus both the averaged and individual models are suggestive of a specific deficit in fear recognition. Yet results for the differences in effect sizes contradict this finding: differences

Table 5
Random-effects models for all modalities by emotion for the affective factor of psychopathy[a].

	Hedges–Vevea random-effects model						Homogeneity test (Q-statistic)			I^2	Rosenthal fail-safe *N*
Emotion	Mean *r*	Lower *r*	Upper *r*	*z*	*p*	*k*	χ^2	*df*	*P*		
Mean all emotions	–.108	–.198	–.016	2.309	**.021**[*]	12	10.691	11	.470	0%	28
Mean excluding FEA and SAD	–.054	–.133	.025	1.340	.180	9	6.597	8	.581	0%	–
FEA minus other[b]	–.084	–.221	.055	1.184	.237	9	7.239	8	.511	0%	–
SAD minus other[c]	.005	–.087	.096	.097	.922	9	7.954	8	.438	0%	–
FEA and SAD minus other[d]	–.030	–.122	.062	.645	.519	7	5.960	6	.428	0%	–
Anger	–.043	–.130	.045	.957	.338	8	6.788	7	.451	0%	–
Disgust	–.002	–.144	.140	.030	.976	5	1.884	4	.757	0%	–
Fear	–.211	–.353	–.061	2.735	**.006**[**]	11	8.919	10	.540	0%	**73**[e]
Happy	–.056	–.135	.023	1.382	.167	9	6.119	8	.634	0%	–
Sad	–.088	–.196	.022	1.567	.117	9	8.403	8	.395	5%	–
Surprise	–.065	–.208	.080	.876	.381	4	.821	3	.844	0%	–

Note. FEA = fear. SAD = sad.
[a] All results shown in this table were calculated using Field and Gilletts' (2010) syntax Meta_Basic_r.sps.
[b] *r* for fear minus mean *r* for all other emotions for each study.
[c] *r* for sadness minus mean *r* for all other emotions for each study.
[d] Mean *r* for fear and sadness minus mean *r* for all other emotions for each study.
[e] Fail-safe *N* exceeds the criterion of 5*k* + 10 proposed by Rosenthal (1979).
[*] $p < .05$.
[**] $p < .01$.

between effect sizes were non-significant for all models (fear minus other emotions, sadness minus other emotions, fear and sadness minus other emotions), indicating that the deficit for fear was not significantly greater than that for other emotions. It is also difficult, on the basis of these results, to rule out deficits for other emotions (for which effects are all negative) for the affective factor of psychopathy, given that the number of relevant studies was lower than for total psychopathy (and thus power was lower).

3.5. Meta-analysis by age group for facial cues for total psychopathy

Subgroup analyses were run for each age group for facial expressions (Table 6). Notably, effect sizes were all negative, except for anger for adults, though several effects were very small in magnitude.

3.5.1. Subgroup meta-analysis for adults

For adults, significant deficits were found for happiness and surprise, but no significant deficits were observed for any other individual emotion or all the emotions combined. The differences between effect sizes for all models (fear minus other emotions, sadness minus other emotions, fear and sadness minus other emotions) were also non-significant.

3.5.2. Subgroup meta-analysis for children/adolescents

For children/adolescents, a significant deficit was found for the all emotions model, and the model remained significant even when fear and sadness were excluded, indicating that deficits were pervasive. Significant deficits for individual emotions were also found for children for anger, fear, and sadness. The differences between effect sizes were significant for the fear minus other emotions and fear and sadness minus other emotions models, but not for the sadness minus other emotions model, indicating that the effect size for fear was significantly greater than that for other emotions.

Interpretation of these differences between adults and children/adolescents, however, is problematic because the adult samples were almost exclusively forensic, whilst the child studies used healthy community (approximately half of child studies) or clinical samples. Thus differences may be due to other factors associated with the forensic samples (e.g., substance abuse in forensic populations), rather than development per se.

3.6. Moderation analysis for task difficulty for total psychopathy

Even though the assumption of homogeneity was met for all meta-analyses of individual emotions, because *Q* is frequently underpowered (Schulze, 2007) we still investigated whether task difficulty might explain the different findings between studies for facial expressions (N.B. there were not enough studies for individual emotions for vocal cues for moderator analyses to be conducted). There were no significant moderation effects for task difficulty.

3.7. Homogeneity tests

For all analyses, the assumption of homogeneity (*Q*-statistic) was met and I^2 was below 25%, indicating low heterogeneity of effects.

3.8. Publication bias

Begg and Mazumdars' (1994) rank correlation was significant ($ps < .05$) only for the following models: sadness for vocal cues for the total sample; fear and sadness minus other emotions for the affective factor; fear for the affective factor; fear and sadness minus other emotions for adults; and fear minus other emotions for adults. Together these results indicate there may be some publication bias for the fear and/or sadness models, but there was no evidence of publication bias for other emotions. Funnel plots and sensitivity analyses for the main analyses are included in the supplementary materials.

4. Discussion

The current meta-analysis is, to the best of our knowledge, the first to evaluate emotion recognition across modalities in psychopathy. Results showed psychopathy was associated with significant impairments for positive as well as negative emotions, across both facial and vocal modalities. Deficits were observed for emotions other than fear and sadness for adults and children/adolescents separately (facial only; vocal not tested), as well as for the total sample (facial and vocal). These findings are contrary to the results of a previous, influential meta-analysis of facial expression recognition (Marsh and Blair, 2008) which found deficits only for fear and sadness, and instead indicate that deficits

Table 6
Random-effects models for facial cues by emotion for adults and children/adolescents[a].

	Hedges–Vevea random-effects model						Homogeneity test (Q-statistic)			I^2	Rosenthal fail-safe *N*
Emotion	Mean *r*	Lower *r*	Upper *r*	*z*	*p*	*k*	χ^2	*df*	*p*		
Adults											
Mean all emotions	−.040	−.110	.031	1.102	.271	12	4.343	11	.959	0%	–
Mean excluding FEA and SAD	−.057	−.130	.017	1.504	.133	11	2.620	10	.989	0%	–
FEA minus other[b]	.021	−.084	.125	.388	.698	11	10.498	10	.398	5%	–
SAD minus other[c]	.043	−.044	.129	.967	.334	11	9.734	10	.464	0%	–
FEA and SAD minus other[d]	.027	−.047	.100	.714	.475	11	6.202	10	.798	0%	–
Anger	.008	−.088	.103	.162	.871	11	12.318	10	.264	19%	–
Disgust	−.061	−.221	.103	.730	.466	8	6.236	7	.513	0%	–
Fear	−.026	−.129	.078	.490	.624	12	10.766	11	.463	0%	–
Happy	−.097	−.169	−.023	2.578	**.010***	11	4.501	10	.922	0%	7
Sad	−.078	−.157	.002	1.901	.057	11	9.806	10	.458	0%	–
Surprise	−.133	−.245	−.017	2.248	**.025***	8	3.322	7	.854	0%	6
Children/adolescents											
Mean all emotions	−.179	−.279	−.076	3.385	**.001****	9	2.961	8	.937	0%	27
Mean excluding FEA and SAD	−.125	−.235	−.013	2.187	**.029***	8	3.933	7	.787	0%	4
FEA minus other[b]	−.203	−.308	−.092	3.564	**.000*****	8	3.270	7	.859	0%	28
SAD minus other[c]	−.111	−.254	.036	1.479	.139	8	7.818	7	.349	10%	–
FEA and SAD minus other[d]	−.188	−.294	−.077	3.297	**.001****	8	3.333	7	.853	0%	28
Anger	−.214	−.343	−.077	3.036	**.002****	8	6.905	7	.439	0%	34
Disgust	−.053	−.167	.063	.898	.369	7	3.541	6	.738	0%	–
Fear	−.314	−.405	−.216	6.053	**.000****	9	5.874	8	.661	0%	**109**[e]
Happy	−.063	−.174	.050	1.087	.277	8	1.890	7	.966	0%	–
Sad	−.265	−.408	−.110	3.292	**.001****	8	7.649	7	.365	8%	**57**[e]
Surprise	−.050	−.242	.146	.497	.619	5	3.969	4	.410	0%	–

Note. FEA = fear. SAD = sad.
[a] All results shown in this table were calculated using Field and Gilletts' (2010) syntax Meta_Basic_r.sps.
[b] *r* for fear minus mean *r* for all other emotions for each study.
[c] *r* for sadness minus mean *r* for all other emotions for each study.
[d] Mean *r* for fear and sadness minus mean *r* for all other emotions for each study.
[e] Fail-safe *N* exceeds the criterion of $5k + 10$ proposed by Rosenthal (1979).
* $p < .05$.
** $p < .01$.
*** $p < .001$.

are more pervasive, in line with recent amygdalar theories of social-relevance processing (e.g., Dadds et al., 2011a,b).

Pervasive emotion recognition deficits in psychopathy in the full sample were confirmed via two methods. First, for both facial and vocal expressions, meta-analyses averaging all six 'basic' emotions found emotion recognition overall was impaired, and these findings remained significant (facial cues) or were approaching significance (vocal cues) even when fear and sadness were excluded. Second, for individual emotions, significant deficits were found for fear, happiness and surprise for both facial and vocal expressions, and for sadness for facial expressions. Weighted mean effect sizes were also negative for all other emotions in each modality (facial: anger and disgust; vocal: anger, disgust and sadness), albeit not significantly so.

Findings for the affective factor of psychopathy were less clear. Results were inconsistent in that, on one hand, there was a significant deficit observed for fear, and not for other emotions, but on the other hand, the deficit for fear was not found to be significantly greater than that for other emotions. The limitations of the available data (discussed later in Section 4.4) mean that deficits for other emotions cannot be ruled out. It may be that there is a general deficit in emotion recognition which is perhaps more severe in respect to fear for the affective factor.

4.1. Neurological implications

Selective deficits for fearful and sad expressions have been used to argue that the amygdala is an important brain region in psychopathy (e.g., Blair, 2003), given that amygdala lesions were often associated with very specific impairments in fear recognition (Adolphs et al., 1995; Calder et al., 1996; Broks et al., 1998). However, the finding of pervasive impairments in emotion recognition is not at odds with amygdalar theories of psychopathy, as it has more recently become apparent that the amygdala does not only respond to fear, as early studies suggested, or even threat per se (Adolphs, 2010). For instance, studies with large ($N = 9$) groups of patients with bilateral amygdala lesions have shown more pervasive emotion recognition deficits, even when the recognition of fear is the most greatly affected (Adolphs et al., 1999). Neuroimaging data also shows that the amygdala responds to a range of facial expressions (Fitzgerald et al., 2006), novel faces (Balderston et al., 2011) and is likely to have some role in influencing face-specific regions, such as the fusiform gyrus (Herrington et al., 2011). Together these findings suggest that the amygdala probably has a more general role in face processing, although it may be more involved in processing fear than other emotions.

It is notable that the findings for facial and vocal cues were largely in agreement as to which individual emotions were significantly impaired. This supports the idea that the effects are multi-modal and more likely to stem from brain regions that are involved in processing emotion regardless of the source (such as the amygdala, superior temporal cortex).

An important challenge for the literature however is to explain why deficits are not significant for anger and disgust, and why they trend towards being largest for fear and sadness. One possibility is that other cognitive and neurological mechanisms involved in emotion processing, beyond those associated with the amygdala, are also impaired. Other neurological regions that have been implicated in psychopathy include the orbitofrontal cortex (Blair, 2007) and paralimbic structures, such as the insula (Kiehl, 2006). These other neurological regions may contribute to emotion recognition deficits in a couple of ways. They may, for example, have some role in the general uncaring temperament of psychopathic individuals, and this uncaring temperament may contribute to generalized deficits in emotion task performance via decreased effort. But this does not explain why the deficit is significant for some individual emotions and not others. More specifically, the insula has been associated with processing of disgust and anger (Fusar-Poli et al., 2009), so dysfunction in the paralimbic system may contribute to the (non-significant) deficits seen for these emotions. The orbitofrontal cortex also has a widely recognized role in socio-emotional functioning (Zald and Andreotti, 2010).

It does, however, seem that the amygdala is central to the affective processing deficits observed in psychopathy. A recent review of 105 fMRI studies involving facial expression recognition found fearful, happy and sad faces, but not angry or disgusted faces, were associated with activation of the amygdala (Fusar-Poli et al., 2009; surprise was not tested). This pattern of activation mirrors our finding of significant deficits for fearful, happy and sad faces, but not for disgusted or angry faces, consistent with the notion that the amygdala is key.

Interestingly, our findings for psychopathy also contrast with those for Huntington's Disease (HD) in ways that are consistent with differences in the neural systems that are believed to be impaired in each disorder. Like psychopathic individuals, HD patients show evidence of pervasive deficits in emotion recognition, but in the case of HD evidence is strongest for impairments in disgust and anger (Henley et al., 2012). Adolphs (2002) argues that the basal ganglia and insula, which are both impaired in HD (Reiner et al., 2011), play a critical role in processing disgust, and Fusar-Poli et al.'s (2009) review of 105 fMRI studies also found that the insula was specifically activated for facial expressions of anger and disgust. This contrasts with our findings of significant impairments for fear, happiness, sadness, which are associated with amygdala activation (Fusar-Poli et al., 2009), and also surprise, which Fusar-Poli et al. did not test.

4.2. Neurobehavioural and theoretical implications

One mechanism whereby amygdala dysfunction may contribute to pervasive emotion recognition deficits is abnormal attention to the eye region of faces. Current theories suggest the amygdala has a special role in detecting salient and socially relevant cues, and in resolving ambiguity (e.g., Adolphs, 2010). One such cue is the eyes, and there is some evidence that amygdala damage is associated with abnormal processing of the eye region in laboratory tasks (Adolphs et al., 2005; Gosselin et al., 2011) and real-life interactions (Spezio et al., 2007). Notably, these findings have been replicated in high-CU children (Dadds et al., 2011a,b) and adolescents (Dadds et al., 2008). Some researchers (e.g., Adolphs et al., 2005) have argued that the eye region is particularly important for recognizing fear, more so than other emotions, and that impaired attention to the eyes thus underlies the apparently selective deficit for recognizing fear. Indeed, when instructed to look at the eyes, deficits in fear recognition are ameliorated for amygdala-damaged patients (patient SM; Adolphs et al., 2005) and high-CU children (Dadds et al., 2006) and adolescents (Dadds et al., 2008), supporting the notion that impaired attention to the eyes causes deficits in recognizing fear.

But this does not mean that impaired processing of the eye region *only* affects fear recognition; certainly it would be imprudent to assume so. Adolphs et al. (2005) found patient SM with bilateral amygdala lesions showed abnormal processing of the eye region for all emotions, as did high-CU adolescents in Dadds et al.'s (2008) study. Thus abnormal attention to the eyes could provide a plausible mechanism contributing to the more pervasive deficits in facial emotion recognition found in the current review.

A difficulty however with a straightforward 'attention-to-the-eyes' explanation is that, although it explains pervasive deficits across emotions for facial expressions, it doesn't provide an immediate explanation of deficits being found for other modalities (vocal and postural). To account for these, there are two other possible explanations. The first is that the amygdala is involved in directing attention to socially relevant cues in general, of which the eyes are just one, but which may also include things like tone and biological motion for vocal and postural cues respectively.

The second way in which amygdala dysfunction might contribute to cross-modal deficits in recognition is via *experience* of emotion, in that mirroring or simulating an emotion contributes to better recognition (simulation theory; Goldman and Sripada, 2005). Reduced experience of fear has been reported for both psychopaths (e.g., Lorber, 2004; Marsh et al., 2011) and amygdala lesion patient SM (Feinstein et al., 2011). It may be that this impaired experience of fear (and potentially of other emotions) contributes to impaired recognition of emotions in psychopathy (and amygdala lesion patients). Support for the idea that impaired experience of fear contributes to pervasive deficits in emotion recognition in psychopathy comes from a recent study by Buchanan et al. (2010) that found self-reported intensity of personal fear experiences was associated with better recognition of fear, happiness and surprise, whilst self-reported intensity of happy experiences was associated with better recognition of happiness only.

4.3. Clinical implications

Had the deficits been restricted to fear and sadness this might have suggested certain kinds of interventions focused on increasing understanding and internalisation of these specific emotions. However the finding of more pervasive deficits suggests training of all emotions is likely to be useful, and indeed a recent study (Dadds et al., 2012) has found emotion recognition training (ERT) across emotions and modalities to be effective for reducing problematic behaviours in children with high-CU traits. It is unclear however whether ERT per se was the effective component of treatment as there was no corresponding improvement in emotion recognition. ERT was partly administered via empathic interactions between parents and children, so it may in fact have been this interaction style that was important. Another possiblity is that ERT works because it increases attention to socially relevant cues.

4.4. Influence of other variables and limitations of available data

The present meta-analysis also attempted to consider some important variables that may influence results, including analysing the affective factor of psychopathy separately, and performing subgroup analyses for adults and children/adolescents.

First, in relation to findings for the affective factor, because of the inconsistencies in the results that were highlighted earlier in the discussion, it is unclear whether there is just a specific deficit for fear, or whether there might also be deficits for other emotions that the present meta-analysis had insufficient power to reveal. Neither can we rule out that emotion recognition deficits might differ for the affective factor when compared to total psychopathy, particularly given the evidence of different aetiologies for the two psychopathy sub-factors (e.g., Harpur et al., 1989) and that total measures confound them. Future studies should routinely report results for both psychopathy factors separately. Whether or not each factor is associated with different emotion recognition deficits has important implications for our understanding of the aetiology of psychopathy, and even whether the two factors should be considered as distinct disorders that warrant different interventions.

Second, in relation to findings by age group, for both adults and children/adolescents, deficits were observed for emotions other some role in the general uncaring temperament of psychopathic individuals, and this uncaring temperament may contribute to generalized deficits in emotion task performance via decreased effort. But this does not explain why the deficit is significant for some individual emotions and not others. More specifically, the insula has been associated with processing of disgust and anger (Fusar-Poli et al., 2009), so dysfunction in the paralimbic system may contribute to the (non-significant) deficits seen for these emotions. The orbitofrontal cortex also has a widely recognized role in socio-emotional functioning (Zald and Andreotti, 2010).

It does, however, seem that the amygdala is central to the affective processing deficits observed in psychopathy. A recent review of 105 fMRI studies involving facial expression recognition found fearful, happy and sad faces, but not angry or disgusted faces, were associated with activation of the amygdala (Fusar-Poli et al., 2009; surprise was not tested). This pattern of activation mirrors our finding of significant deficits for fearful, happy and sad faces, but not for disgusted or angry faces, consistent with the notion that the amygdala is key.

Interestingly, our findings for psychopathy also contrast with those for Huntington's Disease (HD) in ways that are consistent with differences in the neural systems that are believed to be impaired in each disorder. Like psychopathic individuals, HD patients show evidence of pervasive deficits in emotion recognition, but in the case of HD evidence is strongest for impairments in disgust and anger (Henley et al., 2012). Adolphs (2002) argues that the basal ganglia and insula, which are both impaired in HD (Reiner et al., 2011), play a critical role in processing disgust, and Fusar-Poli et al.'s (2009) review of 105 fMRI studies also found that the insula was specifically activated for facial expressions of anger and disgust. This contrasts with our findings of significant impairments for fear, happiness, sadness, which are associated with amygdala activation (Fusar-Poli et al., 2009), and also surprise, which Fusar-Poli et al. did not test.

4.2. Neurobehavioural and theoretical implications

One mechanism whereby amygdala dysfunction may contribute to pervasive emotion recognition deficits is abnormal attention to the eye region of faces. Current theories suggest the amygdala has a special role in detecting salient and socially relevant cues, and in resolving ambiguity (e.g., Adolphs, 2010). One such cue is the eyes, and there is some evidence that amygdala damage is associated with abnormal processing of the eye region in laboratory tasks (Adolphs et al., 2005; Gosselin et al., 2011) and real-life interactions (Spezio et al., 2007). Notably, these findings have been replicated in high-CU children (Dadds et al., 2011a,b) and adolescents (Dadds et al., 2008). Some researchers (e.g., Adolphs et al., 2005) have argued that the eye region is particularly important for recognizing fear, more so than other emotions, and that impaired attention to the eyes thus underlies the apparently selective deficit for recognizing fear. Indeed, when instructed to look at the eyes, deficits in fear recognition are ameliorated for amygdala-damaged patients (patient SM; Adolphs et al., 2005) and high-CU children (Dadds et al., 2006) and adolescents (Dadds et al., 2008), supporting the notion that impaired attention to the eyes causes deficits in recognizing fear.

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Second, in relation to findings by age group, for both adults and children/adolescents, deficits were observed for emotions other than fear and sadness. These results are consistent with our main finding for the total sample that deficits pervade beyond fear and sadness. For children however, the deficit for fear was found to be greater than that for other emotions. Together these results suggest that there is a general deficit in emotion recognition that is perhaps more severe for fear for children. In light of our results for the affective factor, which are also suggestive (albeit inconsistently) of a general deficit plus more severe deficit for fear, it may be that children are scoring high on measures of psychopathic traits because of high levels of CU traits more so than because of elevated antisocial behaviour. Supporting the idea that child/adolescent samples were not particularly likely to have high levels of antisocial behaviour, approximately half the studies included here used community and the other half clinical samples (i.e., they were not forensic samples, which are much more likely to have high levels of antisocial behaviour).

In future studies, it is important to resolve the confound between age (child versus adult) and sample source (community/clinical versus forensic), because there is theoretical reason to think that there could be developmental differences in emotion recognition deficits in psychopathy. Both children and adults show impairments on behavioural tasks associated with amygdala function, but only adults show impaired performance for tasks associated with the orbitofrontal cortex (e.g., Weber et al., 2008). One idea here, first proposed by Blair et al. (2001a), is that abnormalities that appear relatively early in development, such as that for the amygdala, may propagate abnormalities in regions that they relay to, such as the orbitofrontal cortex. Yet, if anything, the adults tested here showed less severe and pervasive deficits in emotion recognition. It may be that adults have developed compensatory mechanisms for recognizing prototypical expressions like the ones used in most experiments included in this meta-analysis.

Thus whether there are developmental differences in emotion recognition deficits in psychopathy remains an important question. A useful way to address the current limitations of the data would be to conduct more studies investigating emotion recognition deficits associated with psychopathic traits in adult community samples. This would provide valuable data to be compared with child community samples (to test for developmental differences) and adult forensic samples (to test for sample source effects). An additional, important advantage is that it would provide data about non-criminal adult psychopaths, who manage to live within the general community, perhaps by directing their callousness into more successful pursuits (e.g., business; Boddy et al., 2010).

4.5. Statistical power

One likely reason why the present meta-analysis has been able to reveal more pervasive deficits, even with limiting data to published studies and and using the proper type I error rate, is because the greater number of studies available means power has increased compared to previous similar meta-analyses. Even in the current meta-analysis, however, only a small number of studies provided data for vocal cues (and only one for postural cues), and the number of studies was particular small for some emotions (e.g., surprise). Thus lack of power (combined with effect size) may also explain why we did not find significant effects for anger or disgust for facial and vocal cues, or for sadness for vocal cues. Using more liberal criteria (which give greater power), Wilson et al. (2011) did find significant deficits for anger and disgust for facial expressions. There are some differences in the studies included by Wilson et al. (2011). However when we used the same procedure as Wilson et al. (2011; fixed-effects modeling and alpha level of .10) we also found psychopathy was associated with a significant impairment in recognizing anger and p for disgust (.13) was approaching .10. Thus it seems plausible there might be deficits for these emotions, although they are very small.

Low power also potentially explains how, even though pervasive deficits are emerging across studies, there are big differences between individual studies. There are two power-related issues that are of particular importance that are not currently being adequately addressed by individual studies.

The first issue is sample size. The present meta-analysis indicates that effect sizes associated with psychopathy tend to be rather small (range = −.087 to −.333 for significant deficits for individual emotions for total psychopathy), but individual studies have typically used sample sizes that are unlikely to have enough power to detect effects of this size. To illustrate, only three studies included in this meta-analysis have used samples larger than 100, yet to detect an effect size of r = .100 with power of .80, for example, requires a sample size of 614 (G*Power; Faul et al., 2007).

The second power-related issue is task internal reliability. Many studies have used a very small number of trials (13 of the 27 experiments had less than 10 trials per emotion). Internal reliability is related to the number of trials and has a substantial impact on the power of correlational studies, as is commonly known, but also on between-groups studies (Perkins et al., 2000). Only two studies (both correlational; Del Gaizo and Falkenbach, 2008; Muñoz, 2009) reported the overall reliability of their emotion recognition tasks, and even then they did not report reliability for individual emotions. In future it would be valuable to report reliability and, in correlational studies, also the upper bound correlation (the square root of variable A multiplied by the square root of variable B). Note that range is also important here, in that sufficient range is necessary for reliability. A surprising finding of the current review, which may have been hidden in individual studies by insufficient range due to ceiling effects, is that of deficits for happiness for both facial and vocal cues.

5. Conclusion

The results of this meta-analysis indicate that emotion recognition deficits in psychopathy are pervasive across emotions and modalities. Such a finding is consistent with recent theorizing about the role of amygdala dysfunction in psychopathy and attention to socially relevant cues. Results by age group for total psychopathy were all consistent with pervasive deficits, although results for the affective factor and for children/adolescents (but not adults) also tentatively suggest the deficit might be more severe for fear. We also revealed that important limitations in current data were that age was confounded with sample source, and that there were insufficient studies reporting results for the affective sub-factor of psychopathy. The affective sub-factor is of particular theoretical importance because it uniquely discriminates psychopathy from other forms of antisocial behaviour, and appears to have a strong genetic basis that may moderate response to treatment.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.neubiorev.2012.08.006.

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3.5 Supplementary materials

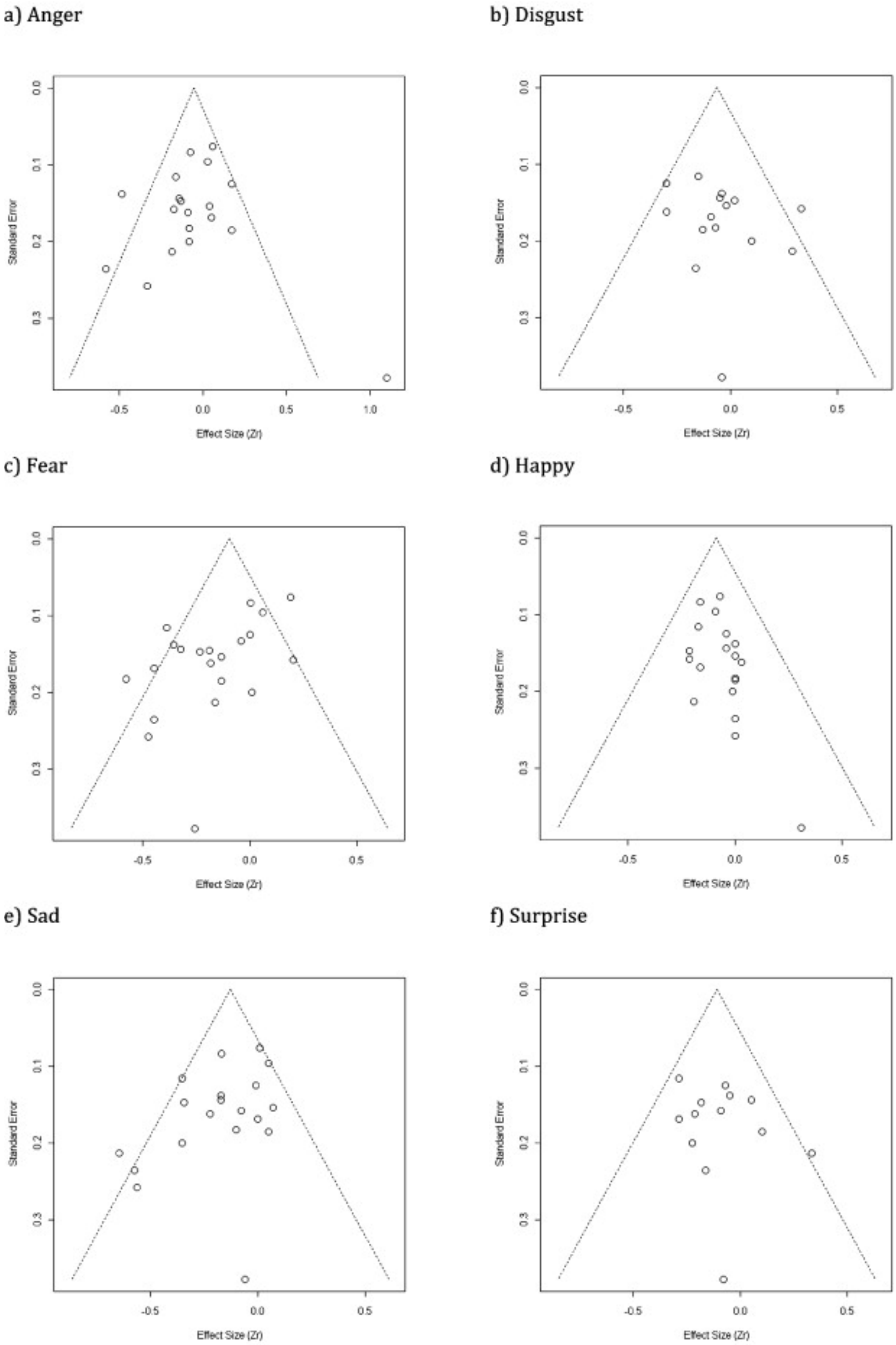
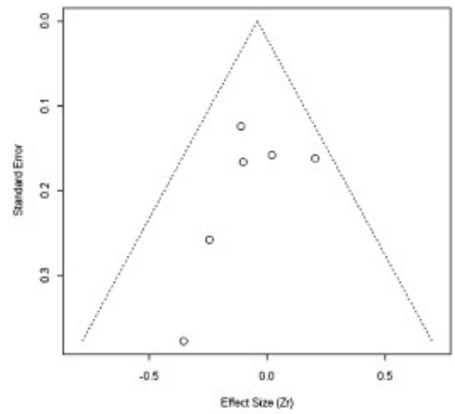
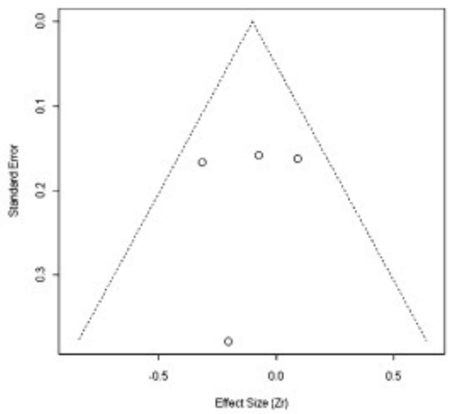


Fig. S1. Funnel plots of effect size (*Zr*) against standard error for facial cues for the six emotions.

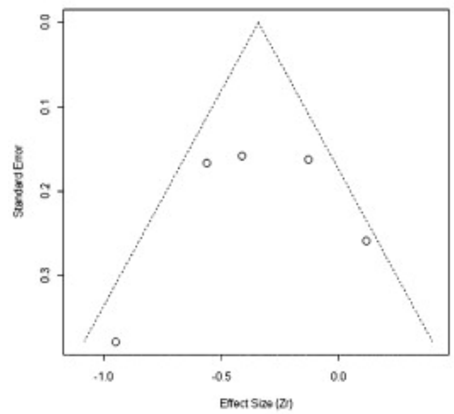
a) Anger



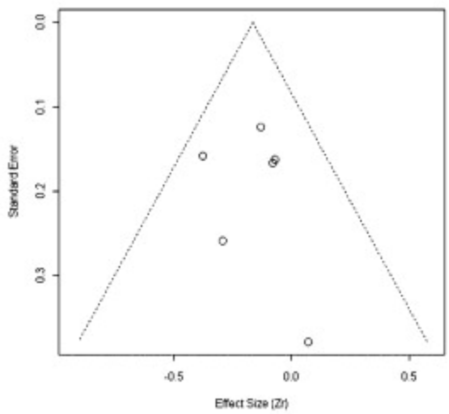
b) Disgust



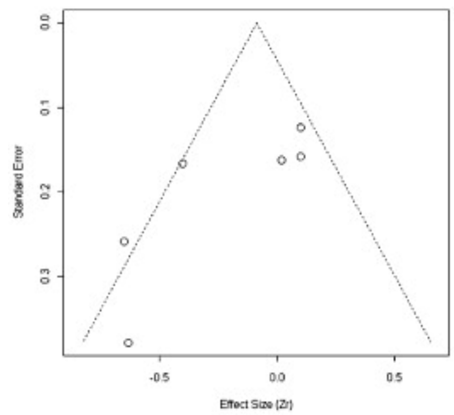
c) Fear



d) Happy



e) Sad



f) Surprise

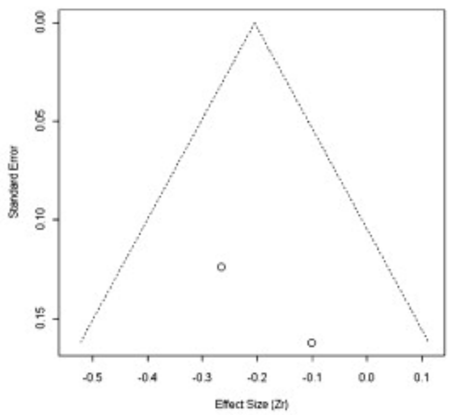


Fig. S2. Funnel plots of effect size (*Zr*) against standard error for vocal cues for the six emotions. Note that measures of publication bias are not very informative when *k* is small, such as for the vocal studies, because it is difficult to detect patterns and publication bias aims to detect patterns in selection of studies. We have however included all plots for comprehensiveness.

Table S3

Vevea and Woods (2005) sensitivity analyses for selection bias for random-effects models.

	Unadjusted parameter estimates			Moderate one-tailed selection			Severe one-tailed selection			Moderate two-tailed selection			Severe two-tailed selection		
Emotion	*zr*	*v*	*r*	*zr*	*v*	*r*	*zr*	*v*	*r*	*zr*	*v*	*r*	*zr*	*v*	*r*
Facial cues															
Anger	-0.066	0.011	-0.066	-0.040	0.011	-0.040	0.018	0.019	**0.018**[a]	-0.063	0.011	-0.063	-0.060	0.011	-0.060
Disgust	-0.059	0.005	-0.059	-0.014	0.008	-0.014	0.374	0.176	**0.358**[a]	-0.049	0.005	-0.048	-0.037	0.006	-0.037
Fear	-0.152	0.027	-0.151	-0.100	0.027	-0.100	0.481	0.448	**0.447**[a]	-0.132	0.026	-0.131	-0.110	0.026	-0.110
Happy	-0.087	0.000	-0.087	-0.061	0.000	-0.061	-0.030	0.000	-0.030	-0.076	0.000	-0.076	-0.062	0.000	-0.062
Sad	-0.151	0.011	-0.150	-0.117	0.010	-0.117	-0.065	0.014	-0.065	-0.136	0.011	-0.136	-0.120	0.010	-0.119
Surprise	-0.110	0.000	-0.110	-0.079	0.000	-0.079	0.386	0.226	**0.368**[a]	-0.096	0.000	-0.096	-0.078	0.000	-0.078
Vocal cues[b]															
Anger	-0.042	0.000	-0.042	-0.009	0.000	-0.009	0.039	0.000	**0.039**[a]	-0.036	0.000	-0.036	-0.029	0.000	-0.029
Disgust	-0.101	0.000	-0.101	-0.066	0.000	-0.066	-0.004	0.006	-0.004	-0.088	0.000	-0.087	-0.071	0.000	-0.071
Fear	-0.343	0.024	-0.330	-0.310	0.025	-0.301	-0.262	0.032	-0.256	-0.329	0.024	-0.318	-0.311	0.025	-0.302
Happy	-0.164	0.000	-0.163	-0.134	0.000	-0.133	-0.098	0.000	-0.097	-0.146	0.000	-0.145	-0.122	0.000	-0.121
Sad	-0.157	0.048	-0.156	-0.104	0.043	-0.103	-0.011	0.055	-0.011	-0.146	0.046	-0.145	-0.133	0.045	-0.132
Surprise	-0.205	0.000	-0.202	-0.184	0.000	-0.182	-0.159	0.000	-0.157	-0.188	0.000	-0.186	-0.164	0.000	-0.162

Note. [a]Bolded *r* values are those that change valence under this type of selection bias. [b]Note that measures of publication bias are not very informative when *k* is small, such as for the vocal studies, because it is difficult to detect patterns and publication bias aims to detect patterns in selection of studies. We have however included all analyses for comprehensiveness.

3.6 Additional studies published since meta-analysis

3.6.1 Details of additional studies

Since the initial literature search for the meta-analysis (conducted on 10 November 2010), there have been six studies (7 samples) published investigating emotion recognition from facial expressions (Bowen, Morgan, Moore, & Goozen, 2013; Schwenck et al., 2012, 2014; Snowden, Craig, & Gray, 2013; Wolf & Centifanti, 2013; 2 samples; Iria, Barbosa, & Paixão, 2012) and one study (1 sample) published investigating emotion recognition from body postures (Wolf & Centifanti, 2013) in psychopathy and CU traits. Sample characteristics for these studies are shown in Table 3.6.1a, and stimuli and task variables are shown in Table 3.6.1b. The expression of pain is included because some data are now available and it has theoretical relevance; pain is another expression that, like fear and sadness, signals distress. Of note, half of the new studies used dynamic expression stimuli (Schwenck et al., 2012, 2014; Wolf & Centifanti, 2013).

Table 3.6.1a

Sample characteristics for additional studies

Study	Total *N*	*M* age	Age range	% Male	Sample	Psychopathy measure	Psychopathy group (*n*)	Control group (*n*)
Bowen et al. (2013)	60	15.8	13-17	100	Forensic	YPI	YPI > 2.5 (20)	YPI < 2.5 (40)
Iria, Barbosa, & Paixão (2012)	62	39.5	NR	100	Forensic	PCL:SV	Factor 1 PCL:SV ≥ 7	Factor 1 PCL:SV < 7
Iria, Barbosa, & Paixão (2012)	51	37.6	NR	100	Community	PCL:SV	Factor 1 PCL:SV ≥ 7	Factor 1 PCL:SV < 7
Schwenck et al. (2012)	70	12.3	6-17	100	Clinical	ICU	ICU ≥ 32 (36)	ICU < 32 (34)
Schwenck et al. (2014)	32	13.2	8-17	0	Clinical	ICU	ICU > 35.5 (16)	ICU < 35.5 (16)
Snowden, Craig & Gray (2013)	150	21.0	NR	49	Community	PPI-R	Correlational analyses	n/a
Wolf & Munoz Centifanti (2013)	Facial = 37; postural = 50	14.3	11-16	100	Clinical	YPI-CU, ICU	Correlational analyses	n/a

Note. NR = not reported. PCL:SV = Psychopathy Checklist Screening Version (Hart et al., 1995). PPI-R = Psychopathic Personality Inventory-Revised (Lilienfeld & Fowler, 2006). ICU = Inventory of Callous Unemotional Traits (Essau et al., 2006). YPI-CU = Callous subscale of Youth Psychopathic Inventory (Andershed et al., 2002).

Table 3.6.1b

Stimuli and task variables for additional studies

Study	Stimuli	Exposure duration	Response format	Number of trials						
				AN	DI	FE	HA	SA	SU	PA
Facial cues										
Bowen et al. (2013)	PFA; morphed with neutral for 25%, 50%, 75%, and 100% intensity displays	NR	AFC key	NR	NR	NR	NR	NR	NR	–
Iria, Barbosa, & Paixão (2012)	MacBrain NimStim	500 ms	Key press; go/no-go task; blocked by emotion	8	–	8	–	8	–	–
Schwenck et al. (2012)	Dynamic morphed KDEF (neutral to expression)	Morphing = 9s, exposure to final frame = unlimited	Key unspecified	12	12	12	12	12	–	–
Schwenck et al. (2014)	Dynamic morphed KDEF (neutral to expression)	Morphing = 9s, exposure to final frame = unlimited	Key unspecified	12	12	12	12	12	–	–
Snowden, Craig & Gray (2013)	PFA; morphed with neutral for 40% intensity	500 ms	AFC unspecified	32	–	32	32	32	–	–
Wolf & Munoz Centifanti (2013)	Dynamic expressions based on Ekman criteria; validated	Unlimited	AFC unspecified	4	4	4	4	4	–	4
Postural cues										
Wolf & Munoz Centifanti (2013)	Dynamic patch-light displays	Unlimited	AFC unspecified	4	4	4	4	4	–	–

Note. NR = not reported. AN = anger. DI = disgust. FE = fear. HA = happy. SA = sad. SU = surprise. PA = pain. AFC = alternative forced choice. key = keyboard. PFA = Pictures of Facial Affect (Ekman and Friesen, 1975). MacBrain NimStim (Tottenham et al., 2009). KDEF = Karolinska Directed Emotional Faces (Lundqvist et al., 1998).

3.6.2 Summary of results from additional studies

The main findings of each study are summarized in Table 3.6.2. Overall there is some new evidence of psychopathy-related deficits for the distress-emotions of fear, sadness, and pain (although one study found an advantage for fear), but not for the positive emotion of happiness. In relation to anger and disgust, findings are mixed, and do not provide strong evidence either way. For surprise, the one new study did not find any relationship with psychopathy (Bowen et al., 2013). Results by cue type are detailed below.

Table 3.6.2

Summary of results of additional studies

Study	Summary of results
Bowen et al. (2013)	The high CU group showed worse recognition of facial disgust at 50% intensity compared to the low CU group.
Iria, Barbosa, & Paixão (2012)	High psychopathy forensic and community samples more often failed to identify (by responding 'go') fearful and sad facial expressions (but not angry expressions) than low psychopathy forensic and community samples respectively.
Schwenck et al. (2012)	There were no significant differences in facial expression recognition between the high and low CU groups.
Schwenck et al. (2014)	The high CU group showed better recognition of fearful facial expressions; this result was replicated in correlational analysis controlling for conduct problems.
Snowden, Craig & Gray (2013)	PPI scores were negatively correlated with recognition of facial expressions of fear in males but not in females.
Wolf & Munoz Centifanti (2013)	Facial cues: YPI-CU scores were negatively correlated with recognition of facial expressions of pain; however ICU scores were positively correlated with recognition of facial expressions of anger. Postural cues: YPI-CU scores were negatively correlated with recognition of postural expressions of anger; however ICU scores were positively correlated with recognition of postural expressions of disgust.

3.6.2.1 Facial cues

Of the seven samples tested for fear recognition, three showed deficits associated with psychopathy (Iria et al., 2012; Snowden et al., 2013), and in one case this finding was restricted to the male half of the sample (Snowden et al., 2013. On the other hand, one sample showed *better* recognition of fearful expressions with higher psychopathy (Schwenck et al., 2014). For sad, only two of seven samples tested showed psychopathy-related deficits in recognition (Iria et al., 2012). For pain, the only sample tested showed deficits, but only for one of two psychopathy measures (for the YPI-CU but not the ICU; Wolf & Centifanti, 2013). In relation to other expressions, one study found CU was associated with worse recognition of disgust (tested in 4 samples) but only at 50% intensity (Bowen et al., 2013), whilst another study found CU traits was associated with better recognition of anger (for the ICU but not the YPI-CU; Wolf & Centifanti, 2013; anger was tested in all 7 samples). No study found evidence of any relationship between psychopathy and recognition of happy (tested in 6 samples) or surprised (tested in 1 sample) expressions.

3.6.2.2 Postural cues

In the single sample tested, CU traits were associated with *worse* recognition of postural expressions of anger, but with *better* recognition of disgust (Wolf & Centifanti, 2013). In both instances, these findings held for only one of two CU measures.

3.6.3 Consideration of results and implications for meta-analysis

An important finding of the meta-analysis was that of deficits in recognizing the positive emotion of happiness, in addition to emotions like fear and sadness. This finding for happy was not replicated by any new study; however, neither was this finding replicated by 18 of the 19 individual studies included in the meta-analysis. It was only when studies were combined that power was sufficient to reveal the deficit for happiness. In the meta-analysis we argued that ceiling effects for happy may contribute to insufficient power in individual studies (end of section 4.5 on p. 2302 of meta-analysis). Indeed, recognition accuracy for happiness continues to be greater than 95% for around half of studies (e.g., Schwenck et al., 2014; Wolf & Centifanti, 2013). Also, there is now fMRI evidence that neural activation to happy expressions is related to psychopathy (Decety, Skelly, Yoder, & Kiehl, 2014). Thus I do not believe that these additional studies refute the conclusion of the meta-analysis that there are problems with processing happy expressions in psychopathy.

An interesting new finding, which is in line with the argument for pervasive emotion recognition deficits, was that of a psychopathy-related deficit in recognizing pain (Wolf & Centifanti, 2013). Caveats are that the relationship with pain recognition was limited to one of two measures of CU traits, and this result has yet to be replicated. Nevertheless, it is supported by fMRI evidence of psychopathy-related differences in neural activation to pain expressions (Decety et al., 2014) and for imagining others' in pain (Decety, Chen, Harenski, & Kiehl, 2013; Marsh et al., 2013). Pain is of particular interest to future research because of its theoretical relevance to distress-specific accounts of psychopathy (Blair, 1995, 2006).

Another shift in the literature is the increasing use of dynamic, moving expression stimuli. Of the new studies, half used dynamic stimuli(Schwenck et al., 2012, 2014; Wolf & Centifanti, 2013), whereas the vast majority of studies in the meta-analysis used static stimuli (i.e., still photographs or images). Interestingly, none of the studies using dynamic expressions found deficits in recognition for fear or sadness, but two of the three studies using static expressions did (Iria et al., 2012; Snowden et al., 2013). It could be that people with high levels of psychopathic traits are able to accurately decipher dynamic but not static expressions. This has implications for real world functioning because facial expressions normally involve movement. If expression recognition deficits in psychopathy are limited to static stimuli, then it is difficult to see how they could have a core etiological role. Direct comparison of static and dynamic expression stimuli in psychopathy would help to resolve this issue.

Finally, in relation to the recommendations for future research in the meta-analysis, it is promising that several of the additional studies have focused on the affective factor of psychopathy, and that there has been a large community study (Iria et al., 2012). On the other hand, it is disappointing there has been only one new study of cross-modal deficits for postural cues (Wolf & Centifanti, 2013). There is no new evidence for vocal cues.

3.7 Chapter summary

The key findings of this chapter are that psychopathy is associated with pervasive emotion recognition deficits, for positive as well as negative emotions, and across modalities. Ceiling effects are a problem for studying recognition of happiness though, and there is a need to use different types of stimuli (e.g., less intense happiness) or use different, more sensitive methods (e.g., rating *how much* happiness is being shown). Additional studies since the publication of the meta-analysis point to a possible difference in results for dynamic compared to static stimuli, and recommend the expression of pain for further investigation.

3.8 Additional references

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Iria, C., Barbosa, F., & Paixão, R. (2012). The identification of negative emotions through a go/no-go task. *European Psychologist*, *17*(4), 291–299. doi:10.1027/1016-9040/a000101

Marsh, A. A., Finger, E. C., Fowler, K. A., Adalio, C. J., Jurkowitz, I. T. N., Schechter, J. C., … Blair, R. J. R. (2013). Empathic responsiveness in amygdala and anterior cingulate cortex in youths with psychopathic traits. *Journal of Child Psychology and Psychiatry*, *54*(8), 900–910. doi:10.1111/jcpp.12063

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Chapter 4: Fearful faces drive gaze-cueing and threat bias effects in children on the look out for danger

4.1 Chapter overview

The purpose of Chapter 4 is twofold. First, it is the first investigation in this thesis of limitations to currently-used expression stimuli. Here the issue is context, which is examined in relation to typical development. The vast majority of developmental studies investigating how facial expressions are perceived have used pictures of faces shown in isolation, in the absence of any broader context. Yet recent empirical evidence from adults has established context has an important role to play. Chapter 4 presents one of the first investigations of context effects in children. Specifically, I investigate how fearful faces interact with a context that involves looking for dangerous animals to drive threat bias and social attention, measured via attentional cueing by eye-gaze direction in non-anxious samples (i.e., with typical-population levels of anxiety). The use of non-anxious samples is important because, when stimuli and the context in which they are appear are emotionally neutral, threat-bias is typically found only in high-anxious samples (Bar-Haim et al., 2007). The results I present in this chapter show that threat-bias can also occur in samples *without* elevated levels of anxiety, when the context requires vigilance for danger. Thus it seems that threat bias can be driven by internal factors (e.g., anxiety) and/or external factors (e.g., environmental context).

The second purpose of Chapter 4 is to establish the eye-gaze cueing paradigm used in Chapter 5. Chapter 5 investigates theorized mechanisms that might contribute to abnormalities in processing others' emotions by testing attentional cueing as a function of CU. Although Chapter 5 presents data for adults only, developmental effects are tested here because an important avenue for future work is to explore whether our findings extend to children with high CU.

4.2 Publication status

This manuscript has been published as follows:

Dawel, A., Palermo, R., Irons, J., O'Kearney, R., & McKone, E. (2014). Fearful faces drive gaze- cueing and threat bias effects in children on the look out for danger. *Developmental Science,* epub ahead of print. doi: 10.1111/desc.12203

4.3 Author contributions

- **Dawel** proposed the project.
- **Dawel** was responsible for the literature review.
- **Dawel** conceived and designed the experiments, with advice from Palermo, Irons, McKone, and O'Kearney, and from an overseas colleague (Dr Andrew Bayliss), who advised on the specific method required to obtain gaze-cueing.
- **Dawel** and Irons programmed the experiment and modified the stimuli.
- **Dawel** collected most of the data, with some assistance from Irons and a Research Assistant (Ms Emma Cummings).
- **Dawel** analyzed the data and produced the figures, with suggestions from McKone.
- **Dawel** drafted the manuscript.
- **Dawel** and McKone together refined the manuscript, with detailed editing provided by McKone. Palermo and O'Kearney also reviewed the manuscript and provided general content comments and suggestions, and some editing.
- After reviews were received from *Developmental Science*, all authors contributed to the discussion of the reviewers' points, and the same writing process described above was repeated for the final revision.

4.4 Manuscript: Fearful faces drive gaze-cueing and threat bias effects in children on the look out for danger

4.4.1 Abstract

Most developmental studies of face emotion processing show faces in isolation, in the absence of any broader context. Here we investigate two types of interactions between expression and threat contexts. First, in adults, following of another person's direction of social attention is increased when that person shows fear and the context requires vigilance for danger. We investigate whether this also occurs in children. Using a Posner-style gaze-cueing paradigm, we tested whether children would show greater gaze-cueing from fearful than happy expressions when the task was to be vigilant for possible dangerous animals. Testing across the 8-12 year old age range, we found this fear priority effect was absent in the youngest children but developed to reach adult levels in the oldest children. However, even the oldest children were unable to sustain fear-prioritization when the onset of the target was delayed. Second, we addressed the development of 'threat bias' – namely faster identification of dangerous animals than safe animals – in the social context provided by expressive faces. In our non-anxious samples (i.e., with typical-population levels of anxiety), adults showed a threat bias regardless of the expression or looking direction of the just-seen cue face whereas 8-12 year olds only showed a threat bias when the just-seen cue face displayed fear. Overall, the results argue that some, but not all, aspects of expression-context interactions are mature by 12 years of age.

4.4.2 Introduction

In everyday life, facial expressions are not typically seen in isolation but within an environmental and social context. In some cases, this may help us interpret an expression; for example, an ambiguous expression may be resolved as *fear* if the face is seen to be looking at a tiger. Or, in the situation investigated in the present study, interactions between expression and context may influence how likely we are to follow the direction of social attention indicated by a person's eye-gaze. For example, we might be more likely to follow their gaze if the face is displaying fear and the context is one in which a tiger might potentially be encountered (as compared to, say, the face displaying happiness, or the context being one in which a dangerous animal never occurs).

Recently, the literature on facial expression processing in adults has put strong emphasis on the importance of expression-context interactions (e.g., Barrett & Kensinger, 2010; Hassin, Aviezer, & Bentin, 2013; Wieser & Brosch, 2012). The extent to which such interactions occur in children, and at what age they emerge and mature, has received less investigation. To date, it is known that body postures affect judgments of a face's expression as early as six years of age (Mondloch et al., 2013). Some older studies (Gnepp, 1983; Hoffner & Badzinski, 1989; Reichenbach & Masters, 1983) also suggest that judgments of how a person feels are driven jointly by facial expression and scene or story context in 8-12 year olds, while 3-5 year olds rely on only one source or the other.

To our knowledge, there have been no previous studies investigating whether expression-context interactions influence following of social attention in children of any age. The following of social attention is operationalized by measuring the tendency of an observer to follow another person's direction of gaze; for example, for the observer to shift their attention left when the person is looking left, and to shift their attention right when the person is looking right (Friesen & Kingstone, 1998). Strength of this gaze-following is then measured using the *gaze-cueing effect* (Figure 1a), namely the amount by which responses are faster for targets that are looked-at (by cue faces) compared to those that are looked-away-from (Friesen & Kingstone, 1998).

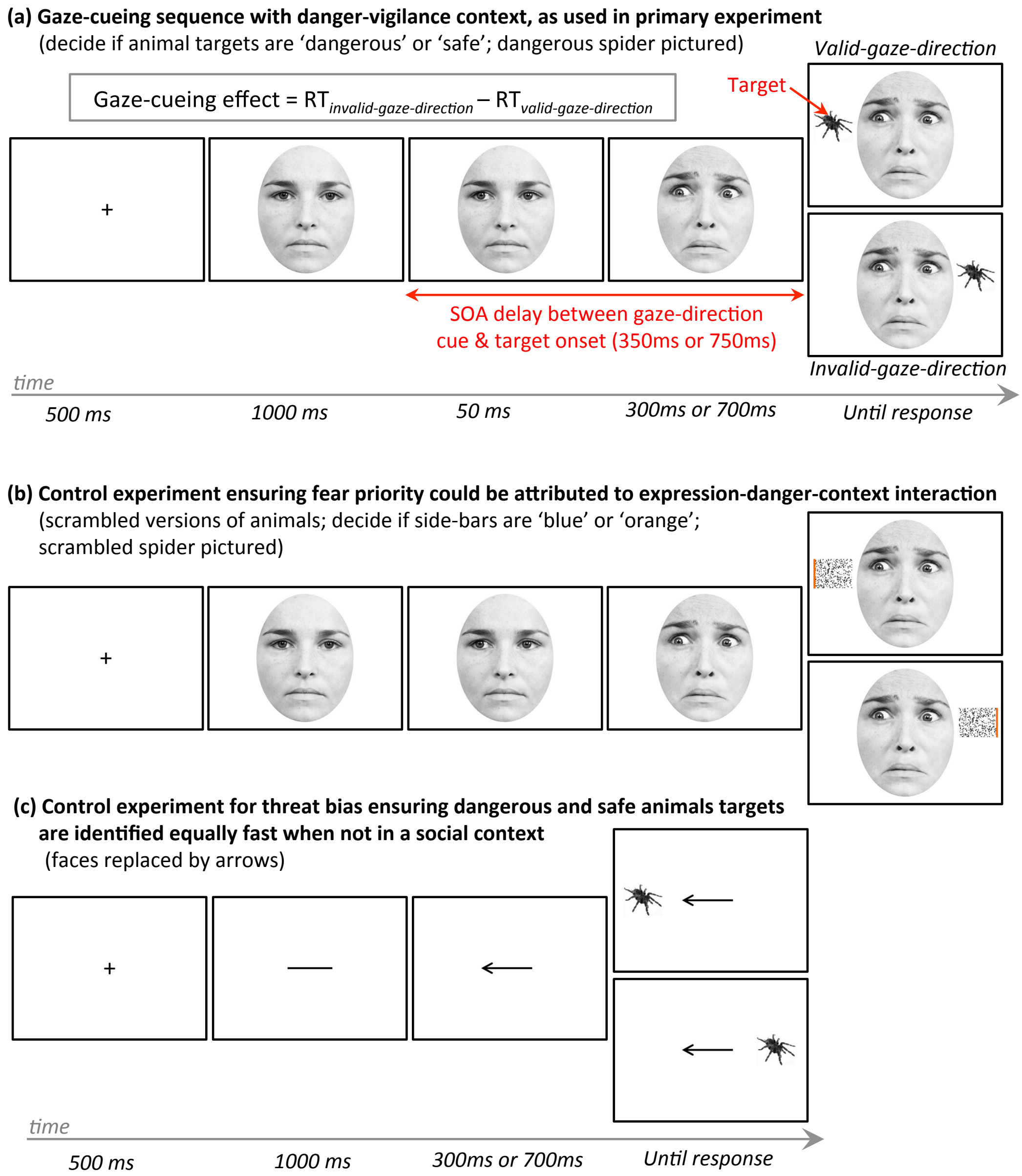

Figure 1 *Trial sequences for (a) the main experiment, and (b) and (c) control experiments. Cueing effects are calculated, for each participant, as mean RT for invalid-direction trials minus mean RT for valid-direction trials. We used a dynamic gaze-cueing sequence in which the neutral face first looks to the left or right and then quickly changes expression, as though noticing something in the environment, after which the target appears.*

In adults, this method has shown that gaze-cueing effects can be influenced by the interaction of facial expression and context. For example, gaze-cueing was greater from fearful expressions than happy expressions when looked-at objects included a dangerous attack-dog, but not when looked-at objects were emotionally-neutral letters (Friesen, Halvorson, & Graham, 2011; also see Bayliss, Schuch, & Tipper, 2010; Kuhn & Tipples, 2011).

In the present study, our first question was whether a similar gaze-cueing context effect occurs in children aged 8-12 years. There is good evidence that information from emotional expressions and gaze are integrated in perception from infancy (e.g., Rigato et al., 2013), but to our knowledge there have been no previous studies investigating how this interacts with context in children of any age. Our context required vigilance for danger, namely a task in which participants decided whether animal targets were 'dangerous' or 'safe', following a change in expression of the cue face from neutral to either fear or happiness (see Figure 2a).

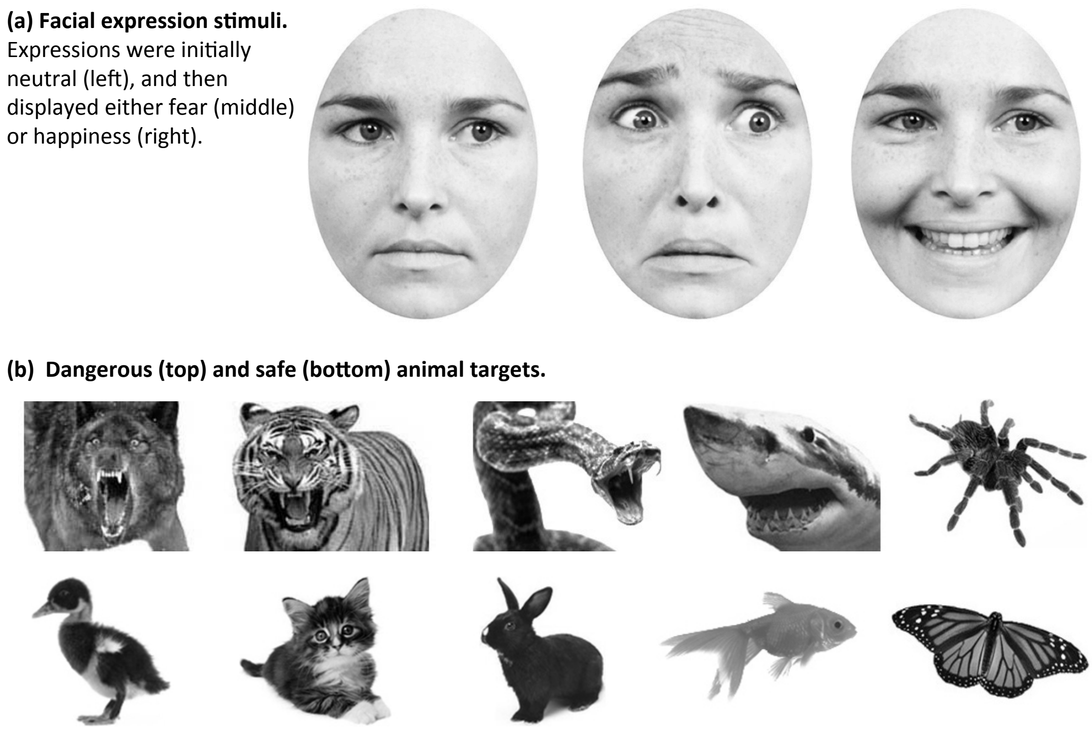

Figure 2 *The stimuli for the main experiment.*

Based on previous studies of gaze-cueing in context (Bayliss et al., 2010; Friesen et al., 2011; Kuhn & Tipples, 2011), we expected adults would show greater gaze-cueing effects for fearful compared to happy faces in our danger-vigilance paradigm, consistent with an interpretation that it is adaptive to prioritize following fearful gaze when there is potential for danger. Our question was then whether, and at what age, children would show the same pattern of fearful gaze priority (i.e., greater gaze-cueing from fear than happy). Some theorists propose an innate component to threat-processing for biological stimuli such as faces and animals (non-associative model of fear-acquisition; Poulton & Menzies, 2002), which implies even our youngest children might show adult-like processing of our fearful stimuli given the animal-danger context. Others instead argue that threat associations are learned (associative model of fear-acquisition; Rachman, 1977), although they may be more easily learned for biological stimuli than for non-biological stimuli (prepared learning model; Öhman & Mineka, 2001). Thus fear priority in danger contexts may emerge later in development.

In our paradigm, animals appeared after a short delay from the initial gaze-cue (SOA of 350ms) or a longer delay (SOA of 750ms; Figure 1a). We manipulated SOA because children's neural processing speed is slower than adults, and increases with age within the 8-12 year range (e.g., Kail, 2000; Kuefner, de Heering, Jacques, Palmero-Soler, & Rossion, 2009). Thus, it was possible that context-influenced prioritization of fearful gaze in children might require longer delay times than in adults. Note that with delays of less than ~250ms even adults do not show gaze-cueing context effects (Friesen et al., 2011; Pecchinenda et al., 2008), presumably because there is insufficient time for the brain to integrate knowledge of the expression and context, and shift attention accordingly.

A second question that our design allowed us to address was whether, regardless of the *direction* of the face's gaze, children might show a 'threat bias' for processing dangerous animals over safe animals (which might be learned, [Rachman, 1977] or innate [Poulton & Menzies, 2002]; and theoretically might lead to an evolutionary survival advantage; Öhman & Mineka, 2001). A review of the literature by Bar-Haim et al. (2007) found that, while such threat bias occurs in children and adults, it is typically found only in highly anxious participants. However, some recent studies report threat bias in samples unselected for anxiety. The review of LoBue and Rakison (2013) describes a number of such findings from visual search tasks. Concerning *interactions* between external threat and facial expressions, as are of interest here, we are aware of only two previous studies. Rakison (2009) reported that infants preferentially learned associations between fearful expressions and snakes compared to other facial expressions and other non-animal objects. And, in a study using the same gaze-cueing paradigm as here, Friesen et al (2011) tested an adult sample and found a threat bias (faster recognition of a target attack-dog than a target baby), regardless of eye-gaze direction, when the targets were presented in the context of a face displaying a relevant expression (fear) but not an irrelevant expression (happiness). In the present study, we tested samples with normal population levels of trait anxiety, and examined whether 8-12 year old children, and adults, demonstrate gaze-independent threat bias in the presence of fearful faces, when they are being vigilant for danger.

To summarize, we addressed whether children's processing of expression-context interactions is mature by 8-12 years in two specific aspects: (i) prioritization of fearful gaze-following in a danger-vigilance context (i.e., we tested whether gaze cueing was greater from fear than happy, in a task requiring determining whether animals are dangerous), and (ii) threat bias for dangerous animals in the presence of a social context, including fearful facial expressions. Our design first compared 8-12 years olds treated as a group to adults, and then subsequently examined developmental changes within the 8-12 age range via correlations of individuals' scores with their exact age in months. In addition to our main experiment, which provided data that addressed both of our research questions, we also conducted two control experiments. One was aimed at ensuring that prioritization of fearful gaze-following could be attributed specifically to interaction with the danger-vigilance context (i.e., no fearful gaze priority should be seen when the animals were scrambled). The second was aimed at ensuring that any threat bias was due to the presence of the social context rather than intrinsic differences in ease of identification between our dangerous and safe animals (i.e., no overall threat bias when arrow cues replaced the faces).

4.4.3 Method

4.4.3.1 Participants and design

In the main experiment, participants were 54 children aged 8-12 years (31 females, M_{age} = 124 months, SD_{age} = 14.7, $\text{range}_{\text{age}}$ = 99-148) and 50 adults (38 females, M_{age} = 20 years, SD_{age} = 1.8, $\text{range}_{\text{age}}$ = 18-25). Trait anxiety levels were typical of the normal population, as measured for adults with the Spielberger State-Trait Anxiety Inventory (Spielberger et al., 1983) and for children with the Spence Children's Anxiety Scale (Spence, 1999), and compared to published norms (Table 1).

All participants were Caucasian (same as the face stimuli to avoid other-race effects on expression processing; Elfenbein & Ambady, 2002), and reported no disorders that can affect face processing (e.g., psychosis, autism, ADHD). Children were recruited from two Canberra public schools in middle-class districts, and adults via fliers posted at the Australian National University. Written informed consent was obtained from adults, and from the parent or guardian of child participants.

Table 1
Comparison of anxiety scores with population norms

			Anxiety	Sample		Norms			
Sample	*N*	Task	measure	*M*	*SD*	*M*	*SD*	*z*	*p*
Adults[1]	50	Danger-decision	STAI-Y2	44.58	(10.6)	40.39	(12.3)	.341	.733
Children[2]	54	Danger-decision	SCAS	15.24	(9.1)	15.95	(10.3)	-.069	.945
Adults[1,3]	54	Color-decision	STAI-Y2	42.96	(10.3)	40.39	(12.3)	.209	.834

Note. STAI-Y2 = State-Trait Anxiety Inventory (form Y2 measures trait anxiety; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). SCAS = Spence Children's Anxiety Scale (Spence, 1999). [1]Norms for Australian 18-24 year olds from Crawford, Cayley, Lovibond, Wilson, & Hartley (2011). [2]Norms for Australian 6-11 year olds from Nauta et al. (2004). [3]$t(102) = .79$, $p = .431$, for comparison to adult participants in main experiment (danger-decision).

4.4.3.2 Stimuli

Faces (Figure 2a) were greyscale photographs of a single woman (after Bayliss et al., 2010; Friesen et al., 2011; Kuhn & Tipples, 2011) displaying a fearful, happy and neutral expression. The face was Model 61 selected from the Radboud Face Database (because her expressions were recognized with over 90% accuracy; Langner et al., 2010). The faces subtended 9.4° x 12.9° of visual angle.

Targets (Figure 2b) were gray scale photographs of five dangerous animals (attack-dog, tiger, snake, shark, spider – all baring their teeth except the spider) and five safe animals (duckling, kitten, rabbit, goldfish, butterfly). The maximum size was 6.3° x 4.4°. Prior to the experiment, we confirmed that each child correctly perceived the danger status of all targets: all children successfully sorted cards showing the 10 animals into 'dangerous' and 'safe' categories.

4.4.3.3 Gaze-cueing paradigm

The trial sequence is shown in Figure 1a. Participants were instructed to look at the central face, but were told (truthfully) that its gaze-direction would not predict where animals would appear. The task was to quickly press a key to indicate whether a 'dangerous' or 'safe' animal appeared. Gaze-direction of the faces was nonpredictive, with 50% of trials *valid-direction* (looking at the animal) and 50% *invalid-direction* (looking away from the animal). Faces looked left or right equally often. Animals were located 8.0° horizontally away from screen center, vertically aligned with the face's eye position, and were presented until a response was obtained. Inter-trial interval was 1000ms.

In order to ensure that RTs to dangerous and safe animals could be validly compared (as necessary for threat bias analysis), response hand assignment (e.g., 'dangerous' or 'safe') to left-right buttons was counterbalanced across participants.

Participants completed 8 practice trials and then 3 blocks of 84 test trials. Breaks between blocks were a minimum of 20 seconds long, and participants initiated the next block by pressing a button. The first 4 trials of each test block were discarded from analyses to allow participants to settle into the task (total test trials analyzed = 240). Test trials included all combinations of gaze-validity (valid-direction, invalid-direction), target animal type (dangerous, safe), SOA (350ms, 750ms), and expression (fearful, happy, neutral). The order of trials was randomized for each participant, with the limitation that no more than four trials of the same SOA occurred in a row.

4.4.3.4 Initial data screening

Reaction times for individual trials were excluded if they were pre-emptive (<200ms), unusually delayed (>3000ms), or were upper outliers based on remaining RTs for each block (>$RT_{mean+2.5SD}$) (<3.5% of trials for children, <2.8% for adults), or where the response was incorrect (<2.3% of trials for children, <2.8% for adults). Accuracy in the dangerous-safe decision averaged 97.7% in the child group, with even the youngest (8 year olds) highly accurate (M = 98.2%).

4.4.4 Results

4.4.4.1 Do children (and adults) prioritize following fearful gaze in a danger-vigilance context?

An initial analysis showed that whether the specific target on a trial was dangerous or safe did not influence gaze-cueing effects in any way (i.e., no interactions of danger/safe status with gaze-cue validity, child/adult age group, expression, SOA, or any combination thereof, all *p*s > .230; see Supplementary Table 1 for means and *SD*s in all conditions). This indicates that the effects we will subsequently describe reflect the general top-down danger-vigilance context and do not require specifically a dangerous animal to be present on the trial; that is, the relevant factor is that dangerous animals occur on *some* trials, not that a dangerous animal is present on *this* trial.

Figure 3 shows gaze-cueing effects ($RT_{invalid\text{-}gaze\text{-}direction} - RT_{valid\text{-}gaze\text{-}direction}$) from fearful and happy faces, collapsed over whether the trial animal was dangerous or safe, for adults, and for all children averaged together. An ANOVA (Age x Expression x SOA) revealed a significant three-way interaction, $F(1,102) = 5.78$, *MSE* = 3349.56, *p* = .018, indicating that the pattern of cueing effects by expression and SOA differed between adults and children. We thus analyzed each age group separately.

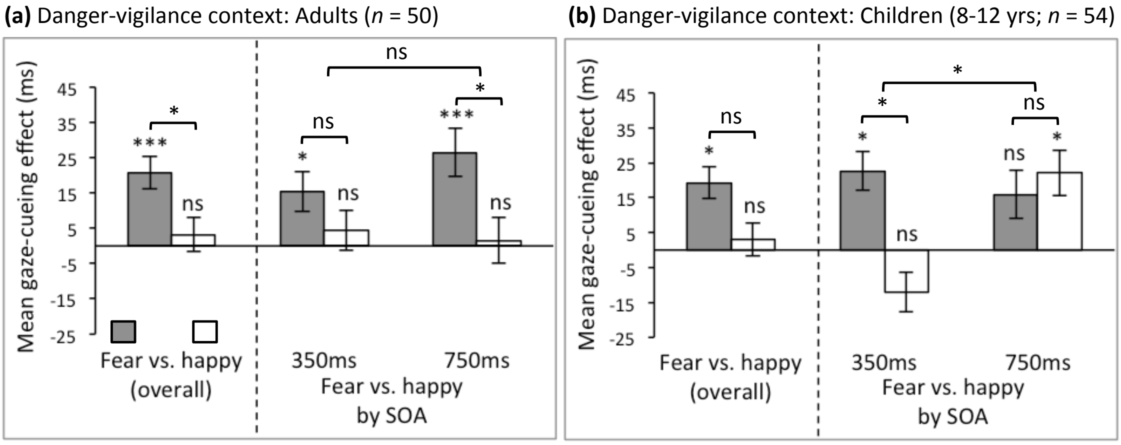

Figure 3 *Gaze-cueing effects ($RT_{invalid\text{-}gaze\text{-}direction} - RT_{valid\text{-}gaze\text{-}direction}$) from fearful versus happy faces in danger-decision context (main experiment), collapsed across SOA (left of each panel) and by SOA (right of each panel). Error bars indicate ±1 SEM. *p < .05. **p < .01. ***p < .001. Exact values reported for ps = .05 to .10. ns = non-significant at p > .10.*

For adults, gaze-cueing from fearful expressions (21ms) was significantly larger than gaze-cueing from happy expressions (3ms), *t*(49) = 2.54, *p* = .014, indicating priority of following fearful gaze in a danger-context and replicating previous studies (e.g., Friesen, Halvorson, & Graham, 2011). There was no interaction with SOA, indicating that adults' prioritizing of following fearful gaze was similarly strong regardless of the delay between the gaze-direction change and the animal-onset, *F*(1, 49) = 1.35, *MSE* = 1793.41, *p* = .251.

For children, in contrast, a significant Expression x SOA interaction was observed, *F*(1,53) = 4.67, *MSE* = 4788.27, *p* = .035. At the shorter 350ms delay, children prioritized following fearful gaze, with significantly greater gaze-cueing from fearful (23ms) than happy faces (-12ms), *t*(53) = 2.19, *p* = .033. However, at the longer 750ms delay this was not the case: there was no difference between fearful and happy gaze-cueing, *t*(53) = .35, *p* = .729 (indeed, the trend was in the opposite direction: fearful = 16ms, happy = 22ms), and there was significant gaze-cueing from happy faces (white 750ms bar in Figure 3b; the only condition in the whole design where significant gaze-cueing from happy faces occurred). Note that this change in children's results with SOA cannot reflect slower expression-context integration in children than in adults (due to slower neural processing): slower integration could have explained fearful gaze prioritization being present only at the *longer* delay, but cannot explain fearful gaze prioritization being found only at the *shorter* delay. (An alternative explanation is considered in the Discussion.)

To summarize, the key findings are that (a) adults prioritized following fearful over happy gaze, as indicated by greater gaze-cueing effects from fearful faces than from happy faces, and that this occurred regardless of SOA, (b) children demonstrated the same ability to integrate expression and context to drive social attention, showing prioritization of following fearful over happy gaze at the 350ms SOA, and (c) children showed an unexpected pattern at the longer 750ms delay, in which they did not prioritize following fearful gaze specifically because they also followed happy gaze.

4.4.4.2 Does fearful–gaze prioritization develop across the 8-12 year old age range?

We now address whether the fearful gaze prioritization emerges or strengthens within the age range of 8-12 years, or alternatively is stable across that age range. To do so, we computed each child's gaze-cueing score as a percentage of overall speed ($[RT_{invalid\text{-}direction} - RT_{valid\text{-}direction}]/([RT_{invalid\text{-}direction} + RT_{valid\text{-}direction}]/2) * 100$) (cf. Ramon et al., 2010). This is important to do when making quantitative comparisons in cueing across age. Children's reaction times on cognitive tasks typically decrease noticeably between 8 and 12 years – a result replicated here (RT averaged across all conditions was significantly negatively correlated with age in months, *ρ*[1](52) = -.550, *p* < .001) – meaning that, without correction for baseline changes with age, younger children would have more room to show greater cueing effects (McKone et al., 2012).

[1] Where distributions were significantly non-normal we evaluated relationships using the non-parametric correlation measure Spearman's rho.

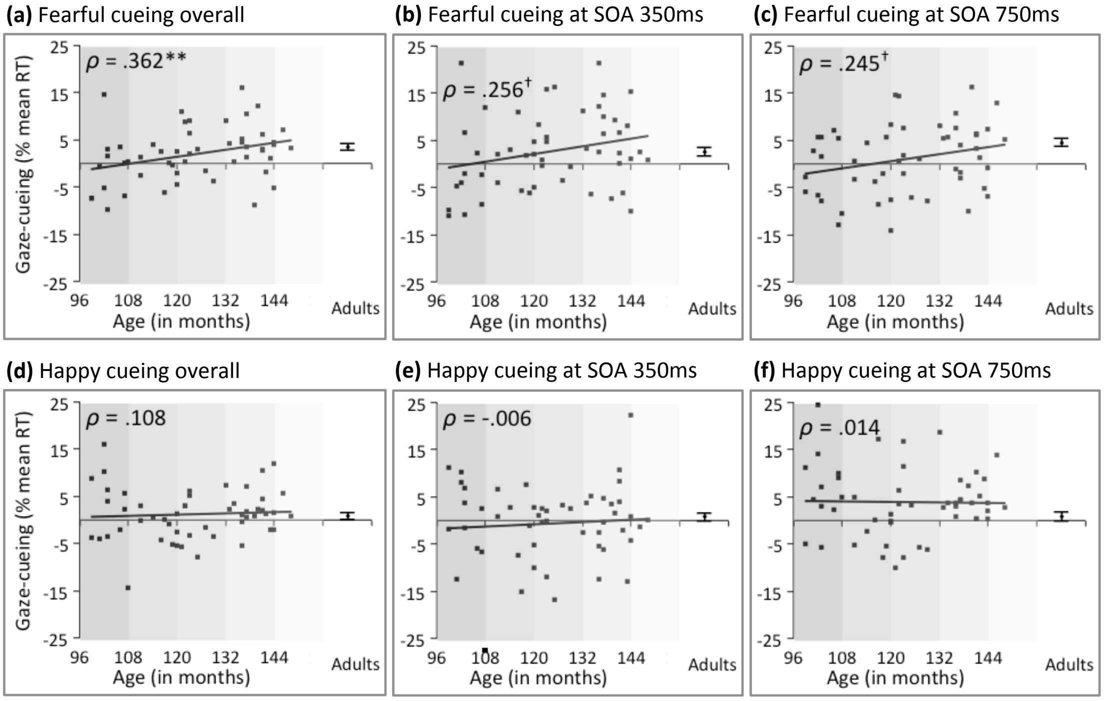

Figure 4 *Linear relationships between age of children (in months;* n = *52) and gaze-cueing effects in the danger-decision context, expressed as percentage of total mean RT for that condition* $(RT_{invalid\text{-}gaze\text{-}direction} - RT_{valid\text{-}gaze\text{-}direction})/([RT_{invalid\text{-}gaze\text{-}direction} + RT_{valid\text{-}gaze\text{-}direction}]/2 * 100$*. The mean for adults (n = 50) is shown on the right of each panel with SEM bars.* $^{**}p < .01$*.* $^{\dagger}p < .10$*.*

Figure 4 shows correlations of fear gaze-cueing, and of happy gaze-cueing, with age in months for 52 children (two statistical outliers with cueing effects more than 3*SD*s larger than the group mean were excluded; outliers were aged 9 years 7 months and 10 years 1 month). Results show that gaze-cueing from *happy* faces remained stable across the 8-12 year old age range – at approximately zero (as in adults) for the short SOA (Figure 4e), and at greater-than-adult levels for the long delay (Figure 4f) – with no correlations between percent-cueing and age (all ρs > .444). In contrast, gaze-cueing from *fearful* faces increased significantly across 8-12 years (Figure 4a). The correlation of fearful gaze-cueing with age in months was positive and significant when collapsed across SOA, $\rho(52) = .362$, $p = .008$. Similar trends were also demonstrated within each SOA separately, $\rho(52) = .256$, $p = .067$ for 350ms (Figure 4b), $\rho(52) = .245$, $p = .080$ for 750ms (Figure 4c; note scores for each SOA separately were more noisy due to having half the number of trials contributing to the score.) Numerically, the average trend line (collapsed across SOA as in Figure 4a) indicated no fear-gaze cueing in 8 year olds (-1.6%), followed by an increase of 1.5 percent-units per year, until by 12 years children's fear-gaze cueing had reached adult levels (12 years = 4.4%; adults = 3.6%).

The pattern of age-related increase in fear-gaze cueing, together with the stability of happy gaze-cueing, leads to the conclusion that priority for following fear gaze in a danger-vigilance context emerges across childhood, being absent at 8 years, and reaching adult levels by 12 years of age when looking at the overall results or those for SOA 350ms. Interestingly, there is no evidence that fearful gaze prioritization is sustained when the onset of the target is delayed, even in the oldest children tested here: even though following of fearful gaze at SOA 750ms has reached adult levels by 12 years (Figure 4c), following of happy gaze at SOA 750ms is still evident when it is absent for adults (Figure 4f).

4.4.4.3 Is the fear prioritization specific to the danger-vigilance context?

To be able to interpret these results of the main experiment in terms of the *interaction* of facial expression with the danger-decision context, it is important to rule out a general 'fearful gaze priority' (which is sometimes present even in younger children and infants; Hoehl, Palumbo, Heinisch, & Striano, 2008; Hoehl & Striano, 2010; Neath, Nilsen, Gittsovich, & Itier, 2013), which can arise from low-level stimulus differences between fearful and happy faces. For example, more eye-white (sclera) is normally visible in fearful than in happy expressions, and this could potentially enhance the salience of gaze-direction cues (Lee, Susskind, & Anderson, 2013) regardless of the context. To rule out a general fearful gaze priority arising from the facial expressions alone, we ran a control experiment replacing the target objects with scrambled versions of the animals, in which the faces appeared as in the main experiment and removed the context of danger-vigilance by changing the task to deciding whether a side-bar was blue or orange (Figure 1b).

This control experiment was completed by a new set of 54 adults with typical-population levels of anxiety (Table 1). Results showed a significant overall gaze-cueing effect ($t(53) = 3.42$, $p = .001$, for comparison to zero) and, critically, no evidence of a difference between amount of cueing from fearful and happy expressions, $t(53) = 1.26$, $p = .214$. There was also no interaction between expression and SOA, $F(1,53) = 1.08$, $MSE = 1477.91$, $p = .303$ (see Supplementary Table 1 for means and *SD*s by condition). Thus, differences between cueing effects from fearful versus happy expressions in the main experiment cannot be due to low-level face differences, and also must reflect the interaction of the facial expression with the danger-decision context. Also note these results imply there is no need to test children on the control experiment. This is for two reasons. First, we found age-related *increases* in fear priority with the danger-vigilance context (intact animals) yet even the *oldest* age group (adults) did not show any fear priority without the danger-vigilance context (scrambled animals). Second, the *youngest* children (8-year-olds) did not show any fear priority even *with* the danger-vigilance context, and there is no reason therefore to expect they would show any in an emotionally neutral context.

4.4.4.4 Do non-anxious children (and adults) show a threat bias in the presence of fearful expressions?

Returning to the main experiment using animal targets, we next examined whether the presence of fearful expressions (regardless of gaze direction) biased responses in favor of danger, in our typical-anxiety participants. Threat bias scores were calculated as the RT advantage for recognizing dangerous compared to safe animals ($RT_{safe} - RT_{dangerous}$). Note that collapsing over gaze direction is formally justified by no interaction between gaze-validity and animal-dangerousness for adults, $F(1, 49) < .01$, $MSE = 1845.87$, $p = .969$, or children, $F(1, 53) = .58$, $MSE = 6663.79$, $p = .449$ (and no 3-way interactions involving SOA, *ps* > .470). Supplementary Table 2 lists means and *SDs* in all conditions.

Figure 5 plots the key findings. Our first question was whether threat bias (responses to dangerous animals faster than responses to safe animals) was present *overall* in a general face context (i.e., irrespective of the specific expression or gaze direction). In analysis collapsing across expression (fear, happy, neutral), adults did show an overall threat bias ($M_{dangerous}$ = 558ms, M_{safe} = 572ms, $t(49) = 3.04$, $p = .004$). In contrast, the children did not ($M_{dangerous}$ = 748ms, M_{safe} = 746ms, $t(53) = 289$, $p = .773$). A correlational analysis within children also showed no increase in baseline-corrected threat bias ($[RT_{safe} - RT_{dangerous}]/([RT_{safe} + RT_{dangerous}]/2) * 100$) with age (i.e., no positive correlation with age-in-months, $\rho(52) = -.205$, $p = .146$). Confirming the different pattern for adults and children, there was a significant interaction between age group and animal-dangerousness, $F(1, 102) = 6.21$, $MSE = 8090.04$, $p = .014$.

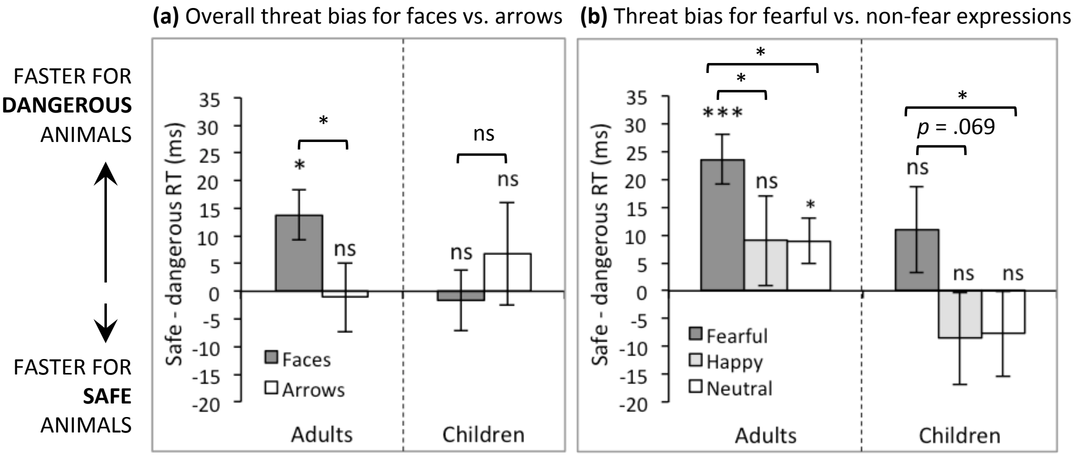

Figure 5 *Threat-bias scores. Values greater than zero indicate an RT advantage for dangerous over safe animals. (a) Adults show this threat bias when the context is social (i.e., main experiment including faces, averaged across the three facial expressions) but not when faces are replaced by arrows, while children do not show an overall threat bias even in the social context. (b) Both children and adults show a fear-specific threat bias; that is, stronger bias to process dangerous animals when the trial showed a fear face than a non-fear face. Error bars indicate ± 1SEM. *p < .05. **p < .01. ***p < .001. Exact values reported for ps = .05 to .10. ns = non-significant at p > .10.*

It is important to note that the threat bias in adults could not be attributed simply to the specific five danger images we selected as targets being easier to identify than the specific five safe images. A control experiment[2] (Figure 1c) conducted with the same adults (results shown in Figure 5a as white bars) showed both item sets were responded to equally rapidly when the cues were arrows rather than faces (adults: $M_{dangerous} = 595$ms, $M_{safe} = 594$ms, $t(49) = .17$, $p = .865$; note children also showed no threat bias in the context of arrows; $M_{dangerous} = 737$ms,

[2] The procedure was identical except that the faces were replaced by arrows pointing left or right (i.e., replacing gaze-direction) and there were only 40 trials.

M_{safe} = 742ms, $t(53) = .55$, $p = .584$). These arrow results additionally rule out the possibility that the threat bias in adults could be attributed to this group having higher mean anxiety levels than children (i.e., even though both our samples were typical of their population age-groups, population anxiety itself can change between child and early-adult ages; Bongers et al, 2003[3]): any such anxiety difference would have produced a threat bias in the presence of arrows cues. Together these results indicate there was something particular about including faces (presumably, the fearful faces), possibly in interaction with the explicit danger-vigilance task, which induced the overall threat bias in adults. In contrast, even the combination of a danger-vigilance task and the presence of faces was insufficient to induce an overall threat bias for dangerous animals in children.

Our second analysis addressed whether children, and adults, might show greater relative bias towards threat rather than safety if the *specific expression shown on a given trial was fear*. Figure 5b shows that this was the case. Both age groups showed bias scores that were significantly more positive when the cue face on a trial showed fear than non-fear emotions (happy or neutral, i.e. dark grey bars in Figure 5b are more positive than light grey and white bars). The difference between the fearful and non-fearful face trials was of a similar degree in children and adults (for children, threat bias for fear 15ms greater than average of happy and neutral; for adults 19ms difference), with no significant interaction between age and expression, F(1.74, 177.78 with Greenhouse-Geisser correction) = .044, $MSE = 3896.79$, $p = .940$. For adults, planned contrasts confirmed that threat bias was greater for fearful faces relative to happy faces, $t(49) = 2.31$, $p = .025$, and neutral faces, $t(49) = 3.29$, $p = .002$. For children, threat bias was greater for fearful relative to neutral faces, $t(53) = 2.27$, $p = .030$, and there was a trend in the same direction for fearful relative to happy faces, $t(53) = 1.86$, $p = .069$. Within the children, there was no increase in a *fear minus average-of-happy-and-neutral* baseline-corrected threat bias score with age-in-months, $\rho(52) = -.202$, $p = .152$, indicating that the effect was no weaker in 8 year olds than in 12 year olds.

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[3] Note we cannot assess any such changes in our own groups, nor use anxiety as a covariate in our age-difference analysis of threat bias, because we used different instruments to measure anxiety in children and in adults.

In summary, our analyses in typical anxiety participants found that 8 through 12 year olds showed one aspect of adult-like threat bias, with both groups quicker to respond when a fear face was presented immediately prior to the animal than when a non-fear face was presented. However, children were not adult-like in showing an overall threat bias induced by having faces (rather than arrows) present in the global 'fear-might-be-present' context of the experiment.

4.4.5 Discussion

Our results show, for the first time, that expression-context interactions influence emotional gaze-following and threat bias in children, and also that children are not fully mature in all of these abilities. We found that one aspect of expression-animal-context interaction was at adult levels by 8 years, namely threat bias for dangerous animals when cued specifically by fearful faces (irrespective of gaze direction). Another aspect developed across the 8-12 years range, reaching adult levels by 12 years, namely priority for following fearful gaze when the task required participants to be on the look out for danger and there was a short delay between face and animal onset. Finally, other aspects were not mature even by 12 years. Even older children showed no priority for following fearful gaze during danger vigilance with a longer delay between face and animal onset. Children also did not show an *overall* threat bias for dangerous animals (in the general context of faces regardless of expression or gaze direction).

4.4.5.1 Social attention: Fearful gaze priority in following eye-gaze when on the look out for danger

Regarding social attention, we have provided the first evidence that children use top-down information about a context in which the environment might contain danger to prioritize following fearful over happy gaze-direction. This ability was present with short delays (SOA of 350ms) between the facial expression and the target, and developed over the 8-12 year old age range, with the oldest children showing adult levels of fearful gaze priority (overall), and the youngest children showing no fearful gaze priority.

One question of interest is why we found that fearful gaze priority in a danger-vigilance context emerges so late (i.e., after 8 years). This issue arises because several other studies have found that a different form of fearful gaze priority can emerge much earlier in development. In infants, ERP studies have found that babies show priority in shifting attention when faces display fear, in studies testing non-social, non-emotional contexts that did not involve danger (looking towards toy cars or balls; Hoehl et al., 2008; Hoehl & Striano, 2010). Similarly, in children, Neath et al. (2013) reported that from age seven years children prioritize fear (and surprise) gaze at adult levels, in a Posner-like paradigm using emotionally neutral, non-danger contexts: the looked-at stimuli were asterisks. The key difference between these previous findings and the present study is that we have tested *top-down context-driven* fearful gaze priority, namely gaze-following to look towards animals where dangerous animals could occur on some trials and the task required vigilance for that danger. Importantly, our control experiment results also confirmed that the fearful gaze priority in our study was specifically due to this expression-context interaction; that is, it could not be explained by differential cueing *per se* between our fearful and happy expression stimuli (because differential gaze-cueing was absent in the non-danger color-decision/scrambled animal context).

Thus, considering all results together, we suggest that that the following interpretation would be consistent with the currently available findings: (a) children prioritize following eye-gaze in 'attention grabbing' emotions (fear, surprise) from young ages (possibly due to large low-level differences that typically occur in real-world faces such as more sclera; Neath et al., 2013; Tipples, 2006), and that (b) a more advanced taking into account of top-down task context ('attentional set'), sufficient to support the danger-context-specific fearful gaze priority revealed in the circumstances of the present study, emerges later. This late emergence (after 8 years) suggests that use of expression-context interactions to drive attentional shifts is not an innate ability. Instead, the late emergence implies either that this ability is learned via specific experience – consistent with evidence that associations between expressions and environmental threats such as snakes can be learned (Rakison, 2009) – and/or that it emerges as part of children's general cognitive development across the 8-12 year old age range – as consistent with evidence of development in basic abilities that may contribute to using expression-context interactions to drive attentional shifts (e.g., attention, memory, reasoning; Davidson, Amso, Anderson & Diamond, 2006; Schneider & Pressley, 1997; Plude, Enns, & Brodeur, 1994).

Importantly, we note that the present findings cannot be generalized to a claim that all expression-context interactions emerge only after 8 years. Body postures affect judgments of a face's expression as early as 6 years (Mondloch et al. 2013). And, even when specifically considering shifts in social attention, our present study, as the first on the topic, has tested only one specific set of parameters, and does not rule out the possibility that development of context-specific fear-priority might occur earlier than 8 years in other specific circumstances (e.g., with child rather than adult face stimuli, or in children with different patterns of lifetime experience; see Open Questions).

A final finding suggested by our results concerns ongoing development in fear prioritization even beyond 12 years. Between 12 years and adulthood, a role for attentional control development is implied by our finding that, unlike adults, even the older children were unable to sustain their prioritization of fearful gaze when the onset of the target was delayed. Our finding that older children prioritized fear only at the 350ms SOA, and not the 750ms SOA, could be interpreted in terms of late development of selective attention. For example, selective attention is known to be immature even in 12 year olds and to show ongoing development into the teenage years (e.g., Plude, Enns, & Brodeur, 1994). Thus, it might be that the children were able to maintain selective attention for fearful gaze only for a very brief window period, and that the longer delay tested was outside this window, so that happy gaze was no longer filtered out (i.e., explaining why this was the only condition in which we observed gaze-cueing from happy faces).

4.4.5.2 Threat bias in a fearful-face context (in non-anxious participants)

Turning to our threat bias results, we found that children across the full 8-12 years age range were adult-like in one respect: they used the context of an immediately-present fearful face (regardless of its gaze-direction) to produce a bias in favor of perceiving and responding to threat in the environment. In adults, our finding of stronger threat bias on trials presenting fear faces than on trials presenting other expressions is consistent with Friesen et al. (2011). Here, we have extended these results to children, demonstrating that maturity of the fear-specific threat bias was reached in quite young children (at or before 8 years).

At the same time, children were not mature in all aspects of using context to drive threat bias. Unlike adults, even the older children failed to use the *global* context of the experiment – namely, the presence of expressive faces including fear and the decision context about the dangerousness of animals – to invoke an overall bias for threat.

A final important finding of the present study is that threat bias – faster processing of dangerous than safe animals – was observed in participants with normal population levels of trait anxiety. Commonly, threat bias is only found in highly anxious participants (Bar-Haim et al., 2007). Typically, however, these studies have assessed threat bias in the absence of any social context. Here, in the context of faces displaying emotional expressions including fear, we have found threat bias in both adults and children verified to have normal population levels of anxiety.[4]

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[4] Also note that there were no significant correlations within our samples between individuals' anxiety level and their threat bias (adults overall threat bias, $r = .161$, $p = .265$; adults fear-greater-than-other-emotions threat bias, $\rho = -.084$, $p = .563$; children overall threat bias, $\rho = .218$, $p = .120$; children fear-greater-than-other-emotions threat bias, $\rho = -.088$, $p = .537$). This is as would be expected given the low range of anxiety scores compared to studies that test clinical groups or deliberately select participants only from the extreme ends of the normal range.

4.4.5.3 Open questions

The present results suggest that the age at which children's processing of expression-context interactions emerges, and reaches maturity, varies substantially across different specific aspects (e.g., earlier for fearful-face-specific threat bias, later for fear priority of following eye-gaze when on the lookout for danger). We also note there are factors that might potentially modulate the age of maturity, for the specific situations we have addressed here.

First, in our study, the expressions were displayed by an adult face. We chose this situation as the first to test on the grounds that, in everyday life, children may rely particularly on adults to keep them from harm's way. For future studies, an interesting question is whether children continue to show danger-context-specific fearful gaze priority, and threat bias, if the face displaying fear was that of another child (see Lobue, Matthews, Harvey, & Thrasher, 2013 for suggestions that threat detection varies between child and adult models).

Second, our adult face was unfamiliar to the participants. It is possible that children might show earlier development of danger-context-specific fear-priority if the face displaying the expression is personally familiar to the child.

Third, specific patterns of lifetime experience might play a role, such as the culture or specific personal circumstances in which a child is raised. This idea arises because our results suggest a role for learning, in that we found some aspects of expression-threat interactions were still immature in 8-12 year olds. Considering culture, our participants were westernized children who do not typically experience many real life-threatening dangers (e.g., tigers) early in life on a regular basis. Perhaps priority for following fearful gaze in danger-vigilance contexts might emerge earlier than 8 years of age in societies where it is more important for children's survival for them to learn this ability earlier, such as hunter-gatherer societies or societies at war. Regarding personal circumstances, it is possible that age of emergence of expression-context interactions might be influenced by a history of abuse. This is known to occur for perception of fearful expressions (Masten et al., 2008) and, separately, for perception of environmental threats (Lee & Hoaken, 2007), with maltreated children more sensitive to both than non-abused children. The question in the present case is whether abused children might also show greater sensitivity to expression-environment *interactions* based around fearful faces and a danger-vigilance context. Abused children may have, at a young age, received extensive exposure to expressions of fear (e.g., displayed by their mother or siblings) and become attuned to the need to prioritize following gaze-direction in these faces in a danger context (e.g., to locate their angry father). The gaze-cueing paradigm used in the present study offers a way of investigating whether this experience with social interactions involving danger-vigilance might lead these children to develop priority for following fearful gaze in a danger-vigilance context earlier than the relatively late development that we observed here.

4.4.5.4 Conclusion

Current understanding of the childhood development of emotional face processing is based largely on findings from isolated faces. The results of the present study argue that, like adults, children can show complex expression-context interactions. Our findings extend those of Mondloch (2013) – who found that 6 year olds' processing of facial expressions is influenced by emotional body posture – to other, more complex, interactions involving facial expression and dangerous animal stimuli, and show that some of these interactions take longer to develop than body-posture effects. Also of interest is that the expression-threat interactions we found were bi-directional. Children's following of social attention from fearful faces was enhanced by a threat context. And, in turn, children's threat bias for dangerous animals was enhanced by a fearful face context. Overall we conclude that, in order to fully understand how children process emotional stimuli, future theorizing and empirical work needs to move beyond the study of isolated faces, or isolated threat stimuli, to consider how (and when) processing of facial expressions and the environments in which they occur interact (as has been argued for adults; Barrett, Lindquist, & Gendron, 2007).

4.4.6 Acknowledgements

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4.4.7 References

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4.4.8 Supplementary materials

Supplementary Table 1

Mean RTs in ms with SDs in parentheses for invalid and valid gaze-direction trials and mean gaze-cueing effects

		Primary experiment: Danger-decision/animal targets						Control experiment: Colour-decision/scrambled targets		
		Adults (*n* = 50)			Children (*n* = 54)			Adults (*n* = 54)		
		Fearful	Happy	Neutral[1]	Fearful	Happy	Neutral	Fearful	Happy	Neutral
SOA 350ms	Invalid	572 (-96)	573 (-101)	575 (-98)	765 (141)	752 (128)	767 (139)	499 (94)	500 (100)	503 (95)
	Valid	557 (-85)	568 (-99)	566 (-96)	742 (142)	764 (155)	750 (137)	488 (97)	488 (87)	497 (103)
	Cueing	15 (-40)	4 (-40)	9 (-45)	23 (66)	-12 (76)	17 (74)	11 (38)	11 (38)	6 (38)
SOA 750ms	Invalid	565 (-94)	561 (-91)	583 (-110)	741 (141)	742 (136)	762 (141)	477 (92)	473 (92)	492 (92)
	Valid	539 (-79)	559 (-110)	564 (-105)	725 (138)	720 (146)	740 (147)	466 (92)	473 (94)	480 (86)
	Cueing	26 (-48)	2 (-45)	20 (-34)	16 (81)	22 (69)	22 (71)	11 (40)	0 (40)	12 (32)
Total	Invalid	569 (-93)	567 (-94)	579 (-102)	753 (136)	744 (127)	765 (134)	488 (91)	487 (95)	498 (92)
	Valid	548 (-80)	564 (-103)	564 (-99)	734 (137)	741 (144)	746 (141)	477 (90)	482 (90)	488 (92)
	Cueing	21 (-33)	3 (-34)	15 (-29)	19 (59)	3 (56)	19 (52)	12 (28)	5 (22)	10 (23)

[1]In the present study, the neutral expression cue faces were included to examine our threat bias question rather than our gaze-cueing question, but we present gaze-cueing results from neutral expressions here for interested readers. Note that our analysis of fear-priority in gaze-following was based on comparing gaze-cueing from fearful faces with gaze-cueing from happy faces. This followed previous studies (Friesen, Halvorson, & Graham, 2011; Kuhn & Tipples, 2011) and is based on the argument that it is best to compare one emotional expression with another so that they both convey clear physical signals to emotion. In contrast, any signals conveyed by 'neutral' expressions are weak and ambiguous. Also, neutral expressions are not necessarily perceived as being truly neutral or as having *no* expression (e.g., can be perceived as negatively valenced, e.g., Lee, Kang, Park, Kim, & An, 2008). Thus neutral expressions are a poor baseline for comparison with emotional expressions. Indeed, results in this Table indicate that, in our study, gaze-cueing from neutral faces tended to mimic that from fearful expressions rather than happy expressions in the danger-vigilance context (possibly because neutral faces may have been perceived as slightly fearful in the presence of dangerous objects).

Supplementary Table 2

Mean RTs in ms with SDs in parentheses for safe and dangerous animal trials and mean threat-bias effects

	Adults (*n* = 50)					Children (*n* = 54)				
	Faces				Arrows	Faces				Arrows
	Fearful	Happy	Neutral	Total		Fearful	Happy	Neutral	Total	
Safe	570 (92)	570 (113)	576 (100)	572 (100)	594 (74)	749 (140)	738 (134)	752 (131)	746 (132)	738 (126)
Danger	546 (81)	561 (89)	567 (113)	558 (88)	595 (85)	738 (132)	747 (139)	759 (134)	748 (136)	731 (130)
Threat-bias	24 (31)	9 (57)	9 (28)	13 (32)	1 (44)	11 (57)	-9 (61)	-8 (56)	-2 (41)	7 (68)

Chapter 5: Attention abnormalities in callous unemotional traits are not specific to eye-gaze or fear

5.1 Chapter overview

The purpose of Chapter 5 is to investigate the theoretical mechanisms that have potential to underlie problems with emotion recognition in CU traits. There are three theoretical accounts of why people with high CU show deficits in facial emotion recognition – deficits processing distress, reduced looking at the eyes, or general attention abnormalities. One of these theories has only been tested in relation to childhood and adolescent CU traits, whilst another has only been tested in relation to adulthood psychopathy in forensic populations. Here these three theories are directly compared for the first time, using the gaze-cueing paradigm established in Chapter 4, for which each theory makes different predictions. Data presented here are from the adult participants in Chapter 4.

5.2 Publication status

The following manuscript is currently under review for publication as follows:

Dawel, A., Palermo, R., Irons, J., O'Kearney, R., & McKone, E. ('Major revisions' decision received 17/07/14 from *Personality Disorders: Theory, Research, and Treatment*; manuscript currently undergoing revisions). Attention abnormalities in callous unemotional traits are not specific to eye-gaze or fear.

5.3 Author contributions

- **Dawel** proposed the project.
- **Dawel** was responsible for the literature review.

- **Dawel** conceived and designed the experiments, with advice from Palermo, Irons, McKone, and O'Kearney, and from an overseas colleague (Dr Andrew Bayliss).
- **Dawel** and Irons programmed the experiment and modified the stimuli.
- **Dawel** collected most of the data, with some assistance from Irons and a Research Assistant (Ms Emma Cummings).
- **Dawel** analyzed the data and produced the figures, with suggestions from Palermo and McKone.
- **Dawel** drafted the manuscript.
- **Dawel** and Palermo together refined the manuscript, with detailed editing provided by Palermo.
- The manuscript was then further refined by **Dawel** and McKone, with detailed editing provided by McKone. O'Kearney also reviewed the manuscript and provided general content comments and suggestions, and some editing.

5.4 Manuscript: Attention abnormalities in callous unemotional traits are not specific to eye-gaze or fearful faces

5.4.1 Abstract

Impaired processing of fearful expressions is an established feature of callous unemotional traits (CU). We directly contrast three possible theoretical mechanisms underlying this impairment. Theory 1 proposes specific difficulties in processing others' distress. Theory 2 argues for lack of attention to the eyes of faces. Theory 3 proposes that abnormalities in attention are more general and also encompass non-social stimuli. The theories make different predictions about how individuals with high CU would shift attention in response to directional cues provided by eye-gaze in faces versus non-social stimuli (arrows), and by eye-gaze in fearful versus other facial expressions. We measured Posner-style cueing effects in adults with high CU (n = 32) compared to low CU (n = 68), from fearful, neutral and happy expressions, and arrows. Results supported Theory 3. Directional shifting of attention was decreased in high CU equally in all conditions. This could not be attributed to high CU participants being unwilling to engage in the tasks: both groups showed equal overall accuracy and reaction times. Interestingly, the high CU group's ability to suppress following of eye-gaze cues emerged across blocks. In contrast, the low CU group showed no reduction in eye-gaze cueing even with extensive practice, indicating processing of gaze-direction was mandatory. Thus high CU individuals are able to suppress information that is mandatorily processed in typical, low CU individuals, when it is irrelevant to their top-down attentional goal-set.

5.4.2 Introduction

Callous unemotional traits (CU) refer to a cold, uncaring interpersonal style, lacking in empathy and remorse. CU is a key factor in psychopathy, and is arguably the factor that differentiates psychopathy from other disorders involving impulsivity and antisocial behavior (e.g., ADHD; Frick, Ray, Thornton, & Kahn, 2013).

Individuals with higher levels of CU have problems recognizing fearful facial expressions (for meta-analysis see Dawel, O'Kearney, McKone, & Palermo, 2012). Some theorists argue that this deficit is part of a broader problem with processing others' distress cues in psychopathy (*distress-specific* theory; Blair, 2006). Others postulate that poor recognition of fearful expressions can be explained by lack of attention to the eyes of faces (*attention-to-eyes* theory; Dadds et al., 2006), given that the eyes are particularly important for recognizing fear relative to other emotions (Calder, Young, Keane, & Dean, 2000). Reduced looking at eyes in CU has been demonstrated for all facial expressions (Dadds, El Masry, Wimalaweera, & Guastella, 2008), and theoretically this could be linked to CU via its role in social bonding (Dadds, Jambrak, Pasalich, Hawes, & Brennan, 2011). A third viewpoint, developed using forensic psychopaths, proposes that attention abnormalities are more general and encompass non-social stimuli as well as social stimuli (*general-attention-abnormality* theory; Newman, Curtin, Bertsch, & Baskin-Sommers, 2010). This theory associates psychopathic traits with *enhanced* top down control over suppressing information that is irrelevant to the individual's goals. This could explain lack of attention to the eyes, and in turn problems with recognizing fear from faces, if high CU individuals are able to effectively ignore eyes that otherwise mandatorily attract attention in typical individuals.

Table 1

Brief description and predictions of the three theories

Theory	Gaze-cueing from fearful expressions	Gaze-cueing from other expressions	Arrow-cueing
1. Specific deficit in processing others' distress (Blair, 2006)	Decreased	Normal	Normal
2. Abnormal attention to eyes of faces (Dadds et al., 2006)	Decreased	Decreased	Normal
3. Abnormalities in general attention (including non-social stimuli) (Newman et al., 2010)	Decreased	Decreased	Decreased

We pit these three theories directly against one another for the first time, using a paradigm that tests their differential predictions (summarised in Table 1) about how groups with high CU versus low CU would shift attention in response to directional cues. We contrasted cues from eye-gaze in faces versus non-social stimuli (arrows), and also varied for eye-gaze whether the face displayed fearful versus other facial expressions. Strength of attention shifting (cueing) was measured as the difference in reaction time to identify targets whose location (left or right) was validly versus invalidly cued by the direction of eye-gaze or arrows (Figure 1). Importantly, our direction cues were *nonpredictive* of where the target actually occurred (i.e., only 50% of trials were validly cued). Thus, the direction cues were irrelevant to the direct goal of the task (which is to locate and classify the target).

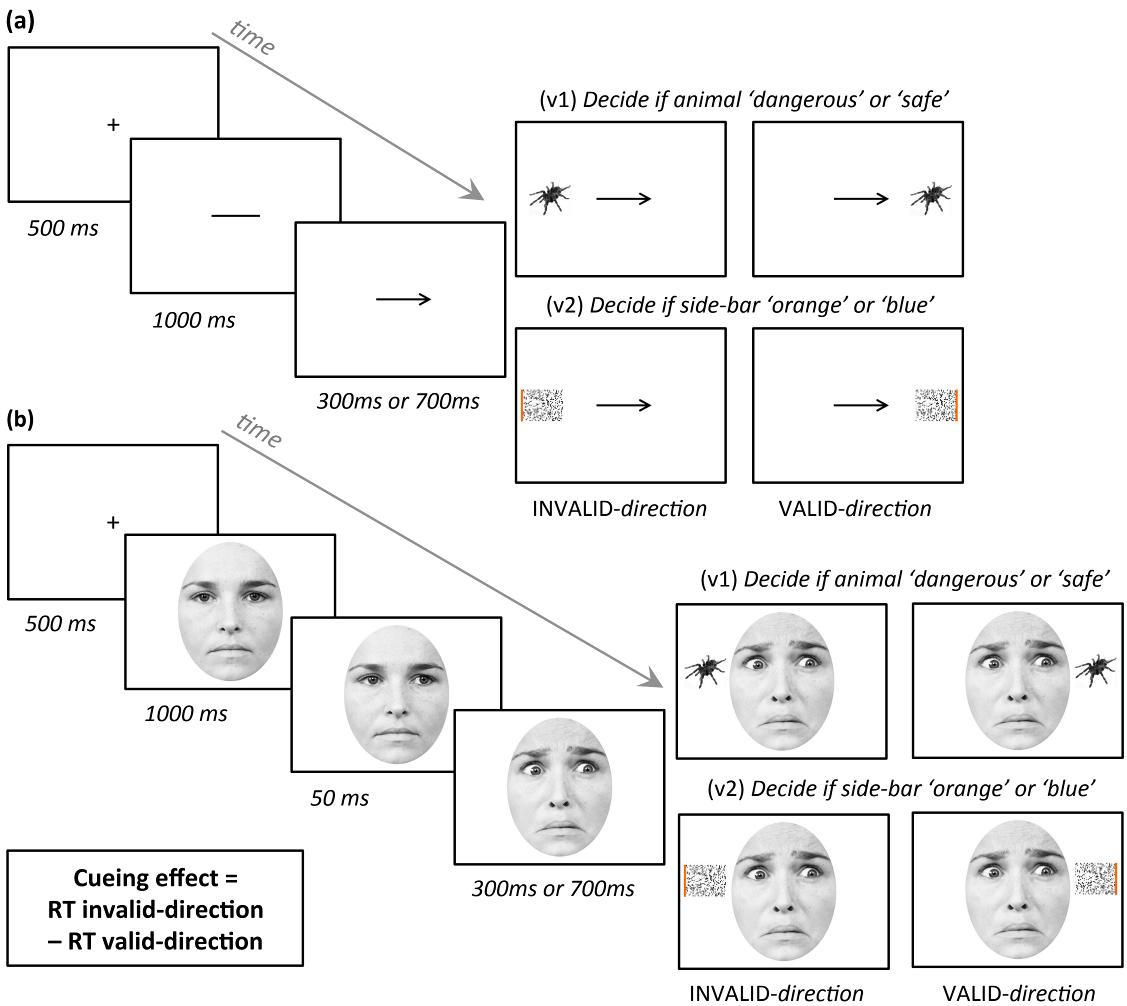

Figure 1. (a) Arrow cueing sequence. (b) Eye-gaze cueing sequence.
(v1) Danger-decision version. (v2) Emotionally-neutral-decision version.

In this paradigm, the *distress-specific* theory would be supported if CU effects on cueing were fear-specific; that is, if cueing from fearful faces was *weaker* in high CU than in low CU (because of theorized *deficits* in processing expressions of distress) and, at the same time, there were no differences for facial expressions that do not signify distress (happy and neutral) or for arrows. This theory also led us to test a dangerous-versus-safe target decision version of the task (v1 in Figure 1), as well as a more traditional emotionally-neutral target decision version (v2). A danger vigilance context increases eye-gaze cueing from fearful faces in typical individuals (Friesen, Halvorson, & Graham, 2011). Thus, this context might maximize the chances of revealing a fear-specific impairment in high CU, because the distress-specific theory predicts lack of processing of both the fearfulness in the face and the danger in the environment.

In comparison, the *attention-to-eyes* theory predicts high CU should be associated with weaker gaze-following irrespective of the face's emotional expression. However, the influence of CU should be specific to faces, with no difference between high and low CU groups for arrows.

Finally, the *general-attention-abnormality* theory predicts that CU effects should be the same for all conditions (all facial expressions, and faces versus arrows). Specifically, in our design using direction cues that are *nonpredictive* of where the target will actually occur, this should take the form of *less* attention shifting in high CU than in low CU. This is because the general-attention-abnormality theory proposes an 'attention bottleneck' established by top-down goal-set, which prevents extraneous bottom-up input that is normally salient, such as signals of fear or the presence of eyes, from capturing attention (Baskin-Sommers, Curtin, & Newman, 2011). Thus, when participants are aware that direction cues do not reliably predict the target location, and are irrelevant to the participant's top-down task goals (making a decision about the *target*, e.g., dangerous or safe), individuals with high levels of CU should be better able to ignore the task-irrelevant direction cues. In contrast, low CU individuals would be expected to show mandatory following of nonpredictive directional cues as has been demonstrated with both eye-gaze and arrows in typical populations (e.g., Stevens, West, Al-Aidroos, Weger, & Pratt, 2008).

5.4.3 Method

5.4.3.1 Low and high CU participants

We tested variations in CU within the general population (c.f. Essau, Sasagawa, & Frick, 2006), which minimized complexities found in testing forensic populations (substance abuse, extreme violence). Participants analyzed were 100 Caucasians (70 females, M_{age} = 20 years, SD_{age} = 3.2, $\text{range}_{\text{age}}$ = 17-42), with n = 48 (34 in low CU group, 14 in high CU group) assigned to the danger-decision version, and n = 52 (34 low CU, 18 high CU) assigned to the emotionally-neutral-decision version. An additional eight participants were excluded because of unusually long reaction times ($>\text{RT}_{M\text{sample} + 1.96 SD\text{sample}}$). No participant reported a disorder that can affect face processing (e.g., psychosis, autism, ADHD). Participants were recruited via fliers at the Australian National University or undergraduate course participation.

CU traits were measured with two self-report scales: the Inventory of Callous Unemotional Traits (ICU; Essau, Sasagawa, & Frick, 2006) and the callous subscale (Brinkley, Diamond, Magaletta, & Heigel, 2008) of the Levenson Self-Report Psychopathy Scale (LSRPS; Levenson, Kiehl, & Fitzpatrick, 1995). We combined the two scales to maximize reliability (Cronbach's α = .824 for combined items). To do so, z-scores were calculated for each scale and then averaged to give a single CU score for each participant. Following Dadds et al. (2011), the final sample was split using these scores into the top 33$^{\text{rd}}$ percentile (n = 32) and the bottom 66$^{\text{th}}$ (n = 68) percentile to form high and low CU groups respectively. Table 2 shows the groups differed significantly on both measures of CU, but not on two variables we included as covariates: antisociality, as measured using the antisocial subscale of the LSRPS (Brinkley et al., 2008); and trait anxiety, as measured by the Spielberger State Trait Anxiety self-report scale (STAI-Y2; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). These were included to allow us to analyse effects of CU independently of any effects of antisociality and anxiety on attention cueing effects.

Table 2

Descriptive statistics for questionnaire measures with t-tests comparing CU groups

	Low CU (n = 68)		High CU (n = 32)				Number of items	Cronbach's α for total (n = 100)
Measure	M (SD)	Range	M (SD)	Range	t	p		
Age (in yrs)	20.0 (2.6)	17-35	20.9 (4.3)	18-42	1.31	0.194	n/a	n/a
ICU total	15.4 (5.4)	4-25	25.8 (5.8)	9-37	8.72	<.001***	24	.817
LSRPS callous	6.1 (1.5)	4-9	9.1 (1.9)	6-14	8.67	<.001***	4	.452
LSRPS antisocial	9.6 (2.3)	5-16	10.0 (2.4)	5-15	0.71	0.482	5	.458
STAI-Y2	43.4 (10.1)	26-71	43.0 (10.4)	23-62	0.18	0.856	20	.927

***$p < .001$.

5.4.3.2 Cueing tasks

Each participant first completed an arrow cueing task (Figure 1a), followed by an eye-gaze cueing task (Figure 1b). In danger-decision versions, the targets that the arrows/eye-gaze pointed towards, or away from, were greyscale photographs of five dangerous animals (attack-dog, tiger, snake, shark, spider) and five safe animals (duckling, kitten, rabbit, goldfish, butterfly) (Supplementary Figure 1a). In emotionally-neutral-decision versions, targets were scrambled versions of the same animals with the orange or blue side-bars (Supplementary Figure 1b). Maximum target size was 6.3° x 4.4°.

5.4.3.3 Arrow-cueing procedure

Participants were instructed to look at the central arrow, but were told (truthfully) that the direction it pointed would not predict where targets would appear. The task was to quickly press a key to indicate whether a 'dangerous' or 'safe' animal, or an 'orange' or 'blue' side-bar, appeared.

Arrow stimuli and fixation bars measured 5.6° x 0.3° and 5.0° x 0.3° respectively. Targets, located 8.0° horizontally away from screen center, were presented until response. Response hand assignment to left-right buttons was counterbalanced across participants. Inter-trial interval was 1000ms.

Following 8 practice trials, participants completed a single block of 44 test trials. The initial 4 trials of were discarded from analyses to allow participants to settle into the task (total trials analyzed = 40). Test trials included all combinations of arrow-direction (left, right), arrow-validity (valid-direction, invalid -direction), target type (5 dangerous animals, 5 safe animals, or their scrambled versions), and SOA between the arrow appearing and target onset (300ms, 700ms; see Figure 1). Varying SOA ensured that participants could not anticipate when targets would appear; note all reported analyses are collapsed over SOA (preliminary ANOVAs showed no interactions involving SOA and low-versus-high-CU group, *p*s > .289). Order of trials was randomized for each participant. No more than four trials of the same SOA occurred in a row.

5.4.3.4 Gaze-cueing procedure

Trial sequence (Figure 1b) was identical to the arrow-cueing procedure with the following exceptions. An additional 50ms neutral face with eyes-averted was included to mimic dynamic shifting of gaze and then reacting with an emotional expression. Cue faces (Supplementary Figure 1c) were greyscale photographs of a single woman (following Friesen, Halvorson, & Graham, 2011) from the Radboud Face Database (model 61, selected because her fear, happy and neutral expressions are recognized at greater than 90% accuracy; Langner et al., 2010). The faces subtended 9.4° x 12.9° of visual angle. Targets were vertically aligned with the face's eye position.

Following 8 practice trials, participants completed three blocks of 84 test trials (total test trials analyzed = 240). Test trials included all combinations of gaze-direction, gaze-validity, target animal type, SOA, and expression displayed by the cue face (fearful, happy, neutral).

5.4.3.5 Initial data screening

In addition to incorrect responses (<3% of trials), outlier reaction times for individual trials were excluded (<3.5% of trials) if they were pre-emptive (<200ms), unusually delayed (>3000ms), or were upper outliers based on remaining RTs for each block (>$RT_{M+2.5SD}$).

5.4.4 Results

5.4.4.1 Nonpredictive cueing effects are smaller in high CU

Our key finding (Figure 2a) was that attentional shifting in response to the nonpredictive direction cues was weaker in the high CU group than in the low CU group, and this effect did not vary significantly by emotional expression (right panel Figure 2a) nor between arrows and eye-gaze (left panel Figure 2a). Further, there was no trend to suggest that the CU difference was strongest for fearful faces, or for eyes rather than arrows, even in the danger-vigilance version of the tasks (Figure 2b). The results thus provide no evidence of specificity of CU effects for either fearful expressions, or for eyes. Instead, results conform to the predictions of the *general-attention-abnormality* theory, and argue that the high CU group were better able to suppress following of directional cues from both faces and arrows. In contrast, in our low CU group – despite knowledge that the cues were nonpredictive – both eye-gaze and arrow cues mandatorily grabbed attention (i.e., all low CU cueing effects were larger than zero in Figure 2).

The statistical analyses that led to these conclusions are as follows (Supplementary Tables show means and *SD*s for all conditions). Preliminary ANOVAs showed no interactions involving CU group and task version (danger-decision versus emotionally-neutral-decision), *p*s > .280. Therefore we collapsed across the two versions in all further analyses, to maximize participant numbers and statistical power. To compare CU effects for different facial expressions we conducted an ANOVA including emotional expression (fearful, happy, neutral) and covariates of antisociality and anxiety. Overall gaze-cueing was significantly smaller in the high CU group (M = 5ms) than the low CU group (M = 12ms), as indicated by a main effect of group, $F(1,96) = 5.41$, $MSE = 3297.72$, $p = .022$. Importantly, this CU-related reduction was equivalent across expressions, as indicated by the absence of a CU-group x expression interaction, F(1.78,171.30 for Greenhouse-Geisser correction) = 1.21, $MSE = 529.47$, $p = .304$. To compare cueing effects for faces versus arrows, we conducted a second ANOVA with cue-type (arrows, eye-gaze collapsed over expression) as the within-subjects variable, and the same covariates. Overall cueing was weaker in high CU relative to low CU, as indicated by a main effect of group, $F(1,96) = 8.13$, $MSE = 6102.30$, $p = .005$, and this decrease was equivalent across arrows and faces, as indicated by the absence of a CU-group x cue-type interaction, $F(1,96) = 1.97$, $MSE = 934.58$, $p = .164$. We also conducted planned contrasts comparing high and low CU in each condition separately. Cueing was significantly smaller in high CU for arrows, M_{highCU} = 8ms, M_{lowCU} = 24ms, $t(98) = 2.44$, $p = .016$, and for neutral expressions, $t(98) = 2.28$, $p = .025$; trends in the same direction were not significant from fearful, $t(98) = 1.55$, $p = .123$, or happy expressions, $t(98) = .42$, $p = .676$. Together, results argue that attention abnormalities in high CU are not specific to the eyes, but also encompass non-social stimuli like arrows. In addition, attention abnormalities in high CU are not strongest for fearful faces; if anything, the evidence was strongest for a CU effect on gaze-following from neutral expressions.

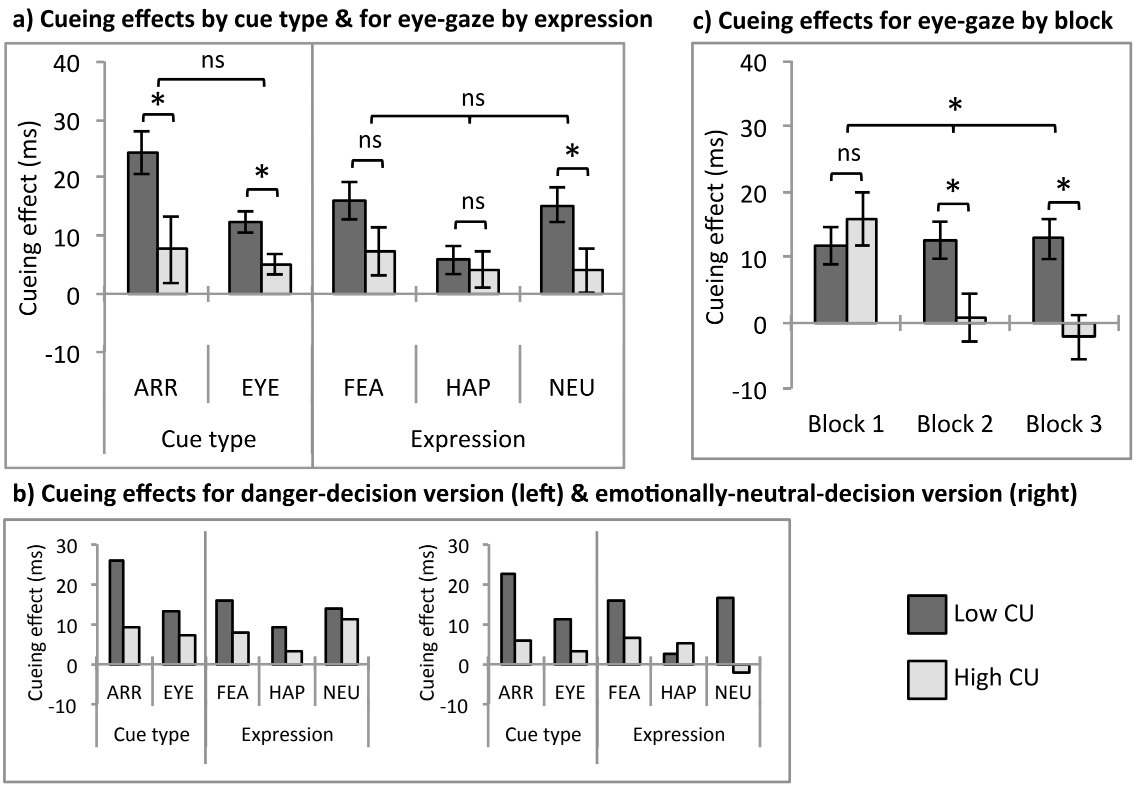

Figure 2. (a) Cueing effects (ms) were decreased in the high CU group compared to the low CU group equally for arrows and eye-gaze collapsed across expression (left panel), and for all expressions tested (right panel). (b) This pattern was similar for both versions of the cueing tasks. (c) Gaze-cueing effects decreased with practice across blocks in high CU, but were maintained in low CU. ARR = arrows.

EYE = eye-gaze. FEA = fear. HAP = happy. NEU = neutral. *$p < .05$.
ns = non-significant.

5.4.4.2 Practice effects on cueing

We also observed changes in patterns of CU effects with practice, across the three eye-gaze blocks (Figure 2c). Different patterns of practice effects were found for the high versus low CU groups, as indicated by a significant interaction between CU group and block[5], F(1.95,187.19 for Greenhouse-Geisser correction) = 4.54, MSE = 1618.11, p = .013 (same covariates as earlier analyses). The low CU group showed no change in cueing effects across blocks (M_{block1} = 12ms, M_{block2} = 13ms, M_{block3} = 13ms, F(1.99, 129.63 for Greenhouse-Geisser correction) = .40, MSE = 496.78, p = .669 . That is, eye-gaze direction continued to mandatorily grab attention throughout, with no evidence of low CU participants being able to learn to suppress following of the nonpredictive – and thus task-goal-irrelevant – directional cues. In contrast, the high CU group showed as much gaze-cueing as the low CU group in block 1, t(98) = .82, p = .412, but their gaze-cueing disappeared from block 2 onwards. For the high CU group, gaze-cueing was stronger for block 1 compared to later blocks (M_{block1} = 16ms, $M_{blocks2\&3}$ = -1ms, t(31) = 3.71, p = .001) and, in blocks 2 and 3, the high CU group showed no effect of cueing at all (M_{block2} = 1ms, t(31) = .24, p = .815; M_{block3} = -2ms, t(31) = .65, p = .518). Cueing was then significantly smaller in the high CU group relative to the low CU group in block 2, t(98) = 2.41, p = .018, and block 3, t(98) = 2.98, p = .004. These results imply high CU participants did not initially suppress following of eye-gaze direction (in block 1), but learnt to do so rapidly with practice, consistent with the task goals to exert top-down control to ignore the direction of gaze in this nonpredictive paradigm.

For arrows, only one block of trials was presented (40 trials total), which always came *first* in the experiment. Thus, there was no opportunity for participants to engage in extensive practice. Interestingly, despite this, the high CU group already showed significantly smaller arrow cueing than the low CU group (left panel of Figure 2a; see earlier for statistics). This suggests that, for high CU individuals,

[5] There was no CU group x expression x block interaction, F(3.80, 364.49 for Greenhouse-Geisser correction) = 1.11, MSE = 1574.33, p = .349, indicating that the earlier pattern of no fear-specificity was consistent across blocks.

non-social arrow cues have weaker effects on shifting attention than eye-gaze in faces (either because they find eye-gaze is a more salient bottom-up cue, or because it is harder to learn to suppress in a top-down manner). Note our 'high' CU group was not at the extreme end of the spectrum; it is possible that in psychopaths suppression of eye-gaze would occur even with no task practice.

5.4.4.3 Task engagement

A final question is whether any of our findings could be attributed to differences in task engagement between high CU and low CU groups. For example, high CU individuals might be less willing to follow experimenter instructions or not try as hard. We can rule out this idea. There were no differences in *target* decision error rate or reaction time between CU groups in any conditions (all ps > .15), and if anything the trend was towards the high CU group performance being slightly better (for means see Supplementary Figure 2). Further, it cannot be argued that the high CU group did not process the *cues*, given that they showed as much cueing from eye-gaze in faces as the low CU group in block 1 of the face task and also showed a significantly greater than zero cueing effect from arrows. The equal reaction time across groups also shows that our differences in cueing cannot be attributed to baseline differences in overall speed.

5.4.5 Discussion

Contrary to the distress-specific theory, there was no specificity for fearful expressions, and, contrary to the attention-to-eyes theory, there was no specificity for the eyes of faces. Results instead support the general-attention-abnormality theory, with the high CU group showing weaker shifting of attention for both non-social arrows and eye-gaze direction cues, irrespective of facial expression. Further, for eye-gaze, the CU effect developed with practice: in contrast to low CU individuals who showed no reduction in nonpredictive eye-gaze cueing across blocks, gaze cueing effects were completely absent for higher CU individuals after the first block of trials. This is consistent with the theory that higher CU individuals can exert top-down control to suppress processing of information that is mandatory in other people. Of note, accuracy and overall response speed were comparable between CU groups, arguing our results are not due to differences in task engagement.

5.4.5.1 No effect of practice on reflexive eye-gaze cueing in typical individuals

Our study is the first to investigate practice effects on gaze-cueing. Our finding that the low CU group showed no reduction in eye-gaze cueing with practice argues that people are typically unable to inhibit following where another person looks, even with extensive practice and top-down knowledge that the direction of gaze is not helpful to their goals. This extends and confirms previous arguments that gaze-following is typically reflexive (i.e., gaze is followed even when *counter*predictive; Driver et al., 1999).

5.4.5.2 Support for, and modification of, the general-attention-abnormality-theory

Present findings support the general-attention-abnormality theory of CU. Results of the one previous study testing eye-gaze cueing can also be seen as consistent with this theory. White et al. (2012) found no difference between a high-psychopathy-trait group and controls in amount of behavioral gaze cueing. Importantly, a difference from our present design is that White et al.'s (2012) gaze-cues were *predictive* of where targets would appear (two-thirds of cue trials were validly-directed). Thus, the general attention theory predicts the lack of psychopathy/CU effect, because participants had top-down knowledge that it was useful to follow the direction cues to achieve their task goal of responding to targets.

While our results agree with Newman and colleagues' general framework, they disagree with one of its more subtle aspects. This concerns the time-course of the application of the 'attention bottleneck'. Specifically, the theory argues that goal-irrelevant information is excluded only after sensory processing of the target item has begun (Baskin-Sommers et al., 2011); in our case, this would be once the animals (or scrambled targets) have appeared, predicting that the high-CU group would *not* be able to suppress directional information from the cue face (or arrow) because this appears earlier than the target. In contrast, our finding of reduced cueing argues that high-CU individuals are engaging an 'attention bottleneck' before the target appears, and thus in the absence of *sensory* information relevant to the task goal. This suggests a modification of Newman and colleagues' theory to allow that top-down goal-set may by itself be sufficient to exclude processing of goal-irrelevant information.

5.4.5.3 Implications for the neurological basis of CU

Our present findings imply the neurological basis of CU should include attention networks. Two imaging studies support such a contribution. White et al. (2012) found psychopathy-related differences in neural activation in general attention orienting networks (superior parietal lobule, inferior parietal sulcus). Larson et al. (2013) reported that psychopathy also affected regions involved in top-down selective attention, and further that activation in these regions explained reduced amygdala activation in psychopaths. This provides a link between the attentional theory and traditional theorizing that the amygdala is central to the neurological basis of CU and psychopathy (Moul, Killcross, & Dadds, 2012).

5.4.5.4 Open questions regarding the general-attention-abnormality theory

Although our results have supported the attentional differences predicted by Newman and colleagues' theory, we do not wish to claim that the theory as it currently stands provides a full explanation of CU/psychopathy. It is unclear how enhanced top-down ability to suppress goal-irrelevant information would, of itself, explain development of the affective characteristics of psychopathy (lack of empathy, etc.). To do so, we suggest enhanced top-down suppression might need to be combined with some other factor. This factor might be, for example, either a general *desire* to ignore others' emotions (e.g., to treat distress emotions as goal-irrelevant in situations where typical individuals would not), or decreased bottom-up salience of others' emotions (perhaps arising from the dysfunction found in the oxytocin system in CU; Dadds et al., 2013). Also, we do not claim that our results imply that poor recognition of fear or lack of attention to the eyes is necessarily irrelevant to the etiology of CU. For example, it might be that distress is one of many things ignored in CU, but it is the ignoring of distress that causes the affective dysfunction in CU/psychopathy.

5.4.5.5 Future comparisons of the three theories

This study is the first to directly contrast the predictions of the three theories, by comparing responses to emotional and non-social stimuli in relation to CU traits. Previous studies have used only facial stimuli (e.g., Blair et al., 2004; Dadds et al., 2006) *or* non-social stimuli such as emotionally neutral words or letters (e.g., Hiatt, Schmitt, & Newman, 2004; Vitale, Brinkley, Hiatt, & Newman, 2007; Wolf et al., 2012; Zeier, Maxwell, & Newman, 2009). An important avenue for future research is to compare responses to emotional and non-social stimuli, using paradigms that have already demonstrated psychopathy-related attention effects for non-social stimuli (e.g., Stroop tasks; Hiatt, Schmitt, & Newman, 2004; Vitale, Brinkley, Hiatt, & Newman, 2007). It will also be important to replicate the present results (e.g., in forensic populations).

5.4.5.6 Conclusion

Until now, Dadds' (2006) attention-to-eyes theory has only been tested in childhood, whilst Newman and colleagues' (2010) general-attention-abnormality approach has only been tested in adult psychopaths. Here we have shown for the first time that Newman and colleagues' hypothesized general-attention-abnormalities in psychopathy extend to adult CU. Unlike psychopathy, CU can be measured in both children and adults, and it also shows stability between childhood and adulthood (Frick et al., 2013). Thus we suggest that CU can be used to bridge the gap between current theories of childhood CU and the later development of psychopathy.

5.4.6 Acknowledgements

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5.4.8 Supplementary materials

Table S1

Mean RTs and cueing effects (with SDs in parentheses) for low and high CU groups for arrow and eye-gaze cues

	Arrows				Eye-gaze			
	Low CU		High CU		Low CU		High CU	
Measure	M	SD	M	SD	M	SD	M	SD
RT invalid-direction (ms)	529	(95)	507	(98)	515	(74)	500	(72)
RT valid-direction (ms)	505	(90)	499	(94)	502	(73)	495	(70)
Cueing effect (ms)	24	(32)	8	(32)	12	(16)	5	(10)

Table S2

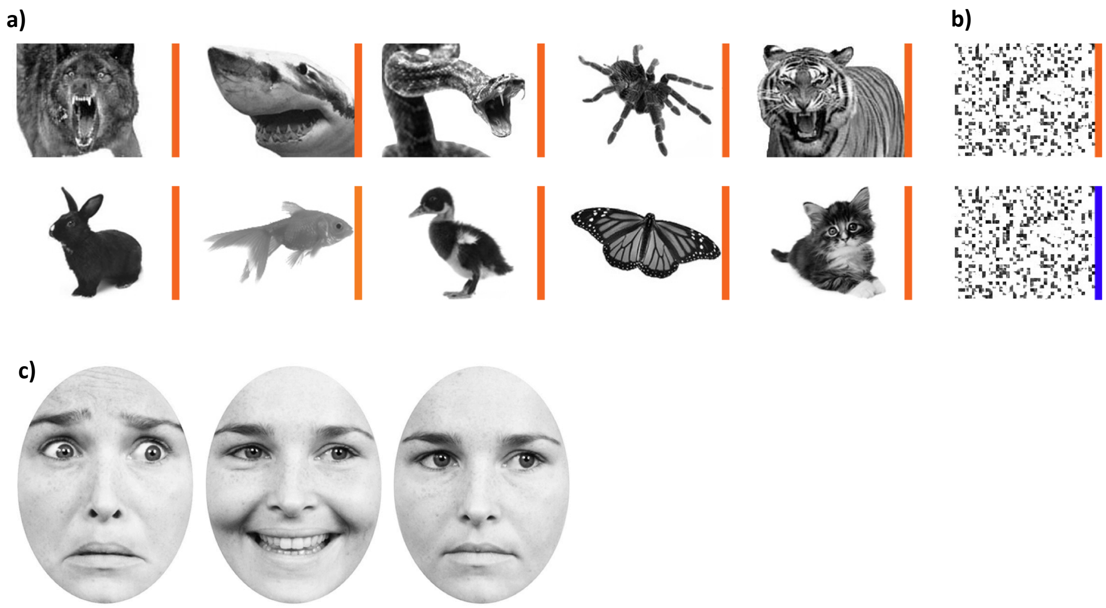
Mean RTs and cueing effects (with SDs in parentheses) for low and high CU groups for eye-gaze cues by facial expression

	Fearful faces				Happy faces				Neutral faces			
	Low CU		High CU		Low CU		High CU		Low CU		High CU	
Measure	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
RT invalid-direction (ms)	513	(73)	497	(73)	510	(76)	495	(69)	521	(77)	508	(77)
RT valid-direction (ms)	497	(72)	489	(73)	504	(75)	491	(67)	506	(76)	504	(76)
Cueing effect (ms)	16	(26)	7	(24)	6	(20)	4	(17)	15	(24)	4	(21)

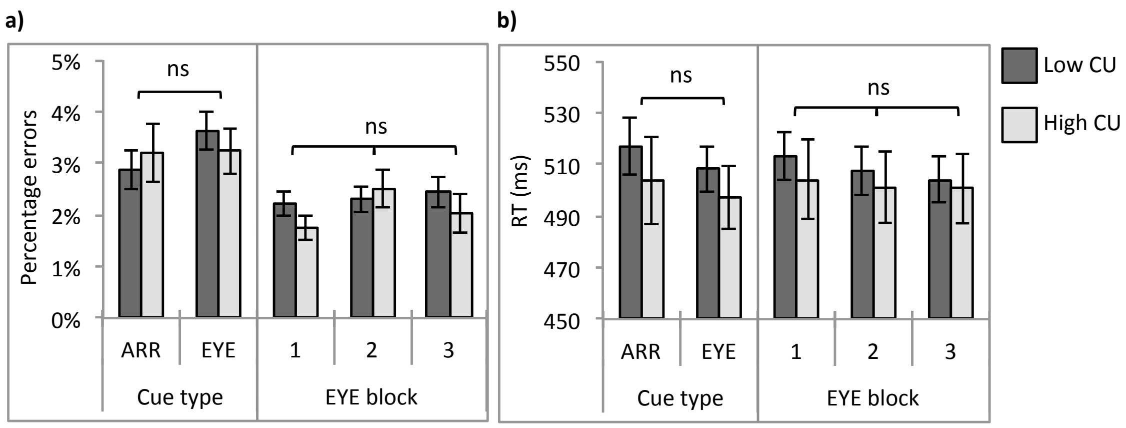
Table S3

Mean RTs and cueing effects (with SDs in parentheses) for low and high CU groups for eye-gaze cues by block

	Block 1				Block 2				Block 3			
	Low CU		High CU		Low CU		High CU		Low CU		High CU	
Measure	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
RT invalid-direction (ms)	520	(78)	512	(88)	513	(80)	501	(81)	511	(76)	500	(76)
RT valid-direction (ms)	508	(80)	496	(87)	501	(77)	501	(78)	498	(75)	502	(79)
Cueing effect (ms)	12	(23)	16	(23)	13	(24)	1	(21)	13	(25)	-2	(19)



Supplementary Figure 1. (a) Dangerous (top) and safe (bottom) animal targets (shown here with orange side-bars, but also with blue bars in the actual paradigm, which participants were instructed to ignore in the animal target version). (b) Examples of scrambled animals (scrambled spider shown here) with orange side-bar (top) and blue side-bar (bottom). (c) Fearful, happy and neutral facial expressions (from left to right).



Supplementary Figure 2. (a) No differences were observed in error rates (%) for high versus low CU groups for arrow cues versus eye-gaze cues collapsed across emotional expression (left panel) or for eye-gaze cues by block (right panel). (b) Similarly, no differences were observed in overall RTs. ARR = arrows. EYE = eye-gaze. ns = non-significant.

Chapter 6: Are you for real? Why faking it isn't good enough for facial expression stimuli

6.1 Chapter overview

The purpose of Chapter 6 is twofold. First, it is the second investigation in this thesis of limitations to currently-used expression stimuli. Whereas Chapter 4 addressed context-expression effects, here the topic of interest is expression genuineness. Studies of facial expression processing have used mostly posed or faked expressions, which show acted, unfelt emotions (e.g., smiling as though for a driver's license photograph). Yet in real life facial expressions often reflect genuinely-felt emotions (e.g., smiling when winning or watching something funny), which convey different meanings and invite different responses. The aims of this Chapter in relation to expression genuineness are to establish: (1) whether currently-used stimuli are in fact perceived as posed; (2) whether it is possible to generate genuinely-felt expressions that are perceived as genuine; and (3) whether the genuineness of expression stimuli can result in different theoretical conclusions (which would have implications for several important findings from the facial expression literature).

The second purpose relates to psychopathic and CU traits and processing of happiness. The meta-analysis presented in Chapter 3 found impairments in recognizing happy expressions in psychopathy. This finding is followed up here via empirical investigation, in relation to our above question about whether the genuineness of expression stimuli can result in different theoretical conclusions. One of the reasons previous individual studies have rarely revealed problems with processing happy expressions may be because they used labeling tasks that suffer from ceiling effects. Thus the present study uses a task that does not have ceiling effects and which would theoretically be expected to show an association with psychopathic and CU traits if there are abnormalities in processing, or responding to, happy expressions. This task is self-reported arousal ratings to genuinely-felt versus posed facial expressions of happiness.

6.2 Publication status

The following manuscript is to be submitted:

Dawel, A., Palermo, R., Irons, J., O'Kearney, R., & McKone, E. (to be submitted). Are you for real? Why faking it isn't good enough for facial expression stimuli.

6.3 Author contributions

- McKone and Palermo proposed the project, with contributions from **Dawel**.
- **Dawel** was responsible for the literature review.
- **Dawel** and McKone together conceived and designed the experiments, with advice from Palermo and Irons.
- The McLellan stimulus faces were provided by Dr Tracey McLellan.
- **Dawel** obtained and edited (e.g., cut out background scene) the NEWS stimulus faces used in Study 1.
- **Dawel** and Irons modified the PoFA, RaFD and McLellan stimulus faces.
- **Dawel** and Irons programmed the experiment.
- **Dawel** collected most of the data, with some assistance from Irons and class tutors.
- **Dawel** analyzed the data and produced the figures, with suggestions from McKone.
- **Dawel** drafted the manuscript.
- **Dawel** and McKone together refined the manuscript, with detailed editing provided by McKone. Palermo and O'Kearney also reviewed the manuscript and provided general content comments and suggestions, and some editing.

6.4 Manuscript: Are you for real? Why faking it isn't good enough for facial expressions

6.4.1 Abstract

Studies of facial expression processing often use posed expressions, which show acted, unfelt emotions (e.g., smiling for a driver's license photograph). Yet in real life facial expressions commonly reflect genuinely-felt emotions (e.g., smiling when winning), which convey different meanings and invite different responses. Here, we introduce a new rating scale for assessing how expression stimuli are perceived by observers, where they judge whether expressions are displaying genuine or faked emotion compared to a neutral point. Results show posed expressions from two widely-used stimulus sets (Pictures of Facial Affect [Ekman & Friesen, 1975]; Radboud Faces Database, [Langner et al., 2010]) – are perceived as displaying clearly faked emotion for most expressions (anger, disgust, fear; plus sad for the latter). This casts doubt on their use in many settings, particularly where the research question concerns perception of, or responses to, other people's felt emotions. We then demonstrate that to produce images that are perceived as showing genuine emotion, lab-elicitation of emotions can be effective for some expressions (e.g., happiness) but other expressions (e.g., anger) require more intense genuinely-felt images obtained from natural settings (news media photographs). Finally, we present an illustrative case in which genuinely-felt and posed expression stimuli lead to different theoretical conclusions. Specifically, we find that psychopathic and callous unemotional (CU) traits are associated with reduced arousal ratings for genuinely happy faces but not posed happy faces. Overall, we conclude emotion research cannot afford to ignore the issue of whether facial expression stimuli are, in fact, displaying an underlying genuinely-felt emotion.

6.4.2 Introduction

The ability of people to perceive and respond to others' emotions is most often studied via responses to facial expression stimuli. The types of questions investigated with such stimuli come from many different research areas, including clinical, social, developmental and cognitive psychology, plus neuropsychology, cognitive neuroscience, clinical neuroscience, psychiatry, and genetics. For example, clinical researchers have tested for impairments or biases in recognizing others' emotions that might contribute to interpersonal problems or play a role in the etiology of various disorders (e.g., Autism Spectrum Disorder, social anxiety, schizophrenia, and psychopathy; Boraston, Blakemore, Chilvers, & Skuse, 2007; Dawel, O'Kearney, McKone, & Palermo, 2012; Kashdan, 2007; Kohler, Walker, Martin, Healey, & Moberg, 2010). Social psychologists have incorporated facial expression stimuli in paradigms such as the Prisoner's Dilemma (Scharlemann, Eckel, Kacelnik, & Wilson, 2001). And cognitive and neuroscience researchers have conducted hundreds of studies using facial expressions in an effort to understand the nature of emotion processing (e.g., discrete emotion categories versus dimensional approaches; Ekman, 1992; Russell, 1980) and its neural basis (e.g., the role of the amygdala in fear; Adolphs, 2008).

Here, we address the question of whether commonly used facial expression stimuli might fail to capture a significant and theoretically important aspect of real face emotions, namely their genuineness. The emotion literature has relied heavily on a small number of face stimulus sets, notably the Ekman and Friesan Pictures of Facial Affect (PoFA; 1976; also the similar-format JACFEE set; Matsumoto & Ekman, 1988), and more recently the NimStim (Tottenham et al., 2009), and the Radboud Faces Database (RaFD; Langner et al., 2010). All these face sets are of one particular type: the expressions were posed in a laboratory setting, with the aim of providing some standardization (e.g., same lighting, head orientation, size, etc.). In some cases (PoFA, RaFD), the posing was done by training people to move specific muscles found in natural photographs of discrete expressions (i.e., anger, disgust, fear, happy, sad, surprise; e.g., (Ekman, 1992). Posed expressions, like these, show acted, potentially unfelt emotions. In contrast, real life facial expressions often signal a corresponding underlying emotional experience (e.g., smiling when winning or watching something funny). These genuinely-felt emotions convey different meanings and potentially invite different responses from posed expressions. Thus, an important question is whether theoretical conclusions (e.g., about the causes of particular disorders) derived from lab-posed expressions hold for genuinely-felt expressions.

6.4.2.1 Criteria for defining genuine expressions

Some researchers have attempted to capture genuinely-felt expressions in the laboratory. Most have used only happy (Calvo, Gutiérrez-García, Avero, & Lundqvist, 2013; Slessor, Miles, Bull, & Phillips, 2010; Thibault, Gosselin, Brunel, & Hess, 2009) or pain (Hill & Craig, 2002; Larochette, Chambers, & Craig, 2006). Here, we discuss the work of McLellan (McLellan, Johnston, Dalrymple-Alford, & Porter, 2010), because these authors have developed a genuinely-felt emotion stimulus set covering five of the six 'basic' emotions, specifically fear, happy, sad, anger and disgust. The happy, fear and sad stimuli are reported in McLellan (2010); the disgust stimuli in Douglas, Porter, & Johnston (2012); and the anger stimuli have not previously been reported in publications but were generated at the same time using the same procedure and group of models (T. L. McLellan, personal communication, November 17, 2010).

McLellan (2010) proposed three criteria that can be applied to assess whether facial expression stimuli are genuinely-felt. Of these, the criterion we consider most important is that *the person displaying the expressions should be feeling the emotion*; after all, the key, defining feature of a genuinely-felt expression is that it reflects an underlying, felt emotion. To produce stimuli meeting this criterion, McLellan (2010) photographed models while they were experiencing emotion-inducing events (e.g., listening to sad music) and then immediately afterwards asked the person to self-report their emotions during the event. Only images for which the model reported feeling a medium to high level of the target emotion were then included in the stimulus set.

McLellan et al.'s (2010) second criterion was that genuinely-felt expressions were displayed in response to a causal event that would be expected to elicit that emotion (e.g., disgust when looking at a picture of mutilation, sadness when remembering a lost loved one). One caveat to this criterion is that not everyone responds in the same way to a given situation. For example, a person with high social anxiety might feel fear in response to a social event that most would find enjoyable. Thus McLellan (2010) excluded stimuli if, for example, a model reported feeling strong sadness (meeting Criterion 1) in response to a stimulus designed to induce anger.

Table 1

FACS coding requirements met by McLellan et al. (2010) faces

Emotion	Core AUs for each expression	Additional AUs for genuine expressions
Anger	At least 2 of AU23, AU24, AU4/AU1+4, AU7	-
Disgust	At least 2 of AU9, AU10, AU4/AU1+4, AU7	-
Fear	At least 2 of AU4, AU5, AU7, AU20	-
Happy	AU12+25 or AU12+26	AU6
Sad	At least 2 of AU1, AU4, AU15, AU17	AU1+4

The third criterion referenced by McLellan (2010) is coding for physiognomic markers, using the Facial Action Coding System (FACS; Ekman, Friesen, & Hager, 2002; see Table 1). FACS is a standardized system for labeling the muscle actions of the face (referred to as action units or AUs; e.g., AU1 codes for inner brow raiser and AU25 codes for lips part). Many studies use FACS coding to determine *what* expression is being displayed, specifically whether the musculature of the face corresponds with prototypical muscle movements for one of the six 'basic' expressions (i.e., anger, disgust, fear, happy, sad, surprise; Ekman, 1992). However, this standard FACS coding does not attempt to distinguish between genuinely-felt and posed emotions. Thus, Ekman (2003) has proposed additional markers that he suggests are displayed only in genuinely-felt expressions. These include the 'Duchenne' marker for genuine happy (AU6), which is signaled by contraction of the obicularis oculi muscle to cause 'crow's feet' around the eyes, and AU1+4 for genuine sadness, which pulls the medial portion of the brow upward and together (Ekman et al., 2002). Ekman (2003) also proposes AU1+2+4 and AU20 for genuine fear and AU23 for genuine anger. Currently, however, the empirical basis for FACS coding of genuineness is not well established for any expression except happy.

There have been no tests of Ekman's proposed AUs for genuine fear and anger, and little investigation for sad expressions (although see studies using McLellan et al.'s stimuli; Douglas et al., 2012; Johnston, Carter, & Mclellan, 2011; McLellan et al., 2010; McLellan, Wilcke, Johnston, Watts, & Miles, 2012; McLellan & McKinley, 2013). The Duchenne marker for happy has received substantial investigation: many results show an association with genuineness (see Krumhuber & Manstead, 2009 for a review), although it seems that even this most established marker can be faked by perhaps 60-70% of the population when activated in conjunction with other musculature (Gosselin, Perron, & Beaupré, 2010; Gunnery, Hall, & Ruben, 2012).

6.4.2.2 Can theoretical conclusions differ for genuine and posed expressions?

There has been surprisingly little investigation of whether posed expressions elicit the same response as genuinely-felt expressions, and whether this matters for theory. Some studies have tested genuinely-felt 'Duchenne' smiles against posed expressions of happiness. These have revealed many differences in *degree* of response; for example, t-shirts are rated more positively when worn by women displaying Duchenne smiles than when worn by the same models displaying posed smiles (Peace, Miles, & Johnston, 2006), and participants in a computer game are more likely to choose an 'opponent' showing a Duchenne smile than one showing a posed smile (Shore & Heerey, 2011).

Under other circumstances, genuine-posed differences could result in *qualitatively* different conclusions. In one case where this is a possibility, a study (Sackeim, Gur, & Saucy, 1978) using the PoFA (Ekman & Friesen, 1976) reported that happy expressions were physically symmetrical while all other 'basic' emotional expressions (anger, disgust, fear, sad, surprise) were not. One interpretation of this difference is that it arises from valence, namely that positive expressions are symmetrical and negative asymmetrical. However, Ekman (Ekman, 1980) reports that the *happy* PoFA faces were in fact genuine (elicited during natural interactions during the course of the session) while the other expressions were posed, and thus that the apparent valence difference could in fact be a genuine-posed difference, with genuine expressions symmetric and posed expressions asymmetric.

In a second case, there is clear evidence that genuine-posed differences led to very different theoretical conclusions. In schizophrenia, the standard view has been that there is impaired recognition of facial expression (Kohler et al., 2010). This view was developed and supported by multiple studies using posed emotion stimuli. However, Davis and Gibson (2000) found that a group with paranoid schizophrenia showed *enhanced* recognition (i.e., better than controls) of genuinely-felt negative expressions (while simultaneously replicating the usual result of impaired recognition for posed expressions). This finding is important because it argues against a common theory that impaired affective processing is implicated in the etiology of schizophrenia (Walker, Kestler, Bollini, & Hochman, 2004).

In the present research, we examine (in Study 2) another situation where impaired recognition of others' emotions has been implicated in the etiology of a psychological disorder. In psychopathy, one long-standing account argues there is an impairment in processing others' emotions if, and only if, those emotions signal distress (i.e., a deficit specific for expressions of fear and sadness), and that this is a causal factor in psychopaths' failure to develop empathy (Blair, 1995, 2006). However, some other recent arguments suggest that problems with emotion recognition might be broader and encompass positive emotions including happiness (Dawel et al., 2012). The literature on which current conclusions of distress-specificity are based uses primarily lab-posed expressions. This raises the question of whether using genuinely-felt stimuli might lead to different conclusions from posed stimuli for psychopathic traits, as occurs for schizophrenia.

6.4.2.3 Measuring perceived genuineness of face stimuli

To investigate the effects of using genuinely-felt versus posed expression stimuli, it is of value to know how the expression stimuli are *perceived* (a question we examine in Study 1). If standard posed expressions (e.g., from Ekman & Friesens' PoFA; 1976) are actually perceived by observers as genuine, then the fact that the expressions were originally posed might be unimportant. On the other hand, if posed expressions from the commonly-used databases are perceived as clearly faked, then this would raise the possibility that conclusions drawn in the emotion literature based on data from those stimuli might not generalize to genuinely-felt emotions (as in the schizophrenia case above). Also, it would mean that, in reassessing those conclusions, it would be valuable to obtain genuinely-felt emotion stimuli that are perceived as genuine.

Currently, we know surprisingly little about whether face expression database stimuli are perceived as posed or genuine. Five published studies using the McLellan faces (Douglas et al., 2012; Johnston et al., 2011; McLellan et al., 2010, 2012; McLellan & McKinley, 2013) have tested whether observers can distinguish genuinely-felt expressions from posed expressions, where both genuine and posed versions were displayed by the same models. Participants were instructed, "Your job is to decide… whether or not they [the person shown] are feeling each emotion. For instance, sometimes when people smile it does not necessarily mean that they are actually feeling happy.'' (McLellan, 2010, p. 1283). Participants were then asked to give a yes/no response to the question "Are the following people *feeling* [emotion]?". For happiness and sadness, all five studies (Douglas et al., 2012; Johnston et al., 2011; McLellan et al., 2010, 2012; McLellan & McKinley, 2013) found that people could successfully discriminate genuinely-felt from posed expressions, as indicated by A' (a non-parametric signal detection score that combines hits and false alarms and ranges from 0 to 1) above .5 (i.e., chance). However, for disgust, the single study that tested this emotion found no discrimination (Douglas et al., 2012); for fear, of the two studies one found no discrimination (Douglas et al., 2012) and the other found significant but weak discrimination (McLellan et al., 2010); and no published study has tested anger. Further, a problem with using A' is that it does not answer questions about whether genuinely-felt expressions are *perceived as being genuine*; it only tells us that genuinely-felt expressions are perceived as relatively more genuine than posed ones.

Another approach has been to use ratings of genuineness. Langner et al. (2010) did this for the RaFD. Participants were instructed to "rate the emotional expression of the shown face with regard to the genuineness" (Langner et al., 2010, p. 6) from 1 'faked' to 5 'genuine'. This provides a fair way of rank ordering genuineness of individual items within a face set. However, it is hard to interpret the mean rating in any absolute sense as implying a percept of genuine or posed. The mean rating across the set was around 3 (Langner et al., 2010). But, the limitation on this rating scale is that there is no neutral point against which to interpret this number. That is, we do not know whether participants might treat 3 (the middle point of the 5 point scale) as the 'zero' value, with ratings of 1 and 2 meaning the faces are perceived as posed, and ratings of 4 and 5 meaning they are perceived as genuine; or, alternatively, whether participants might use 1 for posed, and then any numbers higher than 1 to indicate increasing levels of genuineness. The first interpretation would imply that the RaFD faces were not perceived as genuine at all (except for happy which was rated higher than other expressions at M=3.8/5), whereas the second interpretation would imply that all expressions looked genuine.

Given these limitations of previous methods, in Study 1 of the present article we introduce a method of rating stimuli that includes a neutral mid-point. Our scale went from -7 'completely fake' to +7 'completely genuine' with a neutral mid-point of 0 labeled 'don't know'. Thus ratings above 0 indicate stimuli were perceived as genuine, whilst ratings below 0 indicate they were perceived as posed. This allows us to compare a given stimulus to zero to determine whether it is perceived as genuine or posed in *absolute* terms, whilst still indicating where it lies relative to other stimuli. We also used a finer-grained scale than Langner et al. (2010), to increase sensitivity to differences between stimuli.

6.4.2.4 Are expressions always treated as genuine if they elicit avoidance behavior?

The McLellan studies found no or limited ability to perceptually discriminate genuine from posed expressions for two emotions, namely disgust and fear, while discrimination was much better for happy and sad. They (McLellan et al., 2010) suggested a theoretical interpretation of this difference, namely that happy and sad are distinguished as genuine versus posed because they elicit approach behavior in the observer, and that no distinction is made for emotions that elicit avoidance behavior (i.e., anger, disgust, fear). The reasoning underlying this argument was that it is adaptive to treat all emotions that elicit avoidance behavior as genuine in order to rapidly avoid danger. For example, if a real person is displaying anger, it might be prudent to get out of the way immediately without waiting for a more detailed analysis of whether the anger is genuine or posed. Here, we distinguish between approach and avoidance emotions based on *the behavior they are likely to elicit in the observer* (but note that approach-avoidance motivation can also refer to the behavioral tendencies of the expresser; e.g., Carver & Harmon-Jones, 2009; see Adams, Ambady, Macrae, & Kleck, 2006 for discussion of the differences). In this interpretation, happy expressions signal opportunities for cooperation and social affiliation, and sad expressions signal that help or support is required, and thus both happy and sad expressions elicit approach behavior (Mizokawa, Minemoto, Komiya, & Noguchi, 2013; Seidel, Habel, Kirschner, Gur, & Derntl, 2010). In contrast, disgust and fear signal some form of danger in the environment that should be avoided, and anger signals the expresser is potentially dangerous and should be avoided (Seidel et al., 2010; although cf. Marsh, Ambady, & Kleck, 2005 for evidence that fearful expressions also elicit approach behavior toward the expresser).

An alternative explanation for the data, however, could be that the expression stimuli for avoidance emotions in the McLellan stimulus set were of too low intensity. The McLellan set have not previously been rated for intensity. However, the genuinely-felt avoidance expressions in that set include fewer AUs than their posed counterparts (McLellan et al., 2010; T. L. McLellan, personal communication, December 20, 2010), suggesting less muscle movement away from neutral. This is consistent with the genuine versions of the avoidance emotions being *less* intense than the posed versions. At the same time, in other studies of genuine versus posed *happy* (i.e., faces with and without the Duchenne marker), the genuine versions of this approach emotion are typically rated as *more* intense than the posed versions (e.g., Krumhuber & Manstead, 2009). Thus, it is possible that the McLellan results could have been influenced by confounds with intensity differences between genuine versions of avoidance emotions (low intensity) and genuine versions of approach emotions (high intensity, at least for happy).

6.4.2.5 Obtaining high-intensity genuinely-felt emotion stimuli

How could this potential confound be overcome? A key practical difficulty is the limitation on researchers' ability to elicit intense versions of certain emotions when creating stimuli in the lab. Inducing high-intensity genuinely-felt happiness in the lab is relatively easy. However, inducing high intensity fear or anger is challenging. For somebody to be genuinely and strongly fearful they must believe they are in real danger, but it is not practical or ethical to release a tiger into the lab or arrange a bomb explosion. Thus, for lab-derived stimuli, it may be essentially impossible to obtain avoidance expression stimuli, particularly for fear and anger, which have anything other than mild intensity of emotion underlying the genuinely-felt expressions.

We note, however, that situations do exist which produce genuinely-felt fear or anger emotions that are high in intensity (e.g., fear during the 9/11 terrorist attacks). Thus, potentially, it is possible to obtain photographs of people's facial expressions in such situations, which could then be used as stimuli. This alternative method for obtaining stimuli has received little attention in the psychology and psychiatry literature (although we note that computer scientists developing methods for automatic facial expression recognition often use face images taken from natural settings, e.g., Douglas-Cowie et al., 2007). We suggest that capturing expressions in natural environments in which strongly emotive events occur may well provide images that are both genuinely-felt *and* of high intensity. That is, if the event is strongly emotive it is possible that intense displays of emotion will be captured. Of course, it is likely to be difficult to obtain enough of these photographs for rare expressions like fear. But, anger, for example, is easier. Real and intense anger occurs commonly on the faces of sports players, and there are many images of these events available in good resolution taken by professional photographers.

Thus, in the present study, we obtained images of sporting events from news media. We chose to use happy and angry expressions because both were easy to obtain, and one is an approach emotion (happy) and the other an avoidance emotion (anger). This allows us to test whether the finding from the McLellan stimuli of ability to discriminate genuine from posed for approach emotions, but failure to discriminate for avoidance emotions (Douglas et al., 2012; Johnston et al., 2011;

McLellan et al., 2010, 2012; McLellan & McKinley, 2013), still holds when the avoidance emotion stimuli are high intensity.

6.4.3 Study 1: How are current face emotion stimuli perceived, and is it possible to make better ones?

Our first study obtained ratings of genuineness and intensity for current databases, plus some new images, to address a number of core questions. First, we asked whether the posed face emotion stimuli from current widely-used databases are perceived as showing genuine or faked emotion, using our new neutral-point -7 to +7 rating scale that allows this to be determined in absolute terms. For this purpose, we tested two face databases. We selected the Ekman and Friesen Pictures of Facial Affect (PoFA; 1976) because it has been used extensively over several decades and in a wide range of disciplines (psychiatry, psychology, neuroscience). All PoFA expressions are posed (using instructions to models to move muscles consistent with FACS descriptions of each basic expression; Ekman & Friesen, 1976), except for happiness, which Ekman (1980) explained is genuine because it was captured during natural interactions in between posing the other emotions. One point of note is that the PoFA images are black and white and show actors with outdated hairstyles. It is possible these factors could contribute to stimuli being perceived as posed or inauthentic. Thus, our second database was the RaFD, which is more recent and uses color images. The RaFD is rapidly gaining use, with 72 citations since publication in 2010 (according to Scopus 21/01/2014). All RaFD expressions were posed, using the same method as the PoFA, with the posing in this case including happy expressions.

Second, we wished to evaluate the lab-based approach to producing genuinely-felt emotion stimuli. We tested the McLellan et al. (2010) set because, within the necessary limitations of creating emotions in the lab, we regard their method of creating genuinely-felt stimuli as best practice in this field. Specifically, their stimuli met criteria that: the models self-reported they felt the emotion; the emotion that models reported was the target emotion congruent with the eliciting event; and standard FACS coding confirmed the resulting facial expression displayed the target emotion. We also note that additional FACS coding for genuineness suggested by Ekman (Ekman, 2003) verified the presence of AU6 for genuinely-felt happy and AU1+4 for genuinely-felt sad, and the absence of these markers in the posed versions of these emotions. Importantly, however, the McClellan stimuli have not previously been rated for perceived genuineness, nor for intensity. Here, we obtained these ratings for the genuinely-felt emotions (McLellan-GEN) and also for the posed versions of the same emotions displayed by the same models (McLellan-POS). Results allowed us to determine whether the genuinely-felt stimuli were perceived as clearly genuine (and the posed as clearly posed). They also allowed us to determine whether the lab-based induction method was able to produce stimuli that are perceived as both strongly genuine *and* strongly intense, and, if so, whether this was possible for all emotions or occurred, say, for happy but not for other emotions that are difficult to induce strongly in lab settings (e.g., fear, anger).

Third, we asked whether a novel set of sports media photographs could produce high-genuineness together with high-intensity, including for an emotion that is difficult to produce in the lab. We obtained these images (referred to as NEWS faces) specifically for this study, and included anger and happy. We chose anger because it is an avoidance emotion and nothing is known about genuineness effects for this emotion, and in practical terms it was easy to obtain from sporting events (e.g., arguments with umpires and other players). Note that we have no self-reports from the sports players who displayed the expressions as to what emotion they were feeling at the time. However, we have categorized the NEWS photographs as genuinely-felt based on the fact that there was strong contextual information available and that the emotion being displayed was congruent with this context (e.g., happy in a photograph showing the team winning the trophy; angry in a photograph showing players shaking fists in a disagreement with the umpire).

Finally, we re-evaluate the question (McLellan et al., 2010) of whether observers fail to discriminate genuine from posed emotions when these are emotions elicit avoidance, and make this discrimination only for emotions that elicit approach, using both the genuineness and intensity ratings.

Ratings were obtained for five of the six basic emotions (anger, disgust, fear, happy, sad; surprise was not used because the McLellan set does not contain this emotion). Items from all four face sets were intermixed. This has the advantage that comparisons of ratings can be validly made across sets.

6.4.3.1 Method for Study 1

6.4.3.1.1 Participants

Included in analyses were 37 undergraduate students (30 females, M_{age} = 22 years, SD_{age} = 2.5, $range_{age}$ = 18-35), who participated for course credit, as part of laboratory classes, or for a small payment ($15 for the 1hr experiment). All were Caucasian (same as the face stimuli to avoid other-race effects on expression processing; Elfenbein & Ambady, 2002) and gave consent for their data to be used for publication purpose. Four included participants did not rate the NEWS faces because the NEWS faces were added after initial testing.

Six additional participants were excluded, due to: failing an instruction check regarding the meaning of 'genuine' and 'posed' (2); reporting a diagnosis of a disorder that can affect face processing (2; both ADHD); reporting their data would be invalid for analysis due to lack of effort (2: “too tired, clicked randomly”, “couldn’t concentrate”).

6.4.3.1.2 Stimuli

Example expression stimuli are shown in Figure 1. All five expressions (anger, disgust, fear, happy and sad) were included within each face set, except for the NEWS faces (anger and happy only). For all sets, the specific models (i.e., the person) displaying the expressions vary by emotion. The general reason for this is that it is difficult to obtain good stimuli for all expressions from every model. All stimuli were cropped to standard dimensions so that the face took up most of the frame. Presentation size was 6.9° x 9.1° at a viewing distance of 50cm. Backgrounds to the faces were as per the original stimuli for the RaFD (white) McLellan (white) and PoFA (grey). Grey backgrounds were also used for the NEWS faces. The full list of stimuli (image codes from each database) is provided in Supplementary materials.

Figure 1. Examples of our face expression stimuli. The PoFA faces are not included for copyright reasons, but examples can be viewed at: http://www.paulekman.com/product-category/research-products/. Backgrounds for the PoFA stimuli were grey, as for the NEWS faces. The NEWS images shown in (d) are FXJ189941_ANG (Tim Clayton/Fairfax Syndication) and FXJ209317a_HAP (Vince Caligiuri/Fairfax Syndication).

From the PoFA (Ekman & Friesen, 1976) we included all images showing our five expressions of interest (82 in total). Stimuli were from 14 models (8 females, 6 males), with three to nine images and three to five expressions from each. Some models provided multiple stimuli for the same expression. Stimuli were frontal views, with most eyes looking forward (some images do not make eye-contact with the camera).

From the RaFD (Langner et al., 2010) we included a subset of the images that were available for each expression. Because of practical limitations on the number of stimuli that could be presented, we selected 10 female models for each expression of interest (50 stimuli in total). Female faces were prioritized over males for comparison with the McLellan faces, which include only females on the basis that they are more expressive than males (Buck, Miller, & Caul, 1974; Kring & Gordon, 1998). Stimuli were from all 19 female models used in the RaFD, with one to five expressions from each. No model provided multiple stimuli for the same expression. Stimuli were frontal views with eyes looking forward. To select stimuli, we sorted models within each expression on ratings of genuineness from Langner et al. (2010), and included every second stimulus (i.e., model with highest genuine-posed rating for that emotion, model with third-highest rating, model with fifth-highest rating, and so on). We did this to ensure that stimuli were representative of the overall perceived 'genuineness' of the RaFD female set.

The McLellan faces include four models for each emotion, with each model displaying one posed and one genuinely-felt version of that emotion (40 stimuli in total). Stimuli were from nine models, all female, with one to three expressions from each. No model provided multiple stimuli for the same expression. Stimuli were frontal views with eyes looking forward. Genuinely-felt stimuli were generated as described in the 'Criteria for defining genuine expressions' section of the introduction. Posed stimuli were generated by instructions to pretend expressions, such as 'fake a sad reaction' or 'smile for a license photograph' (for details see McLellan, 2008).

The NEWS faces included five males displaying anger and seven different males displaying happy (12 images in total), taken from eight photographs purchased from Australian news media company Fairfax (Fairfax Syndication, http://www.fairfaxsyndication.com/C.aspx?VP3=CMS3&VF=FXJO50_1). All background scenery from around the faces was removed using Photoshop CS4. Stimuli ranged from frontal to three-quarter view, with eye-gaze direction generally aligned with head direction (i.e., eyes were looking in front of the face). Only faces displaying strong emotions were selected. That expressions were genuinely-felt was determined by the contextual information associated with the original image (e.g., image showed a trophy being presented [happy], or the image caption stated the player was arguing with the umpire [anger]; see Figure 2 for examples of original images; see Table 2 for list of image captions) using the logic that these causal events were congruent with the emotion being displayed and likely to elicit that emotion. The emotion displayed, and the congruence with the context, was determined by agreement of three judges (authors AD, EM, JI). Additionally, FACS coding of the expressions was undertaken by two coders (CF, SS from Acknowledgments). Some minor differences in coding were resolved by discussion. Results (Table 3) show that all of the images met the requirements for the target expression (anger or happy) with the exception of one anger image that contained only one (of a minimum of two) of the core anger AUs. Regarding genuineness, six of the seven happy images included the Duchenne marker (AU6) and, for anger, three of the five images included the marker that Ekman (2003) suggested is associated with anger genuineness (AU23).

Table 2

Description of contextual information used in validation of NEWS faces

Stimuli	Emotion	Description of whole scene	Photograph caption
FXJ189941	Anger	Player walking with his teammate towards an umpire, who has raised his arm to point at the player.	...<name> argues with the referee after conceding a foul on the edge of the box...
FXJ280874	Anger	Player clenching his fists and arms, and straining his neck forward.	...<name> screams at the umpire in disbelief...
FXJ84155a FXJ84155b	Anger	Two players in the same sports uniform grabbing/pulling at a third player in a different sports uniform.	Fight between <team> players <name> and <name> and <opponent team> player <name>.
FXJ96688	Anger	Player walking forward with arms stretched out to either side, in a gesture of protest.	...<name> argues with the umpire...
FXJ209317a FXJ209317b	Happy	Two players wearing medals raising a trophy between them, with one of them raising his other arm in a gesture of triumph. They are surrounded by teammates, who are also making gestures of triumph.	...<team> were the winners of the <year> Grand Final. <name> and <name>...
FXJ283434a FXJ283434b	Happy	Two players wearing medals raising a trophy between them, with one of them raising his other arm in a gesture of triumph.	...<name> and <name> holding the premiership cup...
FXJ331486	Happy	Player wearing a medal and raising both fists in a gesture of triumph.	... <team> player <name> after receiving his premiership medal...
FXT64665a FXT64665b	Happy	Two players wearing medals raising a trophy between them, with one of them raising his other arm in a gesture of triumph. There is a third teammate between them, also making a gesture of triumph.	...<name>, left, celebrates the <team> third grand final win... with <name>, centre, and <name>.

Tim Clayton/Fairfax Syndication Vince Caligiuri/Fairfax Syndication

Figure 2. Examples of the photographed full scene contexts from which our NEWS faces were taken. The faces not blanked out are ones used for our NEWS face stimuli (and are the same as those shown in Figure 1d).

Table 3

FACS coding results for NEWS faces

Stimuli	Target expression	Core AUs present	Meets FACS	AUs for genuineness present[a]	Extra AUs present
FXJ189941	ANG	1B+4C+7B	Y	23C	5B+22C+25C+27E+52D
FXJ280874	ANG	4E+7D	Y	23C	5B+10C+16B+20C+25C
FXJ84155a	ANG	4C+7B	Y	23B	10B+16B+17C+21B+25C+38B+64
FXJ84155b	ANG	4B	N[b]	-	A20A+25C+26B+52E
FXJ96688	ANG	4E+7D	Y	-	A10B+20B+25C+27D+52C
FXJ209317a	HAP	12D+25C+26D	Y	6D	9C (+52unscorable)
FXJ209317b	HAP	12B+25C	Y	6C	7B+27E(+52unscorable)
FXJ283434a	HAP	12D+25C+26C	Y	6D	(+52unscorable)+53C
FXJ283434b	HAP	12C+25C+26D	Y	6C	52B+53B
FXJ331486	HAP	12B+25C	Y	-	4B+7B+27E+51D+53C
FXT64665a	HAP	12D+25C	Y	6D	9B+27B+51B
FXT64665b	HAP	12C+25C	Y	6C	10C (+51unscorable)+61B

[a]The inclusion of AU23 as a marker of genuineness for anger is based on Ekman's (2003) conjecture and is not yet empirically supported. It is however interesting to note that 3 of our 5 genuinely-felt anger stimuli included this marker. [b]The minimum requirement for anger was two core AUs, but this stimulus shows only one. Despite this, the scene context for the face clearly indicates anger.
ANG = anger. HAP = happy.

6.4.3.1.3 Procedure

Genuine-posed ratings and emotion labeling block. The first block of trials presented each face stimulus for participants to rate its genuineness followed by labeling its expression. Before the block started, participants were given detailed written instructions outlining the task, as follows:

> Sometimes people show facial expressions of emotions they genuinely feel, and sometimes they display expressions that are faked or posed (e.g., to be polite or because they are acting).
>
> An example of a genuine expression is when somebody smiles and they really feel happy, like when they get a present or see something funny.
>
> An example of a faked expression is when somebody smiles for a school photo, without feeling any emotion. Or a parent playing a game with their child may put on a 'scared' face to pretend fear, but not actually feel the emotion displayed.
>
> Your task is to decide whether faces are showing genuinely felt expressions or faked/posed/acted expressions.
>
> All the expressions you will see were photographed in laboratories, but some of them are genuine and some are faked.

In **genuine expressions**, emotions were induced by showing people video clips, pictures or sounds, or by asking them to remember an emotional event. For example, some people showing genuine happy expressions were photographed while watching a funny video. Others showing genuine fear were photographed while watching a scary film.

In **faked expressions**, people were simply instructed to act different emotions. For example, some people showing faked happy expressions were photographed when instructed to pose for a photo. Others showing faked fear were photographed when instructed to 'look scared' or to move specific face muscles.

You will rate each face using the following scale:

How genuine does this emotional expression look to you?

Completely fake							Don't know							Completely genuine
[-7]	[-6]	[-5]	[-4]	[-3]	[-2]	[-1]	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]

-7 means you think the expression is completely faked/posed/acted, and that the person does not feel the displayed emotion at all.

7 means you think the expression is completely genuine, and that the person really feels the displayed emotion.

0 means that you can't tell at all, and are just guessing.

Please don't assume that half the faces you see will be genuine and half faked -- this is not true of the face set you will see. We just want to know how genuine or fake you think the expressions are.

If you think that more of the faces you see are at the genuine end of the scale, please use this end more.

If you think that more of the faces you see are at the fake end of the scale, please use this end more.

If you think that they are spread across the scale, then please use the full length of the scale.

A final point: we want you to **ignore the strength** of the expressions when you rate how genuine or fake each expression is.

For example, an expression of sadness may be very subtle but be completely genuinely felt. Such an expression should be rated as completely genuine.

On the other hand, an expression of sadness may be very strong but be completely faked/posed/acted. Such an expression should be rated as completely faked.

After rating each expression, you will be asked to select what emotion you think each face is showing or trying to show from the following labels:

What emotion do you think this face is showing?
[Anger] [Disgust] [Fear] [Happy] [Sad]

Please raise your hand at this point if you have any questions before starting the experiment. Otherwise, click the mouse to begin!

The faces (total trials = 184) were presented in random order for each participant (with all 184 faces from the different databases intermixed, not blocked). Participants were given short breaks after the first 60 and the next 60 trials.. Breaks were a minimum of 30 seconds duration, and participants pressed a button to continue. Face stimuli were presented one at a time, and remained onscreen until response.

Intensity rating block. The 184 face stimuli were then presented again, this time to obtain ratings of the expression of the expressions. The procedure was as above (without the labeling). For intensity ratings, the instructions were:

> Your next task is to rate the INTENSITY/STRENGTH of the expressions.
>
> This time we want you to **<u>ignore the genuineness</u>** of the expressions when you rate how strong each expression is.
>
> You will rate each face using the following scale:
>
> How intense does this emotional expression look to you?
>
> Weak Strong
> [1] [2] [3] [4] [5] [6] [7] [8] [9]
>
> **1** means you think the expression is the weakest possible.
>
> **9** means you think the expression is the most intense or strongest possible.

Validation of NEWS faces in original scene context. In the next task, the NEWS photos were presented again, but now each face was presented in the full original photograph from the sports event (e.g., the winning team holding up the trophy; the target person yelling at the referee with teammates looking on; see Figure 2 for the type of image). The faces of extra people in the photographs were blurred, to avoid any influence they might have on perception of the target face. Presentation order was randomized for each participant. Stimulus size of the whole photographs was 19.3° (maximum – photos varied in width) x 12.6°. Task instructions were as follows:

> In this final part of the experiment, you will see some whole photographs that include people. Some of the photographs will include more than one person, but the faces of any extra people have been blurred.
>
> Your task is to select what emotion you think the main (unblurred) face in each picture is showing or trying to show from the following labels:

What emotion do you think this face is showing?
[Anger] [Disgust] [Fear] [Happy] [Sad]

Assessing player familiarity. Immediately after this last question, we assessed the participant's familiarity with the NEWS models because other sets included only models that were unfamiliar to our participants. The photographs showed players from professional teams in popular Australian sports, and so it was possible that a participant might be familiar with one or more of the players. To ensure familiarity was not a factor in our findings for the NEWS faces, we later excluded any trials where the participant indicated familiarity, when given the following instructions:

> After you have selected what emotion each face is showing, you will also be asked if you have ever seen this person **before today's experiment**, and if you recognised them (i.e., knew that you had seen the person before) when you rated the faces on genuineness and intensity earlier.
>
> Please select one of the following labels:
>
> Have you seen this person before today's experiment?
> If so, did you recognise them when rating genuineness/intensity?
> [Never seen] [Seen but didn't recognize] [Seen and recognized]

Instruction check for genuine-posed. At the end of the study, to check participants understood the genuineness instructions, they were asked two multiple-choice questions that involved selecting examples of genuine and posed expressions. Participants were required to answer both questions correctly to be included in the study. The questions were:

> According to the INSTRUCTIONS for the computer task, an example of a GENUINE expression is:
> When somebody smiles and they really feel happy, like when they get a present [CORRECT]
> When somebody smiles for a school photo, without feeling any emotion [INCORRECT]
>
> According to the INSTRUCTIONS for the computer task, an example of a FAKED expression is:
> When someone experiences fear when watching a scary film [INCORRECT]
> When a parent playing a game with their child puts on a 'scared' face to pretend fear [CORRECT]

Assessment of other inclusion criteria. Also at the end of the study, participants completed demographic and questionnaire information (see Study 2 for Questionnaires). For race, we asked, "What is your race? 'Race' refers to the continent of your ancestry: Caucasian = anywhere in Europe/Britain; Asian = East or South East Asia (i.e., China, Japan, Singapore, Malaysia, etc.); South Asian = India, Pakistan, etc.; Other possibilities are African, Aboriginal Australian, etc.; List two or more if mixed racial heritage (e.g., 'Caucasian and African')".

To screen for validity of data, we asked, "If you signed the consent form, is there any reason we should not use your data from the computer task for research? e.g., your computer crashed, you were interrupted, you are feeling sick today and couldn't concentrate, etc.". Where participants indicated yes, details were requested.

To screen for disorders that can affect face processing, we asked, "Have you *ever* had any form of mental illness or brain-related developmental disorder, e.g., clinical depression, anxiety disorder, ADHD, autism spectrum disorder, schizophrenia, etc." and "Have you *ever* had any form of brain injury, brain-related illness, or period of unconsciousness? This might include, for example, unconsciousness arising from head impact in an accident, epilepsy, stroke, meningitis, encephalitis, etc.". Where participants indicated yes, details were requested.

6.4.3.1.4 Initial data screening

Pre-emptive responses with reaction times less than 150ms were removed prior to any analysis of results (<1% of trials).

6.4.3.2 Results of Study 1

6.4.3.2.1 Labeling accuracy

Table 4 shows percentage of faces correctly labeled for each emotion within each face set. For PoFA and RaFD, labeling accuracy ranged from 78% to 98% across emotions, with happy best and sad (PoFA) or anger (RaFD) poorest; these values are similar to those found in previous research (Langner et al., 2010; Palermo & Coltheart, 2004). For the McLellan stimuli, accuracy was lower, particularly for posed and genuine anger, and genuine fear. Note previous studies using the

McLellan stimuli have reported higher accuracy values (Douglas et al., 2012; McLellan et al., 2010) but assessed labeling only via yes/no confirmation (e.g., "Is this face showing fear?") not by a 5AFC choice as used here. For our new stimulus set, the NEWS photos, labeling accuracy was high for both the anger (73%) and happy (85%) set, with accuracy similar to the established PoFA and RaFD sets. Note these values are for the faces presented alone, without context; when NEWS faces were presented in the full photograph, scene labeling accuracy increased to 82% for anger and 100% for happy.

Table 4

Study 1 results: Mean percentage accuracy of labeling the emotion, with SDs in parentheses

Emotion	PoFA	RaFD	McLellan-POS	McLellan-GEN	NEWS
ANG	82.83 (14.3)	77.84 (13.6)	45.95 (32.6)	55.41 (21.4)	72.73 (17.9)
DIS	79.82 (18.8)	87.84 (17.3)	70.27 (20.3)	75.00 (23.6)	
FEA	92.79 (16)	89.19 (16.7)	49.32 (25.3)	87.16 (22.5)	
HAP	97.9 (4.4)	98.11 (4.6)	97.97 (6.9)	98.65 (5.7)	85.28 (13.1)
SAD	81.08 (13.5)	95.68 (7.7)	80.41 (23.7)	96.62 (13.4)	

Note. N = 37 for PoFA, RaFD and McLellan; N = 33 for NEWS.

6.4.3.2.2 Screening ratings for correct labeling and lack of familiarity

For genuineness and intensity ratings, analyses presented below are for trials presenting correctly labeled stimuli for each participant only (although note that results of analyses including all trials did not change the conclusions in any way). The reason for removing incorrectly labeled trials was that a high genuineness or intensity rating might have been given, but that rating might have related to a non-target emotion (e.g., an expression that a database labels as fear might be perceived by the rater as being genuinely sad rather than fearful). For NEWS stimuli, analyses also exclude the 32% of trials where the participant reported that they knew who the person displayed was; thus, results for all four face sets are for faces unfamiliar to participants. As a consequence of this screening, and the fact that four participants did not rate the NEWS faces, there is some variation in *n* for different analyses.

Mean ratings of genuineness and intensity are presented in Figures 3 and 4, respectively. (Data for individual face stimuli are presented in the Supplementary materials.)

6.4.3.2.3 Standard face databases: Perceived as genuine or fake?

Our first question was whether the widely used PoFA and RaFD database images were perceived as displaying genuine or faked emotions. We analyzed each emotion independently. This was partly for theoretical reasons: the happy PoFA images were genuinely-felt by models while the other PoFA emotions were all posed; happy and sad are approach emotions while anger, fear and disgust are avoidance emotions; and happy has positive valence while all other emotions have negative valence. Separate analysis of each emotion was also justified by results of 1-way ANOVAs on emotion within each face set. These showed significant differences in perception of genuineness across the five emotions, for the PoFA, $F(3.03, 109.20) = 55.44$, $MSE = 4.68$, $p < .001$, and for the RaFD, $F(3.07, 110.66) = 32.85$, $MSE = 6.33$, $p < .001$.

For each emotion, we compared the mean genuineness rating to zero, to determine whether each type of stimulus was perceived as genuine or faked in absolute terms. Values above zero indicate that stimuli were perceived as genuine, whereas values below zero indicate that stimuli were perceived as faked. Alpha was set to .01 to Bonferroni-correct for the five comparisons conducted within each set. Two-tailed tests were used.

As illustrated in Figure 3a, for the PoFA, three of the four posed expressions were perceived as significantly faked (i.e., ratings significantly below zero), specifically anger, disgust, and fear expressions, *p*s < .001. The exception was PoFA sad, which was perceived as slightly in the genuine direction, although non-significantly with Bonferroni correction, $M = .87$, $SD = 2.47$, $t(36) = 2.15$, $p = .038$. For the RaFD (Figure 3b), four of the five expressions were perceived as significantly posed, specifically anger, disgust, fear, and sad expressions, *p*s < .001. RaFD happy was perceived as slightly, but not significantly ($p = .154$) in the genuine direction.

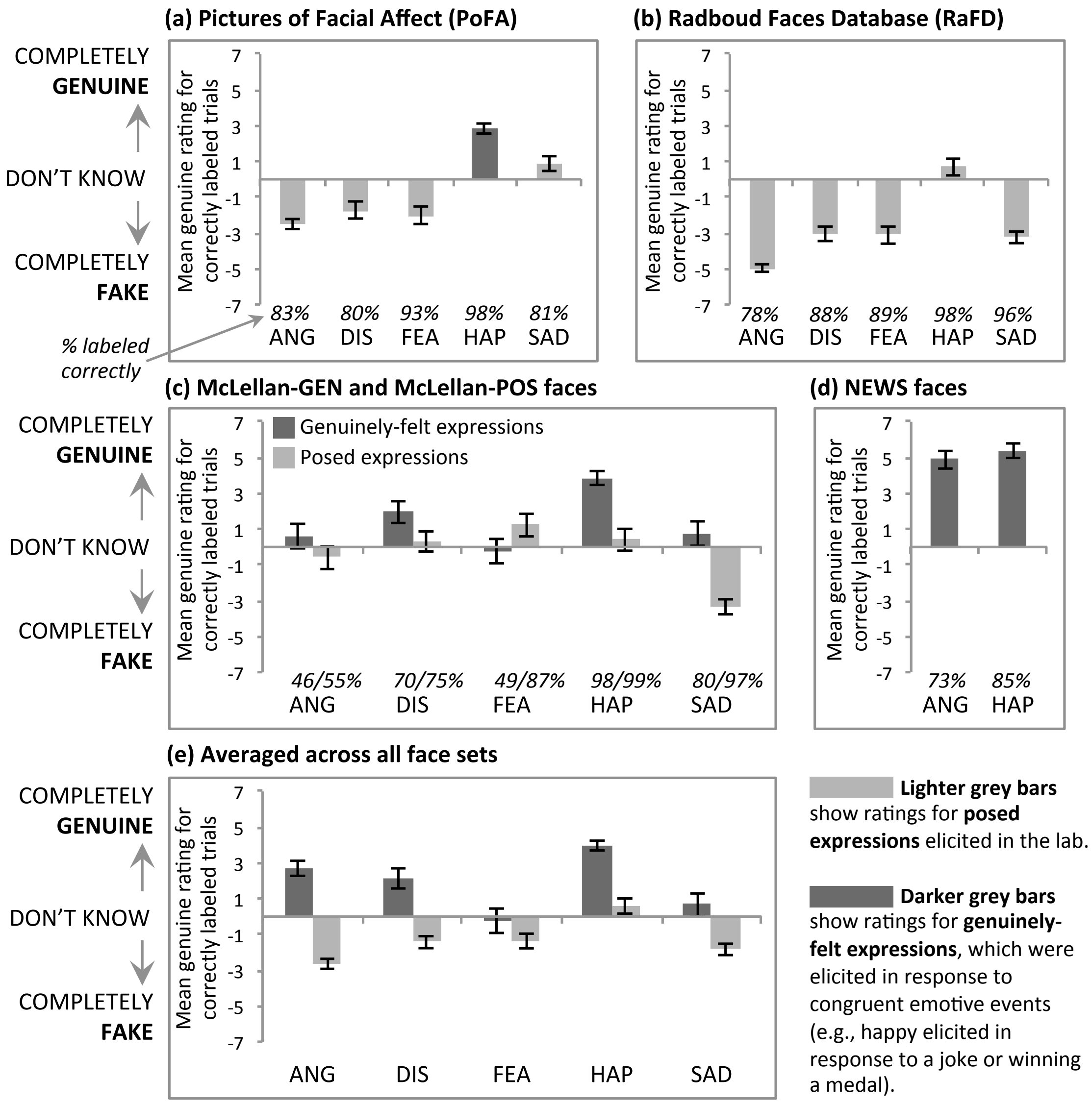


Figure 3. Study 1 genuineness ratings. (a) to (d) Mean genuineness ratings for correctly labeled trials, for each face set (note: NEWS faces presented in isolation, not in scene context). Numbers in italics below each bar indicate the percentage of trials where the expression was correctly labeled. (e) Mean genuineness ratings averaged across all face sets comparing posed expressions with genuinely-felt expressions (e.g., genuinely-felt anger = average of McLellan-GEN anger and NEWS anger; posed anger = average of PoFA anger, RaFD anger and McLellan-POS anger). ANG = anger. DIS = disgust. FEA = fear. HAP = happy. SAD = sad. Error bars indicate SEM.

Note our findings cannot be attributed to any peculiarity of our experiment or participants. We observed strong correlations between our ratings for the RaFD (on our -7 to +7 scale) with the genuine ratings from Langner et al. (on their 1-5 rating scale; 2010), $r(50) = .821$, $p < .001$. This indicates that the rank order in which participants perceived the RaFD stimuli (from most genuine to least genuine) was very similar for our study and for Langner et al.'s (2010) participants tested on the same stimuli. The additional information provided by our study, however, is the information about *absolute* genuineness. We included a neutral point that Langner et al. (2010) did not, and thus our results have been able to reveal that, in absolute terms, all except happy of the RaFD expressions (specifically anger, disgust, fear and sad) are perceived as faked.

Overall then, for stimuli from two widely used databases (PoFA and RaFD), none of the posed expressions were perceived as significantly genuine. Instead, most were perceived as clearly faked, and others as ambiguous. The only case in these databases of an expression perceived as significantly genuine was PoFA happy, $p < .001$ (note happy was also perceived as significantly more genuine than each of the other, posed, expressions in the PoFA set, all *p*s < .005). This result is consistent with Ekman's (1980) information that the happy expressions were in fact naturalistically obtained rather than posed. Overall, our findings argue that when facial expressions are posed, viewers commonly perceive them as such. This implies that use of posed stimuli to address theoretical questions may be problematic in cases where the interest is in the perception of others' genuine emotions.

6.4.3.2.4 Can lab-based induction procedures produce clear genuinely-felt emotion stimuli?

We next examined results for the McLellan face set. Ratings for genuineness (Figure 3c) show that, despite these stimuli having been created using best-practice criteria for lab-based generation of genuinely-felt emotions, results are rather disappointing, with only two of the five emotions (happy and disgust) being *perceived* as significantly genuine.

In statistical analysis, the McLellan faces produced a significant interaction between emotion and posed-genuine status, $F(4,116) =$, $MSE = 9.42$, $p < .001$, formally justifying analyzing the posed and genuine stimuli separately. Also, 1-way ANOVAs then showed significant differences across the five emotions within McLellan-GEN, $F(4,116) = 9.86$, $MSE = 10.02$, $p < .001$, and McLellan-POS, $F(3.07, 110,37) = 10.67$, $MSE = 14.08$, $p < .001$. For comparisons of each emotion to zero, alpha was again .01, given the 5 emotions.

For the McLellan-GEN faces, happy and disgust were perceived as significantly genuine, *p*s < .003. For the remaining McLellan-GEN expressions, results indicated participants were unsure about the genuineness of expressions, with no expression rating more than .74 in either direction, for anger, fear and sad, all *p*s > .276. These results show that it is possible to generate genuinely-felt expressions in the lab that are perceived as significantly genuine for at least one negative emotion (disgust), as well as for happy. However, results for fear, sad and anger are disappointing, in that these emotion stimuli were not perceived as clearly genuine despite their genuinely-felt origins, and stimuli for two of the expressions (fear, anger) were poorly labeled (<50% correct). Also, even for the successful recognition of expressions, genuineness ratings were rather moderate (McLellan-GEN: happy, $M = 3.87$, disgust, $M = 1.93$) compared to the scale maximum of +7.

Figure 4 indicates that a possible reason for these findings might be low intensity of the lab-elicited genuine expressions. From the McLellan set, the only expressions that were perceived as reasonably intense were happy and disgust (Figure 4c, and even these were not as intense as the PoFA and RaFD stimuli, Figure 4a,b); notably, these were also the only two McLellan-GEN expressions that were perceived as significantly genuine. The three McLellan-GEN expressions that were *not* perceived as genuine – anger, fear and sadness – were all perceived as rather weak in intensity.

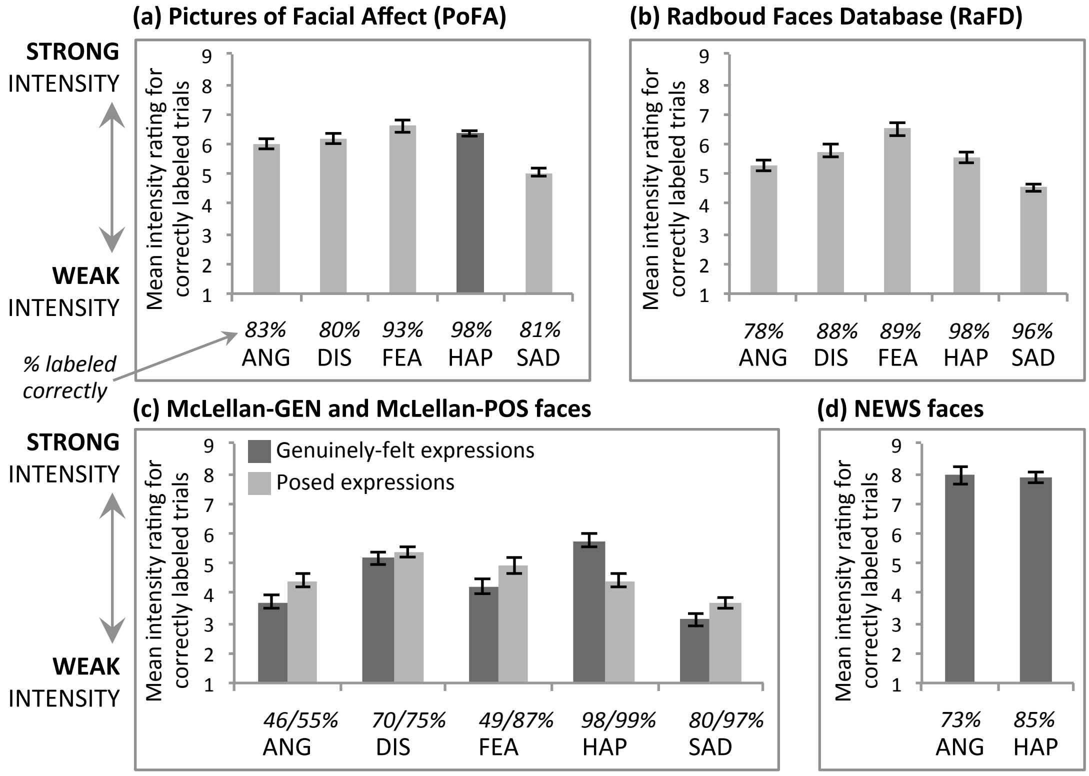


Figure 4. Study 1 intensity ratings. Mean intensity ratings for correctly labeled trials. Figure follows same format as Figure 3. ANG = anger. DIS = disgust. FEA = fear. HAP = happy. SAD = sad. Error bars indicate SEM.

Also of some interest was how the *posed* McLellan stimuli (i.e., McLellan-POS) were perceived for genuineness. Interestingly these stimuli (light bars in Figure 3c) tended to be perceived as less faked than the PoFA and RaFD stimuli (Figure 3a,b). The PoFA and RaFD stimuli were posed by FACS-consistent muscle movements while McLellan's eliciting instructions did not include FACS training for models and explicitly instructed participants to pretend or fake emotions. Thus, our findings suggest that posing via muscle movements may lead to images that appear particularly faked. Regarding comparison to zero, only one of the five McLellan-POS expressions was perceived as significantly posed, namely sad, $p < .001$. For the remaining McLellan-POS expressions, results indicated participants were unsure about the genuineness of expressions, with no expression rating more than 1.23 (out of 7) in either direction, fear, $M = 1.23$, $SD = 3.98$, $t(36) = 1.88$, $p = .069$, anger, disgust, and happy, all *p*s > .372. Overall, these results back up the general conclusion obtained from the PoFA and RaFD posed faces, namely that posed expressions are not perceived by participants as genuine, and instead are sometimes perceived as significantly faked, and sometimes as ambiguous.

6.4.3.2.5 Can we obtain genuinely-felt expression stimuli that are perceived as more strongly genuine?

We next analyzed results for our novel set of genuinely-felt expressions elicited by sporting events (NEWS faces), to address the question of whether real world situations that induce strong emotions might produce stimuli that are perceived as having high levels of genuineness. This did indeed occur. Figure 3d shows that the NEWS faces were perceived as strongly and significantly genuine. Importantly, this occurred not only for happy, $p < .001$, where the McClellan-GEN stimuli were also good (Figure 3c) but for also for anger, $p < .001$, where the McLellan-GEN stimuli were poor. Comparing genuineness ratings across the NEWS and McLellan stimuli suggests that lab-induction of genuine emotion is a suitable method for happy, but is of little value for anger.

The obvious explanation of this difference is that it arises because practical and ethical limitations preclude inducing strongly-felt genuine anger in the lab setting. This interpretation is supported by our intensity rating data, which show much stronger ratings of intensity for NEWS anger (Figure 4d) than for McClellan-GEN anger (Figure 4c). It was further supported by a correlational analysis of the relationship between intensity and degree of perceived genuineness based on individual face stimuli as the unit of analysis (rather than the mean across all items in a condition, as above). This analysis included all emotions. Results for genuinely-felt stimuli showed a significant positive correlation, $r(50) = .790$, $p < .001$, reflecting a pattern (Figure 5a) in which intense genuinely-felt stimuli were perceived as clearly genuine, but low-intensity genuinely-felt stimuli were perceived as ambiguous. This cannot be attributed to participants failing to follow our instructions to rate genuineness independently of intensity because, for posed faces, this increase in genuineness ratings with stronger intensity was clearly absent (Figure 5b), $r(134) = -.124$, $p = .154$. Instead, we conclude that for participants to be able to clearly perceive a facial emotion as genuine, the intensity of the expression needs to be at least moderately strong.

Figure 5. Study 1 relationship between genuineness and intensity. Each dot represents an individual face stimulus item, with intensity and genuineness rating score averaged over all participants (excluding incorrectly labeled trials). (a) Results for genuinely-felt expression stimuli. (b) Results for posed expression stimuli. $^{***}p < .001$. ^{ns}non-significant.

Overall, results from the NEWS photographs show that it *is* possible to obtain stimulus images of genuinely-felt expressions that are perceived as highly genuine (and also strongly intense). We obtained these results for anger, an emotion that is both negative in valence (unlike happy) and an avoidance emotion (again unlike happy). This argues that photographs from the news media may be a promising avenue in future for obtaining strong genuinely-felt stimuli for a range of negative and avoidance emotions.

6.4.3.2.6 Does increasing the intensity of genuinely-felt expressions also increase accuracy of labeling the emotion?

We have shown above that increasing the intensity of genuinely-felt expressions increases the extent to which they are perceived as genuine. Additional analyses showed greater intensity also significantly improved labeling accuracy. Including all genuinely-felt expression stimulus items (from McLellan-GEN, NEWS and PoFA happy), there was a strong positive correlation between increasing intensity and increasing labeling accuracy, $r(50)=.459$, $p=.001$ (which was also present within the McLellan-GEN faces alone, $r(38) = .605$, $p < .001$). The correlation was absent for the posed expression stimuli, which were labeled equally accurately regardless of intensity, $r(134) = .016$, $p = .855$ (items from McLellan-POS, PoFA, and RaFD).

Returning to genuinely-felt stimuli, of the poorly-labeled items 76% (13 out of 17) with accuracy below 80% correct had intensity ratings less than approximately 5.5 (on our 1-9 scale), and 89% (8 out of 9) with accuracy below 40%-correct had intensity ratings less than this value. These results argue that, in order to obtain genuinely-felt stimuli that are accurately labeled, it may be important to use stimuli that are at least moderately intense.

6.4.3.2.7 Where observers fail to discriminate genuine from posed, is this due to avoidance-versus-approach signals or too-low intensity of emotion?

Previous articles using the McLellan stimuli have reported that, using a simple genuine/posed decision, observers can discriminate genuine from posed emotion at significantly above chance for two emotions – happy and sad – but are poor at making this discrimination for other emotions including fear and disgust (Douglas et al., 2012; Johnston, Carter, & Mclellan, 2011; McLellan et al., 2010; McLellan, Wilcke, Johnston, Watts, & Miles, 2012; McLellan & McKinley, 2013). Our rating data for the McLellan stimuli replicate this result. In Figure 3c, the genuine versions are rated as more genuine than the posed version for happy and sad, but not for fear, disgust or anger. Two-sample two-tailed t-tests comparing each dark bar (genuinely-felt) with its corresponding light bar (posed), with alpha = .01 to Bonferroni-correct for the 5 emotions, revealed ratings were significantly higher for the genuinely-felt version for happy, $t(36) = 5.39$, $p < .001$, and for sad, $t(36) = 7.45$, $p < .001$, but not for anger, $t(30) = 1.79$, $p = .083$, disgust $t(36) = 2.41$, $p = .021$ (non-significant with Bonferroni correction), or fear (non-significant trend in the opposite direction), $t(35) = 2.19$, $p = .035$.

At first glance, these results might appear to support McLellan et al.'s (2010) contention that emotions eliciting avoidance (fear, disgust, anger) are treated as if they are real regardless of whether they are genuine or posed, consistent with a theoretical idea that it might be adaptive to respond rapidly to these emotions (e.g., because they signal danger) without pausing to make finer-grained decisions about genuineness which might require additional, slower, processing of the social context to determine. However, other aspects of our data clearly discount this idea.

First, our use of a scale with a neutral point allows us to determine that the lack of discrimination between genuine and posed is not due to the avoidance emotions being perceived as genuine in both cases, as the theory would have predicted; instead, our earlier analysis showed McLellan et al.'s (2010) avoidance emotion stimuli were never perceived as significantly genuine when posed (and were perceived as significantly genuine in only one case of three even when genuinely-felt). Second, because the McLellan stimuli are relatively low in intensity compared to other sets (for both genuinely-felt and posed emotions, Figure 4c), we re-analyzed genuine-versus-posed discrimination after averaging across face sets to include all available stimuli; that is, we now included extra posed stimuli from PoFA and RaFD, extra genuinely-felt stimuli for anger from NEWS, and extra genuinely-felt stimuli for happy from PoFA and NEWS. Results are presented in Figure 3e. For approach emotions, results replicate the McLellan-set-only findings of significant discrimination between genuine and posed happy and sad (both $ps < .001$). However, with the additional more intense items included, we now find a different result for avoidance emotions, with significant discrimination for both anger and disgust ($ps < .001$), although still not for fear ($p = .10$). These results show that it *is* possible for observers to perceive genuinely-felt avoidance emotions as more genuine than posed avoidance emotions, at least for two of the avoidance emotions. Regarding fear, we note that none of the stimulus sets included high-intensity versions of genuinely-felt fear. Thus, we do not wish to conclude that our results argue fear has some special status. Our lack of discrimination for this expression might merely reflect the lack of any intense-emotion images included in the average.

The findings of this section indicate the importance of measuring and considering intensity when obtaining stimuli, and particularly the desirability of obtaining genuinely-felt expressions that display at least moderately intense emotion, and not only the milder versions to which researchers are often limited when using lab-based elicitation.

6.4.3.3 Discussion of Study 1

Study 1 produced several key findings. First, we found that two commonly used sets of facial expressions – Ekman's PoFA and the RaFD – are not perceived as displaying genuine emotion. Surprisingly, despite the widespread use of these stimulus sets in the literature, we have been unable to find any previous studies that have asked observers about the extent to which they perceive the stimuli in these sets as showing genuine or faked emotion. When we did so here, we found that most of the emotions were perceived as clearly faked. We also note that a similar conclusion, of lack of perceived genuineness, was reached using a different method of posing stimuli (i.e., for the McLellan-POS faces). Thus this may well be true of other posed sets, too. This result implies that use of posed stimulus sets to address certain theoretical questions may be problematic. This applies particularly where the research question concerns responses to others' *genuine* emotions. For example, in studies of empathy, one might expect that high-empaths should show high arousal when they perceive genuine distress displayed by other people, but there would be no theoretical reason to expect they would show high arousal in response to clearly faked distress. We consider further the issue of the circumstances in which posed stimulus sets might and might not be suitable in the General Discussion.

Our PoFA and RaFD results also confirm Ekman's (2003) proposal that basic FACS coding – used to determine *what* emotion is present – is not sufficient to guarantee perceived genuineness of the emotion. Both the PoFA and RaFD stimuli meet the requirements of basic FACS coding, yet their stimuli are not perceived as genuine. Regarding whether FACS coding for additional "genuineness markers" can be useful, our results add some information to previous literature (although note we did not set out to address this question, e.g., we collected our novel NEWS stimuli only in genuine versions, with no posed equivalent). Potentially consistent with usefulness of genuineness markers, it is worth noting that the genuine-anger and genuine-happy stimuli we collected from the news did generally contain the genuineness markers proposed by (Ekman (2003; see Method and Table 2; this is of particular interest for anger because there has been no previous empirical investigation of the proposed marker AU23. On the other hand, our rating results for the McLellan genuine-sad stimuli are only partially encouraging. We did find that the posed versions of sad, which do not contain Ekman's genuineness marker AU1+4 (McLellan et al., 2010) were, as would be predicted, perceived as significantly faked. And, the presence of the AU1+4 marker in the genuinely-felt versions removed this perception of fakeness. However, it did not lead the stimuli to be actually perceived as genuine (merely as ambiguous). Given that the McLellan genuine sad faces were particularly low in intensity (Figure 4c), a possible interpretation is that AU1+4 distinguishes a genuinely-*felt* sad emotion even when the expression is mild in intensity, but that for observers to *perceive* the genuineness the markers must be present *and* the intensity needs to be made stronger; that is, the genuineness markers alone are not enough. Overall, our results are not inconsistent with the idea that FACS markers to genuineness might exist, but indicate that substantially more empirical validation and exploration of such markers is required. If FACS markers to genuineness do exist, it might be possible to use them to pose expressions that are perceived as genuine. However, voluntary posed expressions and involuntary genuinely-felt expressions are innervated by different systems (Rinn, 1984) and the musculature operated by the involuntary system is not always controllable by other means (Gosselin et al., 2010). It could also be that genuinely-felt expressions include more subtle signals that cannot be mimicked, such as pupil dilation (Harrison, Wilson, & Critchley, 2007).

Our second key finding concerned the methods required to produce expression stimuli that both display, and are perceived as displaying, a genuinely-felt emotion. Here, our results argued that lab-based elicitation methods can sometimes be effective but overall produce less-than-ideal results. Despite the McLellan genuinely-felt stimuli having been elicited using a well thought out and well justified method, our results show these stimuli are perceived as genuine only for happy and disgust. The emotions that are more difficult to elicit strongly in a lab setting – fear, anger, and sadness – were not perceived as genuine. Our NEWS set results then showed that obtaining more intense examples of genuine emotions from naturally-occurring settings (in our case the news media) was very effective, with ratings of perceived genuineness increased, and anger faces perceived as very clearly genuine. (Note that to do so, however, we had to give up tight control over the format of the faces – that is, the NEWS faces varied in viewpoint, lighting conditions, and eye-gaze direction – a point we consider further in the General Discussion.) Overall, our results are very encouraging in that they demonstrate that it *is possible*, for emotions besides happy, to obtain genuinely-felt facial emotion stimuli that are also perceived as showing genuine emotion: we have demonstrated this for three emotions, namely happy, disgust and anger.

Third, our results refuted the theory that it is adaptive to treat all avoidance emotions as genuine in order to avoid danger. Instead, we found that McLellan's posed avoidance-emotion stimuli were not perceived as genuine, and that the failure of participants to be able to distinguish genuine from posed versions of avoidance emotions was due to a confound with intensity. When average intensity was increased (e.g., by including the NEWS images in the analysis), participants did discriminate genuine from posed avoidance emotions (for anger and disgust).

Finally, we emphasize the value of rating genuineness using our method of a positive-to-negative scale centered around a neutral point of zero, rather than as traditionally done – for example on a 1-5 scale by Langner et al. (2010) for the RaFD set. Of the key findings above, almost all derive from knowing whether faces were perceived as genuine or faked in absolute terms. Thus, they could not have been obtained without the use of the neutral-point rating method.

6.4.4 Study 2: Can theoretical conclusions differ for genuinely-felt compared to posed happy expressions?

Study 1 has shown that commonly used posed face sets are perceived as showing faked emotion. A critical issue that then arises is whether the use of posed versus genuinely-felt expression stimuli actually matters; that is, whether it can lead to different theoretical outcomes. One case where this has been shown to occur is that of paranoid schizophrenia (Davis & Gibson, 2000). If we can demonstrate a second case here – in which a very different theoretical conclusion is drawn depending on whether stimuli show genuinely-felt or posed emotion – then this would add significantly to an argument that emotion researchers cannot afford to ignore the posed-genuine distinction.

Our topic is psychopathic traits. Psychopathic traits are characterized by two main factors, the first being affective and interpersonal deficits (i.e., cold unempathic style of relating to others, lack of guilt and remorse, shallow affect) and the second being antisocial and disinhibited behavior (Hare & Neumann, 2008). We measure the construct of psychopathy in its entirety, and also focus more specifically on the affective and interpersonal deficits factor, measured here as callous unemotional (CU) traits (Frick, Ray, Thornton, & Kahn, 2013; Frick, 2003).

A widely-used theory is that a specific impairment in processing others' distress plays a causal role in the development of psychopathy (Blair, 1995, 2006). This predicts that individuals who are high on psychopathic and CU traits will show impairments in recognizing, and responding to, others' distress emotions – namely, fearful and sad expressions. Indeed, there are many studies showing psychopathic and CU traits are associated with problems identifying fearful and sad expressions (Dawel et al., 2012; Marsh & Blair, 2008). And in terms of *response* to these expressions, two studies show decreased affective responsivity to other's genuinely-felt distress emotions (naturalistic pictures of crying faces: adult psychopaths; Blair, Jones, Clark, & Smith, 1997; children with psychopathic traits; Blair, 1999), as assessed by a measure of arousal (physiological arousal assessed by skin conductance response, SCR). Equally importantly, however, Blair's (1995, 2006) distress-processing-deficit theory of psychopathy implies that deficits will *only* be apparent for processing of distress emotions (i.e., fear and sad) and not for processing of non-distress emotions (e.g., happy). It is this second core prediction that we address here.

We focus on the emotion of happy. The reason for this is twofold. First, happy provides the strongest possible test of the distress-deficit theory in that, of all the basic emotions, it is the only emotion that is positive in valence and thus most unambiguously indicates lack of distress. Second, the results of Study 1 indicate that, for happy, we have available a suitable set of stimuli for testing genuine-versus-posed differences, from the McLellan set. For McLellan-GEN, the genuinely-felt happy expressions were perceived as clearly and significantly genuine (Figure 3c, dark bar); at the same time, for McLellan-POS the corresponding posed happy expressions displayed by the same individuals were not perceived as genuine (Figure 3c, light bar); and the genuinely-felt version was perceived as significantly more genuine than the posed version.

What do previous studies find regarding processing of happy facial expressions? In terms of identifying expressions as happy, many studies have reported that psychopathic and CU traits show no association with labeling accuracy; however, our recent meta-analysis found that, when power was increased by combining all studies together, a significant deficit in labeling for happy emerged (Dawel et al., 2012). A practical difficulty with using labeling accuracy as the measure is that performance for happy commonly approaches ceiling (e.g., see Figure 3), and thus the approach we take here is to measure the observers' emotional *response* to happy faces via ratings of arousal. Such ratings are correlated with physiological arousal (SCR) and do not suffer from ceiling or floor problems (Lang, Greenwald, Bradley, & Hamm, 1993) and are thus a useful way to measure whether psychopathic and CU traits are associated with reduced responsivity. One previous study (Eisenbarth, Alpers, Segrè, Calogero, & Angrilli, 2008) used this measure with images from the Karolinska Directed Emotional Faces set (KDEF; Lundqvist, Flykt, & Öhman, 1998), rating arousal from 1-9, in a forensic psychopath group. Results showed that, for fear (and some other emotions), there was clear evidence of impaired emotional response (reduced arousal in psychopaths). However, results for happy were less clear: the psychopath group had significantly lower arousal to happy than a non-psychopathic inmate patient control group, but not than a prison-employee control group. Thus, these results are somewhat unclear regarding Blair's distress-specificity theory of psychopathy: the reduced emotional response to fear is as predicted by the theory, but the theory also predicts no such reduction to happy.

From our present perspective, the difficulty with these previous studies of happiness is that they have not addressed the issue of whether happy expressions are genuinely-felt or posed, and thus whether theoretical conclusions drawn from each are in agreement or disagreement. Here, we do so, by correlating measures of psychopathic and CU traits with self-rated arousal to the McLellan-GEN happy faces and the McLellan-POS happy faces. We measure psychopathic and CU traits in an undergraduate population (rather than forensic psychopaths), noting that these traits are continuous variables that show natural variation within the general population (Edens, Marcus, Lilienfeld, & Poythress, 2006; Marcus, John, & Edens, 2004). To anticipate, our results demonstrate a clear difference in conclusions depending on whether the happy expression stimuli are posed (where results support Blair's theory) or genuine (where results refute Blair's theory).

6.4.4.1 Method for Study 2

6.4.4.1.1 Participants

Participants were the same 37 participants from Study 1 plus 26 new participants (16 females, M_{age} = 20 years, SD_{age} = 2.8, $\text{range}_{\text{age}}$ = 17-27) who did not participate in Study 1. Recruitment and inclusion criteria were as for Study 1. From the new sample, two additional participants had been excluded because they reported disorders that can affect face processing (specifically epilepsy, severe migraines with aura).

6.4.4.1.2 Procedure

Arousal rating instructions. Face stimuli were presented one at a time and rated for arousal using the following instructions:

> Your next task is to rate how AROUSING you find each facial expression, from low to high using the following scale:
>
> Please rate how arousing you find this facial expression.
>
> Low High
> [1] [2] [3] [4] [5] [6] [7] [8] [9]

Participants rated only the McLellan face sets (McLellan-GEN and McLellan-POS) for arousal, with items from the two face sets intermixed and presented in different random order for each participant. Note that all five McLellan expressions were included, but we present only results for happy here because happy is the only expression that meets our Study 2 requirements that (a) the genuinely-felt version are perceived as significantly genuine, and (b) the genuinely-felt version are perceived as significantly more genuine than the posed version (which in turn is not perceived as genuine) (see Results of Study 1).

Measures of psychopathic and CU traits. All 63 participants completed the Inventory of Callous Unemotional Traits (ICU; Frick, 2003), and the 37 participants from Study 1 also completed the Levenson Self Report Psychopathy Scale (LSRPS; (Levenson, Kiehl, & Fitzpatrick, 1995). Table 5 shows descriptive statistics for both the questionnaire measures, with comparisons from relevant norming studies (Brinkley, Schmitt, Smith, & Newman, 2001; Kimonis et al., 2008; Kimonis, Branch, Hagman, Graham, & Miller, 2013; Levenson et al., 1995). Table 5 indicates that the range of scores in our sample were typical of undergraduate samples (Kimonis et al., 2008; Levenson et al., 1995) and, as is usual, there was some overlap with forensic samples (Brinkley et al., 2001; Kimonis et al., 2013) with the highest scorers in our sample exceeding the mean in general forensic samples (i.e., a general prison population, not specifically prisoners with psychopathy).

Task order. For the participants from Study 1, the arousal rating task was conducted immediately following the intensity rating block. The 26 new participants completed the arousal rating task as one of several face tasks unrelated to those in Study 1. For all participants, the questionnaires measuring psychopathic and CU traits were completed at the end of the experiment.

Table 5

Study 2: Descriptive statistics for questionnaire measures, and comparison to our relevant norm samples

Measure/study	Sample	*N*	% female	*M* (*SD*)	Range	Cronbach's α
ICU						
Our study	Adult undergraduates	37	81%	44.68 (10.1)	26–80	.87
Levenson et al. (1995)	Adult undergraduates	487	72%	48.45 (NR)	NR	NR
Brinkley et al. (2001)	Adult forensic[a]	549	0%	54.66 (11.6)	NR	.85
LSRPS						
Our study[b]	Adult undergraduates	63	73%	16.76 (7.3)	3–42	.82
Kimonis et al. (2013)[c]	Adult undergraduates	687	77%	14.44 (6.8)	-2–47	.81
Kimonis et al. (2008)	Adolescent forensic[d]	248	24%	23.96 (10.3)	NR	.81

LSRPS = Levenson Self Report Psychopathy Scale (Levenson et al., 1995). ICU = Inventory of Callous Unemotional Traits (Essau et al., 2006). NR = not reported. [a]This sample were aged up to 40 years. [b]ICU score characteristics were similar in our Study 1 sample (n = 37) and the additional sample included in Study 2 (n = 26), so we present combined results here. [c]The ICU is typically scored from 0 to 3, but Kimonis et al. (2013) scored it from 1 to 4. We have converted their reported results by subtracting 24 (the total number of items) from the mean and range scores. The minimum score of -2 is presumably for a case where the participant failed to answer two questions, as the lowest possible score should be 0. [d]Mean age of sample was 15.5 years (*SD* = 1.37, range = 12-20).

6.4.4.2 Results of Study 2

Figures 6a and 6b shows relationships between arousal ratings for McLellan genuine and posed happy expressions with (a) LSRPS and (b) ICU scores. Figure 6 also shows there was one participant who was a univariate statistical outlier (within this typical-population sample) on the LSRPS (z = 3.52) and ICU (z = 3.48). This participant scored high on both the LSRPS and ICU, consistent with this being a genuine score. Importantly, the case was not a bivariate statistical outlier, implying it should not affect the strength of correlations, and results reported below did not change if we removed this participants' data. Thus, we report analyses for all participants, with results excluding the outlier in parentheses.

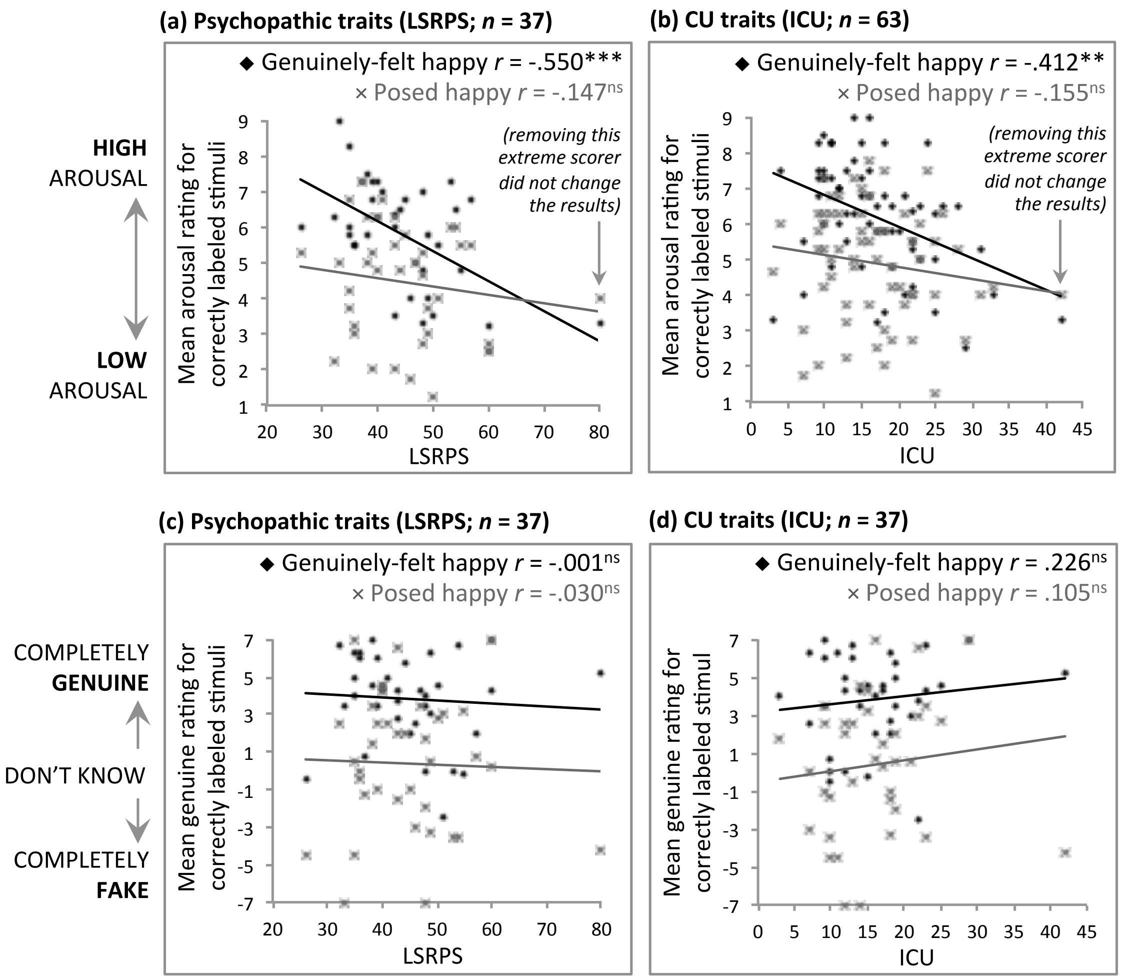


Figure 6. Study 2 results. Lower self-reported (a) psychopathic traits and (b) CU traits were associated with higher mean arousal ratings for genuine happy expressions but not for posed happy expressions (stimuli from the McLellan face set; 2010). This was not due to any inability to differentiate the genuine from the posed happy expressions per se, as there was no relationship of genuineness ratings to either (c) psychopathic traits or (d) CU traits. Note that removal of the extreme high LSRPS/ICU score (LSRPS = 80; ICU = 42) did not change the results (see main text). LSRPS = Levenson Self Report Psychopathy Scale (Levenson et al., 1995). ICU = Inventory of Callous Unemotional Traits (Essau et al., 2006). $^{**}p < .01$. $^{***}p < .001$. ^{ns}non-significant.

Blair's (1995, 2006) distress-specific account of psychopathy predicts that the decrease in responsivity that is established for distress emotions (e.g., arousal to crying faces; Blair et al., 1997; Blair, 1999) should be absent for happy. That is, for happy, arousal should *not* decrease with increasing psychopathy/CU. When we look at the results for posed happy we find that they are consistent with Blair's (1995,

2006) theory, with no significant association between arousal ratings for these stimuli and the LSRPS, $r(37) = -.147$, $p = .385$, or ICU, $r(63) = -.155$, $p = .226$, (outlier removed: LSRPS, $r(36) = -.147$, $p = .391$; ICU, $r(62) = -.147$, $p = .288$). However a starkly different conclusion is reached when we examine results for genuinely-felt happy. Here we observed a significant negative relationship between arousal ratings and LSRPS scores, $r(37) = -.550$, $p < .001$, and ICU scores, $r(63) = -.412$, $p = .001$ (outlier removed: LSRPS, $r(36) = -.503$, $p = .002$; ICU, $r(62) = -.353$, $p = .005$), indicating that low psychopathic/CU-trait individuals rated genuinely-felt happy faces as more arousing than high psychopathic/CU-trait individuals. Moreover, Meng's z-test for the difference between two correlations showed that the relationship observed for genuinely-felt happy was significantly stronger than that for posed happy for both the LSRPS, $z = 2.78$, $p = .006$, and the ICU, $z = 3.04$, $p = .002$ (outlier removed: LSRPS, $z = 2.65$, $p = .004$; ICU, $z = 2.31$, $p = .010$).

This difference in correlations indicates there was a significant interaction between the trait scores and the genuine-versus-posed nature of the face stimuli. Figure 6a and 6b illustrates the form of this interaction, which was that: (a) individuals who were low in psychopathic/CU traits experienced stronger arousal to genuinely-felt happy faces than to faked happy faces; (b) this difference gradually weakened as psychopathic/CU traits increased; until (c) the two trend lines met for individuals who were high in psychopathic/CU traits, with these people experiencing similar arousal as low-trait individuals for posed happy faces but not the greater arousal to genuinely-felt happy faces shown by low-trait individuals.

This pattern has theoretical implications (see Discussion) but also note that, from a methodological perspective, it rules out an uninteresting interpretation of the results for genuinely-felt happy. We have measured arousal via self-ratings and, unlike implicit physiological measures (e.g., SCR), there is the logical potential for arousal ratings to be subject to a reporting bias. However, we can rule out the idea of a general change in reporting bias across the psychopathic/CU trait range (e.g., low-trait individuals being more willing to *report* experiencing arousal than high-trait individuals), because such a bias would predict equal correlations for posed and genuine happy.

A final question concerned what underlies the lack of higher arousal to genuine than posed happy faces in individuals with high psychopathic/CU traits. Specifically, does this reflect (a) a failure to *perceive* the difference, indicating a failure to be able to detect genuineness in others' emotions, or (b) an ability to perceive genuineness accompanied by lack of emotional responsivity to others' genuine emotions. Analysis of the genuineness ratings from Study 1 supported the second alternative. Figures 6c and 6d plots the associations between psychopathic/CU traits and ratings of genuineness, for the n = 37 who completed Study 1 (i.e., the participants from whom we have genuineness ratings scores). Results show that there was no reduction in the ability to discriminate genuinely-felt happy from posed happy as psychopathic/CU traits increased, with no correlation between trait strength and genuineness ratings for either genuinely-felt happy (LSRPS, $r(36) = -.001$, $p = .993$; ICU, $r(36) = .226$, $p = .178$) or for posed happy (LSRPS, $r(36) = -.030$, $p = .858$; ICU, $r(38) = .105$, $p = .538$). Thus, high-psychopathic/CU-trait individuals showed good ability to determine whether a face was displaying a genuine emotion or not, but this was accompanied by a lack of stronger responsivity to the genuine version.

6.4.4.3 Discussion of Study 2

The primary take home message from Study 2 is that the issue of whether face stimuli display genuinely-felt or posed emotions cannot be ignored. One of the dominant theories of psychopathic traits (Blair, 1995, 2006) argues that abnormalities in emotion processing are specific to expressions of distress (fear and sadness). Our results look consistent with this theory when posed happy expressions are used, but refute it when expressions are genuinely-felt. Whether expression stimuli are genuinely-felt or posed clearly matters in this case. This reinforces the conclusion implied by the results of (Davis & Gibson, 2000) with schizophrenia, extending it to a very different psychological topic. In both schizophrenia and psychopathy, using genuinely-felt stimuli leads to a fundamentally different theoretical answer from using posed stimuli.

Our results also have some more specific implications for the understanding of psychopathy. First, our results add to evidence that deficits in psychopathy are not limited to distress expressions but also occur for happy expressions (for labeling in meta-analysis; (Dawel et al., 2012). This is inconsistent with Blair's (1995, 2006) theory of the origin of psychopathy, at least in its strong version that deficits in emotion processing are *completely* specific to distress emotions. However, the results could perhaps be consistent with a weaker version of Blair's theory, in which deficits in emotion processing in psychopathy, while present for all emotions, are *stronger* for distress emotions than for happy. Unfortunately, current literature and stimulus sets do not allow us to address this question, due to confounds between the type of emotion and it's genuinely-felt versus posed status. In particular, of the previous studies of labeling deficits (Dawel et al., 2012) many have used the PoFA set in which the fear (distress) faces are posed (and perceived as clearly faked, see Study 1) while the happy (non-distress) faces are genuinely-felt (and perceived as genuine). And, regarding the only previous study of arousal to facial expressions (Eisenbarth et al., 2008), this used the KDEF set, for which the genuine versus posed status of the faces showing each emotion is unclear. The KDEF set was created using amateur actors, but the instructions to the actors (see General Discussion) did not specify whether the actor was expected to pretend the emotion, or to attempt to feel it. If some actors took the latter approach, then it is likely that they would have done a better job for happy faces than fear faces, noting that people have more everyday practice at inducing themselves to feel happy than at inducing themselves to feel fear. Thus, to clarify whether there is any specific role of reduced response to distress in psychopathy, we suggest that it would be valuable for future studies to compare the relative size of deficits in psychopathy for happy versus fear emotions when the two are matched for status (e.g., both are genuine). A limitation of the present study is that we only tested one emotion: happiness. It will be important in future to extend our paradigm to cover the full range of 'basic' emotions (i.e., anger, disgust, fear, etc.). This would clarify, for example, whether psychopathy-related reduction in responsiveness are more severe to distress emotions than non-distress emotions.

In our second psychopathy-relevant finding, we have provided the first investigation of whether psychopathic/CU traits might affect the ability to discriminate genuine from posed emotion. We found no such association. Instead, results indicated that high psychopathic/CU-trait individuals are as good at perceiving that a happy emotion is genuinely-felt as lower-trait individuals, but show a lack of emotional *responsivity* to that genuinely-felt emotion.

Finally, our specific pattern of interaction in arousal could be explained by a role for *simulation* in psychopathic/CU traits. Typically, people respond to others' expressions by automatically simulating or mimicking them in a way that results in 'catching' or sharing of their emotion (Dimberg, Thunberg, & Elmehed, 2000). For example, when a person sees somebody else smile their same facial muscles are activated and they may feel some degree of happiness as a consequence. Simulation is thought to aid in emotion recognition (Goldman & Sripada, 2005; Heberlein & Atkinson, 2009), empathy (Sonnby-borgström, 2002), and cooperative interpersonal behavior (Barsade, 2002). One possible implication of simulation theory is that it *might* only be possible to 'catch' an emotion that is genuinely-felt by the person displaying the expression. A second, less extreme possibility is that 'catching' of the emotion might be stronger for genuinely-felt expressions than for posed expressions. The underlying reasoning here is that, because posed expressions do not reflect any underlying emotional experience, there is no actual emotion to 'catch'. Thus emotional arousal to genuinely-felt expressions should be greater than for posed expressions. This is exactly the pattern of results that we observed in people with low psychopathic and low callous unemotional traits (large difference between black and grey lines on left of each panel in Figures 6a & 6b). However, with increasing levels of psychopathic and callous unemotional traits we observed less differentiation in arousal to the genuinely-felt versus posed happy stimuli (small or no difference between black and grey lines on right of each panel in Figures 6a & 6b), consistent with the idea that psychopathic traits may be associated with decreased 'catching' of others' emotions. This idea has recently been suggested for fear in psychopathic traits (Marsh, 2013). Our results indicate it may also be the case for happiness.

6.4.5 General discussion

The key findings from our studies are as follows. First, widely-used facial expression stimuli – from the PoFA and RaFD – are perceived as showing faked emotion not genuine emotion. Second, eliciting genuinely-felt emotions in the lab can in some cases produce expression stimuli that are also perceived by observers as showing genuine emotion (specifically for happy and disgust). However, in other cases lab-elicitation is unsuccessful as a method due to it being impractical or unethical to induce strongly-felt genuine emotion in the lab (i.e., for anger, fear, sadness). Third, for these difficult-to-induce emotions, it *is* possible to obtain genuinely-felt stimuli that are also *perceived* as clearly genuine. This can be done using natural images elicited in real world contexts that produce more intense genuine emotion (in our case, news media photographs of anger during sporting events). Fourth, the distinction between genuine and posed facial expression stimuli is not one that can be ignored in its implications for theory. We found that results for genuinely-felt happy stimuli refuted a core prediction of a major theory of psychopathy – that is, that emotion processing deficits in high-psychopathic-trait individuals should be specific to fear and sadness and not occur for happiness – while results for posed happy stimuli alone would have appeared to support the theory. Thus, although posed expressions, such as polite smiles, are displayed in real life interactions and are important to the literature, it does not necessarily follow that findings from posed expressions apply to genuinely-felt expressions.

6.4.5.1 Implications of our results for other available databases

Of the various standard face databases, in the present study we tested only those that used muscle-movement-posing, and found that the resulting images were generally perceived as showing faked emotion. To what extent would we expect the same result from other widely-used databases? This is difficult to predict, because the instructions given to models in other databases often leave it unclear as to whether the models would have displayed posed or genuinely-felt emotions.

In the KDEF (Lundqvist et al., 1998), amateur actors were instructed to practice the specific emotional expressions for an hour before being photographed, and to "try to evoke the emotion that was to be expressed and – while maintaining a way of expressing the emotion that felt natural to them – try to make the expressions strong and clear" ("KDEF and AKDEF," n.d.). These instructions do not specify whether the actor was expected to pretend the emotion, or to attempt to feel it while creating the expression, although we note that practicing for an hour first suggests that pretense was perhaps most likely. For the FACES database (Ebner, Riediger, & Lindenberger, 2010), models went through a three-stage procedure. The first two stages involved looking at emotionally-evocative pictures and then using the pictures to 'relive' a personal experience. The third stage used muscle-movement-posing. Images included in the final database were selected on the basis that they displayed the 'best representation' of the target expression. It is unknown what stage of the elicitation procedure each image is from (N. C. Ebner, personal communication, November 3, 2010). Stage 1 and 2 might potentially produce genuinely-felt emotion images, while Stage 3 uses the same instructions as for PoFA and RaFD and thus would be expected to produced posed expressions perceived as faked. Overall, for both KDEF and FACES, it is possible that some of the images show a model who was feeling the emotion that is displayed in the expression. However, this cannot be assumed.

There are also some databases that have used method acting – the Gur faces (Gur et al., 2002) and, more recently, the MPI faces (Kaulard, Cunningham, Bülthoff, & Wallraven, 2012). Method actors are trained to elicit emotional experiences within themselves in order to give a genuinely-felt performance. Here, the models were amateur actors "coached to re-live appropriate experiences" (Gur et al., 2002, p. 142; MPI used the same method). To the extent that the actors were successful at inducing real emotions, and these were sufficiently intense (see our Study 1), then it may be that these databases could provide a useful source of expression stimuli that observers perceive as genuine. However, it might also be expected that the actor's level of skill would be important (e.g., professional rather than amateur method actors might have greater ability to induce real emotions). We note the MPI stimuli have been rated for 'naturalness' (i.e., "as it [the expression] would occur during a natural conversation"; Kaulard et al., 2012, p. 7), but the rating method suffered from the same problems as the 'genuineness' scale used for the RaFD (i.e., it went from 1 to 5 with no neutral mid-point) so it is unclear whether these expressions are perceived as 'natural' in absolute terms.

In summary, it is possible that some already-existing stimulus sets might include a mix of stimuli, some more genuinely-felt, and some more posed. Our results argue it would be useful to obtain rating data for all stimuli in these databases, using a neutral-point rating scale similar to ours to determine in an absolute sense whether each stimulus is perceived as showing genuine or faked emotion.

6.4.5.2 Advantages and disadvantages of using real-world images

Our results from Study 1 showed that genuinely-felt emotions need to be quite intense to be perceived as genuine (and also to be accurately labeled). Thus, for some emotions it might be difficult, even for reasonably good method actors, for models to feel the emotion in sufficient intensity under lab conditions to produce expressions that are perceived by others as genuine. If this is the case, it might be necessary to obtain real world images from contexts that produce naturally strong emotions, such as our news media approach.

Such an approach has both advantages and disadvantages. The primary advantage is that there is potential to obtain high-intensity genuinely-felt expressions of anger, fear, and sadness, which have so far proved difficult to generate in the lab. Our results indicate that this high intensity leads to clear perceptions of strong genuineness in the case of anger, and we see no reason that it should not also do so for the other emotions. Thus, a news media approach could be very useful where it is essential for the research project to have stimuli for a range of negative emotions that are clearly perceived as showing genuine emotion.

Potential disadvantages of a news media approach are that the viewpoint and eye-gaze direction in the stimuli cannot be controlled. In fact, this may actually increase the appearance of genuineness (some of our participants reported anecdotally that looking straight at the camera made faces seem posed). However, it would be problematic in studies where viewpoint and eye-gaze factors are of interest, such as studies of responses to direct versus averted eye-gaze (Adams &

Kleck, 2005), or of expression-dependent eye-gaze cueing of attention (Bayliss, Schuch, & Tipper, 2010; Kuhn & Tipples, 2011). Another disadvantage of the news media approach is that it is difficult or impossible to obtain images of the same person displaying multiple different expressions. This would make news media stimuli unsuitable, for example, in studies that rely on varying expression while keeping identity constant, or studies of expression caricaturing which require a neutral-expression version of the same individual to caricature away from (Calder, Rowland, et al., 2000). Another limitation worth noting is that it would be difficult or impossible to obtain self-reports of felt-emotion for many news images. Thus we would have to rely on contextual information to determine the felt-emotion, as we have in the present study.

Regarding practical issues, we note that within a news media approach some expressions will be relatively easier to obtain than others. We found that instances of happiness and anger were common in our sports players. However we rarely saw fear or sadness when searching for images. Another challenge may be getting models that people do not have prior familiarity with. One possibility is to swap images between countries of similar ethnicity. Many of our sports players were known to Australians, but would not be familiar to people from other countries. Such international collaboration would also help to address the considerable challenge of obtaining sufficient numbers of high-quality real-world stimuli.

6.4.5.3 When is it necessary to use genuine stimuli, and when will lab-posed do?

Despite the difficulties associated with obtaining genuinely-felt emotion stimuli, we argue there is little point in continuing to use posed stimuli – particularly ones that are perceived as clearly faked – for many research questions. This applies particularly when the research question is about the perception of others' *felt* emotions, or about the participant's *affective* response to others' emotions.

To take one example, a participant's ability to correctly label facial expressions is sometimes used as a proxy for measuring empathy, particularly its affective component (e.g., Wai & Tiliopoulos, 2012). Logically, genuinely-felt expressions would be more appropriate for this purpose. Identification of posed expressions might be measuring cognitive reasoning processes (e.g., 'I see some drawn-together eyebrows so I must be expected to say the expression is angry, even though the person doesn't really look to me like they are feeling angry') rather than emotion processing or affective response. This distinction between affective and cognitive processes involved in face expression tasks could also potentially explain the different effects of schizophrenia on recognition of posed and genuinely-felt expressions (Davis & Gibson, 2000). That is, while the results for genuinely-felt expression indicate that affective emotion recognition is intact, the impaired recognition of posed emotions could arise from the well-established problems with cognition in this disorder (Heinrichs & Zakzanis, 1998; Mesholam-Gately, Giuliano, Goff, Faraone, & Seidman, 2009).

Another situation where an invalid conclusion might be drawn from using current stimulus databases concerns variations in genuine-versus-posed status of emotion across the different expressions within the database. Studies using the PoFA have found deficits for recognizing sad, angry, disgusted or fearful expressions, but not for recognizing happy, in a variety of clinical disorders (e.g., Borderline Personality Disorder; Unoka, Fogd, Füzy, & Csukly, 2011; Huntington's Disease; Henley et al., 2008). To date, this has been construed as a valence effect, namely that processing impaired for negative valence expressions but not positive valence expressions. But a second important difference between these stimuli is that of genuineness, with the happy faces genuinely-felt (Ekman, 1980) and perceived as such (present study), and the other expressions posed and perceived as faked or ambiguous in the case of sad (present study). Thus, it may be that the deficits in recognition are not specific to negative expressions per se, but originate from the expressions being posed. If so, this would lead to a different theoretical understanding of these clinical conditions. We note that the same issue might apply to some studies of the neural basis of emotion processing, where we suggest it may be important to re-evaluate fMRI results showing association of certain brain regions with processing specific emotions (e.g., amygdala for fear, Adolphs, 2008; basal ganglia for disgust; Adolphs, 2002) using genuinely-felt emotion stimuli, given that many of these studies have used the PoFA (e.g., Phillips et al., 1998; Vuilleumier & Pourtois, 2007; Williams, Morris, McGlone, Abbott, & Mattingley, 2004). It is possible that results might differ in kind or degree for genuinely-felt stimuli, which would give rise to a more sophisticated understanding of the neural networks involved in emotion processing.

Are there situations in which it might not matter if expression stimuli are posed? We suggest that posed versus genuine status may be less important where the research question concerns purely perceptual, rather than affective, processes. To take an example, posed expressions are known to show 'holistic processing': for example, they produce a 'composite illusion' in which naming the expression shown in the top half of a face is severely impacted by showing a different expression in the bottom half of the face (compared to a control condition where the two halves are spatially offset; Calder, Young, Keane, & Dean, 2000). There seems no reason to expect this process of perceptual integration would be influenced by whether the expression components are genuine or posed. Thus, it seems unlikely that the conclusion of deficits in holistic expression processing in clinical disorders from the composite paradigm (e.g., in prosopagnosia; Palermo et al., 2011)would change if genuinely-felt stimuli were used instead of posed stimuli (although note we cannot completely rule this out).

Overall, we argue from our results that researchers need to give serious thought to whether their research question requires the use of genuinely-felt emotion stimuli, or can get away with using posed versions. Also, as researchers test genuine and posed expressions in more situations, it may become clearer when the genuine versus posed status of stimuli is likely to matter (might give different results) or can be ignored (should give the same result).

6.4.5.4 Different types of posing

Although we have argued strongly for the importance of using genuinely-felt emotion stimuli in many situations, we do not wish to discount the value of studying posed expressions altogether. Natural posing occurs in real social contexts (e.g., flirting, playing with children, masking anger, pretending to be happy) and is as much a part of everyday interaction as genuinely-felt expressions. Also of interest is peoples' ability to tell the difference between *types* of posed expressions (e.g., a polite smile and a smile used to mask anger have different meanings). Studying perception of, and responses to, these naturally-occurring posed expressions remains of intrinsic scientific interest.

There is also an open question concerning the extent to which naturally-occurring posed stimuli are processed in the same manner as lab-posed stimuli created using FACS-determined muscle movements. Potentially, the natural-posed and lab-posed expressions may be different in subtle ways and/or be perceived or responded to differently.

6.4.5.5 Conclusion

Facial expressions of emotion are an enormously rich vein of scientific inquiry, but obtaining good, ecologically-valid stimuli is difficult. The results of the present study show that expression genuineness is one stimulus factor that cannot be ignored.

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6.4.7 References

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6.4.8 Supplementary materials

Supplementary materials for this section are provided in electronic format at the end of this thesis (DVD in orange envelope).

Chapter 7: Summary and open questions

This chapter summarizes the main findings of the thesis in relation to broader theoretical implications and questions raised. Altogether there are three main topics that this thesis addresses, which are considered here in turn. The topics are facial expression stimuli (Section 7.1), typical development of facial expression processing (Section 7.2), and theories concerning psychopathic and CU traits (Section 7.3).

7.1 Facial expression stimuli

7.1.1 Summary of findings and implications

In real life, facial expressions are dynamic, often signal genuinely-felt emotions, and are interpreted within a broader context. Yet many commonly-used stimuli are static images of isolated, context-free faces depicting posed expressions (e.g., the Pictures of Facial Affect [PoFA] set; Ekman & Friesen, 1976). Two of these stimulus factors were investigated empirically in this thesis, namely context effects (Chapter 4) and expression genuineness (Chapter 6). A major finding is that both factors can influence results in ways that change the fundamental nature of theoretical conclusions.

In relation to context, Chapter 4 found non-anxious participants prioritized following the gaze-direction of fearful faces compared to happy faces in a potentially-dangerous context (in adults, and in children at short delay). This is in contrast to results for an emotionally neutral context, in which no such prioritization was observed. Chapter 4 also showed that the context of fearful faces can induce a threat bias to respond faster to dangerous compared to safe animals in non-anxious participants (adults and children), which is absent in non-social contexts (in this thesis, when faces were replaced by arrows). Some previous studies – which have used emotionally-neutral contexts – have concluded against fearful-gaze-prioritization (e.g., Fox, Mathews, Calder, & Yiend, 2007) and threat bias in non-anxious samples (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). However, the results of this thesis concerning children and adults, together with previous findings in adults (gaze-cueing: Bayliss, Schuch, & Tipper, 2010; Friesen, Halvorson, & Graham, 2011; Kuhn & Tipples, 2011; Pecchinenda, Pes, Ferlazzo, & Zoccolotti, 2008; threat bias: Friesen, Halvorson, & Graham, 2011), show that these effects are evident in the presence of relevant contextual information. At least in the case of eye-gaze following then, results from stimuli presented without relevant contextual information may not accurately represent what happens in the real world. This raises the possibility that this could happen in other cases too.

One such case is *recognition* of facial expressions. Problems with expression recognition are evident in many disorders (e.g., depression: Bourke, Douglas, & Porter, 2010; Huntington's disease: Henley et al., 2012; schizophrenia: Kohler, Walker, Martin, Healey, & Moberg, 2010), including in the case of psychopathy investigated by Chapter 3 of the present thesis (Dawel, O'Kearney, McKone, & Palermo, 2012). However, these studies have invariably (at least in the case of psychopathy) tested facial expressions shown in isolation. It is possible that for some clinical populations problems with expression recognition might be ameliorated by the presence of context. For example, a person may have difficulty recognizing another's facial expression per se as displaying fear, but still be able to determine that the expression is fear by using contextual information (e.g., "they are looking at a spider so they are probably expressing fear"). Consistent with the idea that contextual information can be used to improve expression recognition, typical adults identify facial expressions faster and more accurately when it is presented in a congruent scene (e.g., a happy face superimposed on a picture of a beach) than when the same face is presented in an incongruent scene (e.g., a happy face superimposed on a picture of a storm) (Righart & de Gelder, 2008a, 2008b). Thus it might be that some clinical populations for which impairments have been found using isolated expression stimuli do not have problems identifying facial expressions in typical everyday interactions because they are able to use contextual information to compensate for their impairment. Such a finding for any disorder would argue against an etiological role for expression recognition deficits.

Moving on to expression genuineness, Chapter 6 provided evidence that using genuinely-felt rather than posed stimuli can also lead to different theoretical conclusions, in this case for psychopathic and CU traits. When posed stimuli were used, results were consistent with Blair's (1995, 2006) distress-specific account of psychopathic and CU traits, specifically no association was found between psychopathic or CU traits with self-reported arousal to happy expressions. However, when happy expressions were genuinely-felt higher psychopathic and CU traits were associated with decreased self-reported arousal. Thus using genuinely-felt stimuli resulted in a starkly different conclusion: that processing of happiness – not just distress emotions – *is* impaired in psychopathic and CU traits. This finding of different theoretical conclusions from genuine versus posed expression stimuli is important in light of other core findings of Chapter 6, namely that many commonly-used facial posed expression stimuli are perceived as faked. This included most expressions other than happy from Ekman and Friesens' PoFA (1976) and the RaFD (Langner et al., 2010). These stimuli have been used in many settings, particularly in clinical psychology and psychiatry (e.g., Henley et al., 2008; Simonian, Beidel, Turner, Berkes, & Long, 2001). My results, showing different conclusions arise from posed and genuine expressions, cast doubt on their use in these settings, particularly where the research question concerns perception of, or responses to, other people's felt emotions.

My Chapter 6 rating results for other stimuli – from McLellan et al.'s (2010) set of genuinely-felt and posed expressions and from news photographs of sporting events – showed that it is however possible to obtain genuinely-felt stimuli that are perceived as genuine. With these stimuli it is possible to test if clinical populations who show deficits in processing expressions that are perceived as faked might not show deficits for expressions showing genuinely-felt emotion (or possibly the reverse might be true in some cases). For example, autism spectrum disorder – in which facial expression recognition is impaired when tested with posed stimuli (e.g., for PoFA stimuli in Bölte & Poustka, 2003 and Boraston, Blakemore, Chilvers, & Skuse, 2007) – is characterized by problems with cognitive empathy/Theory of Mind but not affective empathy/emotional reactivity to others' feelings (Blair, 2005). Thus, people with autism spectrum disorder might show normal affective responses to genuinely-felt expressions, such as increased arousal to genuinely-felt compared to posed happy expressions, as was found for the low CU participants in Chapter 6.

7.1.2 Open questions

The results of Chapter 6 concerning expression genuineness suggest that some additional limitations on conclusions within the articles included as Chapters 3, 4 and 5 may need to be considered. This is because results in those chapters were based primarily on results from posed expression stimuli.

One question (regarding Chapters 4 and 5 – although implications related to finding for CU traits in Chapter 5 are discussed in Section 7.3.3.2) is whether gaze-cueing effects might differ for genuinely-felt compared to posed facial expressions. Logically, people should prioritize following the gaze-direction of faces that are perceived as giving genuine and reliable information. In the present thesis however, the individual RaFD faces (from model 61; Langner et al., 2010) used in the eye-gaze cueing paradigm were posed, and results of Chapter 6 imply they were also perceived as such. Specifically, Study 1 in Chapter 6 tested the happy image from RaFD model 61 (in eyes-front version), and it was rated as significantly fake (i.e., mean rating below 0), M = -3.51, $t(34) = 4.79$, $p < .001$. Fear from model 61 was not rated in Chapter 6, but results for fear from model 27 (which was rated as similarly genuine in Langner et al.'s 2010 study; 3.57 out of 5 for model 27 compared to 3.55 for model 61), M = -3.23, $t(34) = 3.68$, $p = .001$, argue that this expression is also perceived as faked. Some researchers (e.g., Mathews, Fox, Yiend, & Calder, 2003) have hypothesized gaze-cueing should be greater for fearful expressions than for other expressions, because a fearful expression signals threat or danger in the environment and so it is important to identify and respond quickly to this signal. However, a faked fearful expression – like that used in the eye-gaze cueing paradigm in the present thesis – does not signal true danger, and thus there is no reason to prioritize following its gaze-direction over a happy face.

This might also explain the results of previous studies, including the study presented in Chapter 4 of this thesis, that found gaze-following from fearful faces was *not* prioritized in emotionally-neutral contexts (e.g., Friesen et al., 2011; Pecchinenda et al., 2008). The vast majority of studies that have investigated effects of expression on gaze-cueing have used posed expression stimuli. Out of twelve behavioral studies that I identified as investigating interactions between expression and gaze-cueing, nine (Fox et al., 2007; Friesen et al., 2011; Graham, Friesen, Fichtenholtz, & LaBar, 2010; Hietanen & Leppänen, 2003; Holmes, Richards, & Green, 2006; Mathews et al., 2003; Pecchinenda et al., 2008; Putman, Hermans, & van Honk, 2006; Tipples, 2006) used Ekman & Friesens' (1976) PoFA, one of which also used Lundqvist, Flykt, and Öhmans' (1998) Karolinska Directed Emotional Faces set (Putman et al., 2006) and another of which also used schematic drawings (Hietanen & Leppänen, 2003). Of the remaining three studies, two used Tottenham et al.'s (2009) NimStim faces (Bayliss et al., 2010; Neath, Nilsen, Gittsovich, & Itier, 2013) and the other cartoon-like images created using Poser software (Kuhn & Tipples, 2011). In the case of the PoFA stimuli, the nine studies together included emotional expressions of anger, disgust, fear and happy, plus neutral faces. In six of these studies however, the only emotional expressions compared were fear and happy (in some cases neutral faces were also included). Results from Chapter 6 verify that the PoFA fear, anger and disgust expressions are perceived as faked, and that the PoFA happy expressions are perceived as genuine. Thus the *emotion* signaled by expressions was confounded with the *genuineness* of the signal in studies using the PoFA stimuli. For example, in the six studies that only included fearful and happy emotional expressions, participants were faced with a choice between prioritizing following the gaze-direction of *faked expression of fear*, or prioritizing following the gaze-direction of *genuine expressions of happiness*, or not prioritizing either (which is what they generally did). It is possible that if fearful expressions were also perceived as genuine people would prioritize following the gaze-direction of these faces even in an emotionally neutral context (because attending to real danger is important for survival). A prediction of my argument is that people might more strongly follow gaze-direction from faces signaling genuine emotion than from faces displaying posed expressions, based on the logic that people will prioritize reliable signals. This could be tested for happiness using stimuli that are already available (e.g., the McLellan genuine-posed set of faces; McLellan et al., 2010).

It is also possible that the reason people did prioritize following gaze-direction from fearful faces in the danger-vigilance context in Chapter 4 is because the 'fear signal' might be perceived as more genuine in the presence of dangerous information. For example, a fearful expression might be perceived as more genuine in the presence of a snake when compared to the same expression presented in isolation (which is how the faces were rated in Chapter 6). Alternatively, the same fearful expression might be perceived as more fake when presented alongside a goldfish. To the best of my knowledge, however, there has been no empirical investigation of context effects on perceptions of expression genuineness.

Finally, a broader question raised by this thesis in relation to facial expression stimuli is what factors are important for ecological validity. I propose that there are three main factors that warrant consideration, namely context, expression genuineness, and expression movement. The results of this thesis demonstrate the importance of context and genuineness. Although expression movement was not directly investigated in this thesis, it was raised as a possible explanation in Chapter 3 for why some studies of emotion recognition that were published after the meta-analysis did not replicate earlier findings. Expression movement is also of direct relevance to expression genuineness, as dynamic information might be particularly useful for discerning genuinely-felt from posed expressions. For example, genuinely-felt expressions show more gradual onsets and offsets than posed expressions (Ekman, 2003; Schmidt, Ambadar, Cohn, & Reed, 2006). This need for more ecologically valid stimuli and paradigms has been recognized in recent literature, and there are efforts to develop dynamic and genuinely-felt expression stimuli (e.g., Zhang et al., 2013), and to investigate expression-context interactions, in adults (Hassin, Aviezer, & Bentin, 2013; Wieser & Brosch, 2012). I note there has been very little examination of these issues in children though.

7.1.3 Conclusion

The findings of this thesis highlight that careful consideration needs to be given to the types of expression stimuli used in experimental work and in the interpretation of results. The elimination of such information as context, expression genuineness, and expression movement can undermine the validity of theoretical conclusions. One challenge of using more ecological valid stimuli is that it might mean giving up control over stimulus characteristics such as head direction, viewpoint, eye-gaze direction, and lighting. There are however instances when giving up control over these characteristics would render experimental paradigms impossible. For example, in the eye-gaze cueing paradigm used in Chapters 4 and 5 faces needed to be frontal view to isolate the effects of gaze-direction because head direction can also shift attention (Langton, Watt, & Bruce, 2000). Thus researchers will need to identify stimulus factors that are important for drawing ecologically and theoretically valid conclusions in relation to their specific research questions, and balance these with stimulus factors that must be controlled for experimental reasons. An important next step is to investigate under what conditions context, expression genuineness and expression movement give different results.

7.2 Typical development of facial expression processing

7.2.1 Summary of findings and implications

Chapter 4 provided one of the first investigations of typical development of expression-context interactions. Interactions were tested via an eye-gaze and arrow cueing paradigm that required participants to decide whether target animals were safe or dangerous. Results showed that 8-12 year olds were mature in some, but not all, aspects of expression-context interactions. In particular, children showed an adult-like threat bias to respond faster to dangerous animals in the context of fearful faces, and by 12 years also showed adult-like prioritization of gaze-following from fearful faces compared to happy faces at a short cue-to-target delay. However, only adults showed prioritization of fearful-gaze at a longer cue-to-target delay, and threat bias for dangerous animals in the general, social context of faces, irrespective of facial expression. Overall, the results of Chapter 4 argue that some more complex aspects of social information processing are still immature at the onset of adolescence.

7.2.2 Open questions

A new question raised by the present thesis relates to the typical development of emotional face processing in general. Specifically, the results of Chapter 6 raise the questions of whether children can discriminate genuinely-felt from posed expressions, and whether the genuine-posed status of stimuli matters for developmental research. Conceptually, children do understand the distinction between 'really feeling' and 'pretending' an emotion (Gosselin, Warren, & Diotte, 2002). However, only two published studies that I am aware of have investigated whether they can actually identify when facial expressions are genuinely-felt, and both studies addressed only the expression of happiness. Gosselin, Perron, Legault, and Campanella (2002) found that 9-10 year olds were able to distinguish genuinely-felt from posed smiles, but 6-7 year olds were not. The second study (Del Giudice & Colle, 2007) did not report statistical significance, but numerically 8 year olds performed slightly better than chance (*M* accuracy for children = 54% where chance is 50%; *M* accuracy for adults = 66%). Thus there is tentative evidence children are able to distinguish genuinely-felt happy expressions from approximately 8 years of age, but nothing is known about whether this affects behavioral outcomes or whether they can discriminate genuineness for other emotions. It is also of interest whether typically developing children (with low CU traits) show heightened arousal to genuinely-felt versus posed expressions of happiness, as did low psychopathic/CU trait adults in Chapter 6. This data would provide a baseline for comparison with high CU children.

What are the potential implications of expression genuineness for the specific results of this thesis regarding typical development? Chapter 4 raised the possibility that the age at which expression-context interactions emerge might be influenced by factors such as the face being that of an adult, or of an unfamiliar person, or that lifetime experience might be important (e.g., more experience with fearful expressions and dangerous stimuli might cause expression-stimuli associations to be learned more quickly). It is also possible that expression-context interactions might emerge earlier for genuinely-felt expressions. Adults learn to repeat actions that are reinforced with genuinely-felt happy expressions more quickly than actions that are reinforced with posed happy expressions (Heerey, 2014). Thus it is possible that children might develop expression-stimuli associations at a younger age for genuinely-felt expressions compared to posed expressions.

Expression genuineness could also have a more immediate influence on expression-context interactions via arousal. The results of Chapter 6 show that arousal is greater from genuinely-felt compared to posed expressions of happiness for adults (except in high psychopathic and CU trait participants). It makes logical sense that arousal would also be greater from genuinely-felt compared to posed versions of other emotions too, although this is yet to be tested empirically. In the case of threat bias, heightened arousal could facilitate faster responses to dangerous animals following genuinely-felt fearful expressions compared to posed fearful expressions. Heightened arousal might also be part of the reason why learning is faster for genuinely-felt expressions than for posed expressions in adults as found by Heerey (2014). Heerey (2014) did not address this possibility in their paradigm, but it could be easily tested by measuring physiological arousal during learning. An initial step with children would be to assess whether low-CU children – like adults – do experience heightened arousal to genuinely-felt expressions of happiness compared to posed happy expressions. It will also be important to test other emotional expressions as good genuinely-felt stimuli become available.

7.2.3 Conclusion

Although there has been an increased focus on the ecological validity of stimuli in adult facial expression research, there has been little examination of how stimulus factors such as expression genuineness and context might affect findings from children. Results from the present thesis suggest that some more complex social skills like expression-context interactions might not fully mature until adolescence. Potentially, this could also be the case for expression genuineness. We know little about children's ability to read subtle social cues, like whether somebody is 'really feeling' an emotion. It is also of interest how such abilities relate to socio-emotional development (e.g., of Theory of Mind, affective empathy, or outcomes like number and quality of friendships).

7.3 Theories of psychopathy and high CU traits

7.3.1 Summary of findings

Chapters 3, 5 and 6 all include evidence that addresses the theoretical underpinnings of the affective aspects of psychopathy. Of particular interest is whether deficits in emotion processing related to psychopathy or high CU are limited to distress, occur across modalities and vary with age. Theoretically, this thesis examined whether deficits in emotion processing can be explained by problems with encoding distress per se, poor attention to eyes, or more general abnormalities in attention, which also encompass non-social stimuli.

Chapter 3 is a meta-analysis, which showed emotion recognition deficits in psychopathy are pervasive across modalities (facial, vocal, postural), and included expressions of happiness, as well as some distress emotions. However, deficits may be more severe for fear, particularly for those people with high scores on the primary affective/interpersonal factor of psychopathy. For facial expressions, the meta-analysis also examined results for children and adults separately, and found differences in the specific emotions for which recognition was impaired. For adults, the recognition of happiness and surprise was impaired, whereas for children, deficits were observed for anger, fear and surprise. However, results by age group could not be compared directly because the types of samples were also different (i.e., adult samples were often forensic or clinical, whereas child samples were generally from community or clinical populations).

Chapter 5 presented an empirical investigation of three mechanisms theorized to account for emotion processing impairments in high CU. Results showed following of gaze-direction and arrows were decreased to an equal extent in a high CU group relative to a low CU group, and gaze-following was similarly decreased for both emotional expressions tested (fearful and happy expressions). These results argue that effects are not specific to distress or poor attention to the eyes, but rather are indicative of general attention abnormalities. Of interest, we also found that both groups initially followed gaze-direction, but the high CU group no longer showed any gaze-following after a single experimental block. These results were interpreted as showing that the high CU group were better able to ignore the gaze-direction and arrow cues that 'grabbed' the attention of low CU participants, in order to focus on the primary goal of the task, which was to respond to different targets. Accuracy and RTs were comparable between the groups, ruling out differences in task engagement as a possible explanation for the results.

Chapter 6 extended previous findings of decreased arousal to expressions of distress (i.e., crying faces) in high psychopathic traits to expressions of genuinely-felt happiness. Specifically, for genuinely-felt expressions of happiness, adults with higher levels of psychopathic traits or CU traits reported decreased arousal in response to the facial expressions compared to those with lower levels of these traits. Also, those participants at the high end of the psychopathic traits and CU spectrums did not differ in self-reported arousal to genuinely-felt versus posed expressions of happiness, whereas those at the lower end of the spectrums reported that the genuinely-felt happy expressions were more arousing than the posed ones.

7.3.2 Theoretical implications

The findings of this thesis provide strong evidence, from a meta-analysis and two different experimental paradigms, that both global psychopathic traits and the more specific construct of CU traits are associated with impaired processing of happy expressions. Specifically, the meta-analysis in Chapter 3 showed impaired recognition of happiness in psychopathy, the gaze-cueing task in Chapter 5 showed impaired following of gaze-direction from happy faces in high CU, and the arousal-rating task in Chapter 6 showed decreased affective responsivity to the genuinely-felt happiness of others with high psychopathic traits and with high CU. Together this evidence argues against Blair's (1995, 2006) distress-specific account of the affective deficits in psychopathy. Instead, results from Chapter 5 concerning attentional cueing support Newman and colleagues' (Baskin-Sommers, Curtin, & Newman, 2011; Newman, Curtin, Bertsch, & Baskin-Sommers, 2010; Wallace, Vitale, & Newman, 1999) proposal that there are general differences in attention that produce an abnormally-enhanced ability to 'tune out' unwanted information (see Chapter 5 for discussion of the theoretical implications of this finding). Abnormalities in general attention could explain impaired processing of happy expressions in the same way they are able to explain impaired processing of distress expressions; that is, via 'tuning out' of emotional stimuli that typically 'grab' attention.

The finding of deficits for happy facial expressions is consistent with clinical descriptions of psychopathy that emphasize shallow affect and poor affective empathy across a broad range of emotions, including happiness, not just distress emotions (e.g., Cleckley, 1941/1988; Hare & Neumann, 2008). For instance, Cleckley (1941/1988) specifically noted that psychopaths are deficient in their experience of *all* types of emotions including joy. Also consistent with this result, using non-face stimuli Herpertz et al. (2001) found psychopathic inmates displayed decreased SCR to pleasant pictures, compared to inmates with Borderline Personality Disorder and community controls. However, in the case of Herpertz et al.'s (2001) study, there were no group differences in self-reported arousal, as there were in the present thesis. In future work, I hope to investigate arousal via physiological measures (e.g., SCR, HR). It will be interesting to see whether self-reports and physiological measures of arousal to happy faces match in high CU participants.

A deficit for happy expressions is also consistent with evidence regarding the biological basis of psychopathy and high CU. For one, the amygdala, which shows abnormalities in psychopathy and high CU, has an important role in processing positive affect (Hooker, Germine, Knight, & D'Esposito, 2006; Murray, 2007; O'Doherty, 2004; Williams, Morris, McGlone, Abbott, & Mattingley, 2004), which has often been overlooked because researchers have focused on the role of the amygdala in fear processing. To illustrate this point, Murray (2007, p. 489) notes:

> *"The idea that the amygdala functions primarily in negative affect remains firmly entrenched, as evidenced by theories treating the amygdala as a 'protection device' that prevents animals from engaging in potentially harmful behaviors or as a 'fear module'. In part, this impression results from the dominance of fear conditioning as a model of emotional learning. Neuroimaging studies, especially early ones, also viewed the amygdala as processing primarily negative emotions. Yet numerous studies point to a role for the amygdala in processing positive affect."*

Thus the standard finding of amygdala dysfunction in high psychopathic and CU traits is very much consistent with abnormalities in processing happy expressions. In addition, deficits for happy expressions are consistent with evidence of oxytocin abnormalities in high CU traits (Beitchman et al., 2012; Dadds et al., 2014), as oxytocin plays an important role in processing happy expressions (Marsh, Yu, Pine, & Blair, 2010) and affiliative behavior (Feldman, 2012). A final point relates to serotonin. Recent evidence has implicated serotoninergic systems in psychopathy (Glenn, 2011; Moul, Dobson-Stone, Brennan, Hawes, & Dadds, 2013; Yildirim & Derksen, 2013). In particular, there is some suggestion that psychopathic traits are associated with the *long* allele of the serotonin transporter gene (Glenn, 2011). Interestingly, processing of happy expressions seems to be *improved* for carriers of the *short* allele (Homberg & Lesch, 2011), which gives rise to the possibility that the opposite may be true for the long allele. However this possibility is yet to be tested empirically.

7.3.3 Open questions

7.3.3.1 What might be the impact of impaired processing of happy expressions?

Whilst there are extensive theoretical propositions about the role of fear recognition in prosocial behavior (Marsh, Kozak, & Ambady, 2007) and inhibition of aggression and violence (Blair, 1995, 2006), theoretical work regarding the impact of deficits in processing happy expressions is limited. An exception is the case of autism spectrum disorder, which is also characterized by empathic deficits. I draw on this literature in the following discussion (e.g., Sepeta et al., 2012), but note that the nature of empathic deficits is different in psychopathy and high CU compared to autism spectrum disorder (Blair, 2008).

Typically, expressions of happiness are socially rewarding (Hooker et al., 2006; O'Doherty et al., 2003; Sepeta et al., 2012), and thus reinforce positive behavior and increase the likelihood that (prosocial) actions will be repeated (e.g, Heerey, 2014). In the example presented in Figure 7.3.3.1a, a child who shares a toy with their sibling might be rewarded with a smile and thus be more likely to repeat this action in future. If happy expressions were not rewarding to the child, however, there would be no reinforcement of the sharing behavior. From this perspective, lack of recognition of or responsivity to happy expressions results would result in there being no 'social reward' for being 'nice', which has also been suggested to be the case in autism spectrum disorders (e.g., Sepeta et al., 2012). This idea is essentially the antithesis of Blair's (1995, 2006) proposal that others' expression of distress are socially punishing or aversive (i.e., cause feelings of guilt, shame, remorse, etc.), and thus inhibit negative behavior and decrease the likelihood that (antisocial) actions will be repeated (Figure 7.3.3.1b).

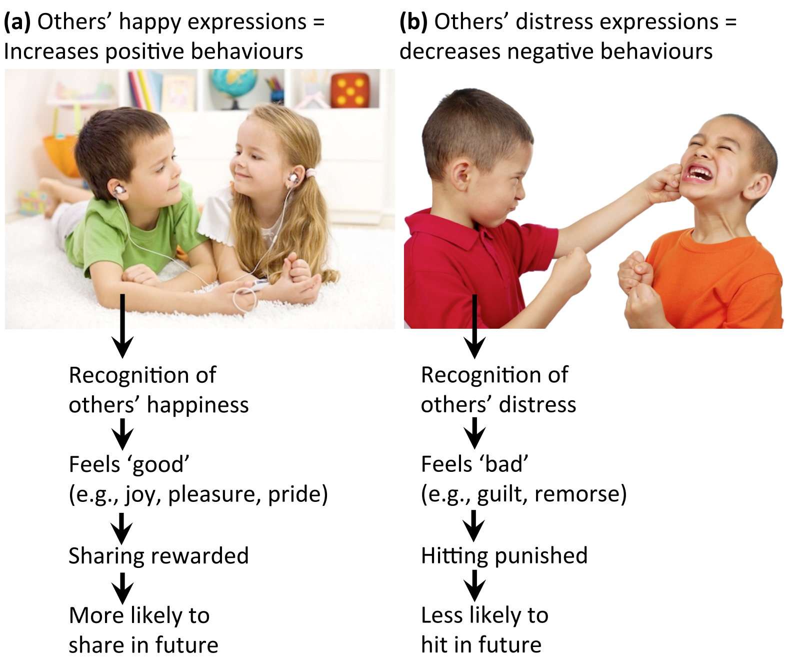

Figure 7.3.3.1. (a) Theorized process by which positive behaviors might be increased via others' happy expressions, leading to more helpful and cooperative behavior. (b) Shows how antisocial actions might be inhibited/decreased by others' expressions of distress, in accordance with Blair (1995, 2006). In this way, the two processes – the first reward-driven and the second aversion-driven – work in tandem to promote prosocial interpersonal behavior.

An implication of this model is that responses to happy faces might be associated with particular facets of psychopathy or CU (e.g., lack of social affiliation and cooperative behavior) while deficits in responses to fearful faces might be associated with other facets (e.g., lack of guilt and remorse, aggressive behavior).

Failure to recognize and emotionally resonate with others' positive expressions could have significant implications for social affiliation, initially with caregivers and later with peers. In relation to caregivers, parental affection and warmth, for example, plays an important role in the development of a secure attachment style (Barnett, 1987). If a child with high CU traits is less emotionally responsive to their mother's smiles then this may impact negatively on attachment. Interestingly, some recent efforts to treat behavior problems in children with high CU traits have found that positive parenting strategies are more effective than negative strategies (Hawes & Dadds, 2005). It could be that increasing the intensity of or focus on positive emotions is particularly important in parenting high CU children. In relation to peers, failure to identify with others' positive emotions could lead to social exclusion and rejection. It may also result in a failure to experience positive social emotions such as pride, which may be consistent with not trying to please others. I note that the ICU (Frick, 2003) includes items that are consistent with a lack of pride, such as 'I work hard on everything I do' (reverse scored) and 'I do not like to put the time into doing things well'.

Impaired processing of happy expressions could also cause diminished perceptions of trustworthiness, which might result in reduced cooperation with others (Krumhuber et al., 2007; van 't Wout & Sanfey, 2008). Typically, there is a positive relationship between ratings of happiness and ratings of trustworthiness for faces (Oosterhof & Todorov, 2009; Todorov, 2008). Thus impaired processing of happy expressions might be associated with impaired judgments of trustworthiness. To the best of my knowledge, only one study (Richell et al., 2005) has tested this idea in psychopathy, and – contrary to my prediction – this study found no differences in judgments of trustworthiness between forensic psychopaths and forensic non-psychopaths (Richell et al., 2005). However only emotionally neutral faces were tested. It is possible that a relationship between psychopathy or high CU and judgments of trustworthiness might be observed for faces displaying happy expressions – or for genuinely-felt happy expressions but not posed happy expressions.

Overall then, there are theoretical reasons why recognition of and emotional responsivity to positive expressions would be expected to be important for successful interpersonal behavior, and why impairments in this domain might contribute to the affective deficits that characterize psychopathy and high CU.

7.3.3.2 Genuinely-felt versus posed expressions and psychopathic/CU traits

The results of Chapter 6 show that participants at the high ends of the psychopathy and CU trait spectrums had no difficulty discriminating genuinely-felt from posed expressions of happiness. An open question, however, is whether the mechanism used for discriminating genuinely-felt from posed expressions was the same across the psychopathic and CU trait spectrums. Adults typically rely on the Duchenne marker – which is located around the eyes – to discriminate genuinely-felt happiness (Del Giudice & Colle, 2007). However, people with high psychopathic or CU traits might not be as sensitive to the Duchenne marker, because of lack of attention to the eyes (note that the results of Chapter 5 do not refute Dadds' [2006, 2008] finding of lack of attention to the eyes in high CU traits; rather they suggest lack of attention to the eyes may arise from general attention abnormalities). It is possible that high CU adults could have discriminated our particular genuine-versus-posed happy expressions using smile intensity alone, as the McLellan genuinely-felt happy smiles were of noticeably higher intensity than the posed ones. If the mechanism for discriminating genuinely-felt from posed expressions is different in high psychopathic or CU traits, then this could explain why they did not show the same increase in arousal for genuinely-felt compared to posed happiness as low CU participants.

Another question is whether results might differ for genuinely-felt and posed expressions of other emotions in relation to psychopathic or CU traits. Of particular interest, given Blair's (1995, 2006) theory, is genuinely-felt versus posed expressions of fear, but suitable genuinely-felt fear stimuli are not yet available (note that the results of this thesis do not rule out deficits for distress emotions, only the *specificity* of deficits to distress). An alternative is to test expressions of pain, for which stimuli are available (e.g., Littlewort & Lee, 1844). Although pain is not considered one of the 'basic' emotions (Ekman, 1992), it does signal distress so impairments might be expected. Indeed, some recent work has started to test recognition of and responsivity to others' pain in relation to psychopathic and CU traits. In Section 3.6 of Chapter 3 of this thesis, I reported a study (Wolf & Centifanti, 2013) that tested recognition of facial expressions of pain. To re-cap, this study found recognition of pain was poorer with higher psychopathic traits, but only for one of two psychopathy measures (for the YPI-CU but not the ICU). In addition, two studies (adults: Decety, Chen, Harenski, & Kiehl, 2013; youths: Marsh et al., 2013) have tested neural responses via fMRI to imagined experiences of own and other peoples' pain. Both studies used a paradigm in which participants looked at pictures depicting various injuries (e.g., a finger being slammed in a door) and were asked to imagine that each situation was happening to him/herself or to someone else. Compared to controls, psychopathic adults (Decety et al., 2013) and youths with high psychopathic traits (Marsh et al., 2013) showed abnormalities in the amygdala (and also the anterior insula, orbitofrontal cortex and ventromedial prefrontal cortex for adults, and the anterior cingulate cortex for youths) when they imagined other people incurring painful injuries, but not when they imagined themselves being injured. These results suggest a lack of emotional responsivity to others' pain, but not to own pain, in high psychopathic traits. In both these studies, however, the images were not facial expressions (e.g., for the finger being slammed in a door stimulus, only the hand, forearm and door were shown; although it is possible some other stimuli did include facial expressions). It would be interesting to test pain recognition and responsivity for genuinely-felt compared to posed facial expressions of pain.

A final question is whether findings from Chapter 5 for eye-gaze cueing in high versus low CU traits would differ if genuinely-felt expressions were used. The paradigm in Chapter 5 used one particular happy expression and one particular fearful expression, both of which were perceived as clearly faked. It is possible that people might typically follow the gaze-direction of faces displaying genuinely-felt expressions more strongly (for the reasons outlined in Section 7.1.2). Thus the high-CU participants might have been less able to suppress following of gaze-direction if faces showed genuinely-felt expressions. However, this would depend on the mechanism that drives enhanced gaze-following from genuinely-felt expressions. Results from Chapter 6 show that participants from the higher end of the CU-spectrum could distinguish equally well between genuinely-felt and posed expressions of happiness compared to those with low levels of CU traits. However, those at the high end did not show any differentiation in arousal to genuinely-felt versus posed happy expressions, whereas those at the low end found genuinely-felt happiness more arousing than posed happiness. Thus, if arousal has some role in driving greater gaze-following from faces displaying genuinely-felt expressions, than there would be no reason to expect that the results of Chapter 5 regarding gaze-cueing would differ if genuine expressions were used.

7.3.3.3 Why have previous studies not found deficits for happiness and how do we overcome these issues?

It is curious why many earlier individual studies have failed to reveal a relationship between processing of happiness and psychopathic traits or CU traits. One possible reason, related specifically to results for emotion *recognition*, raised in the meta-analysis in Chapter 3, is that performance is often at ceiling in commonly-used forced-choice labeling tasks (Dawel et al., 2012). The meta-analysis had more power to detect small differences than individual studies, which may be why Chapter 3 was able to reveal emotion recognition deficits for happiness. A ceiling effect might also explain why Blair et al. (1995) found psychopaths had the same ability as non-psychopaths to label the emotion of vignette characters as 'happy' (23/25 participants in the psychopathic and non-psychopathic groups correctly labeled the happy vignette, "an individual wins the pools"). Also, this task included only one happy item, which restricted range.

A second possible reason, given that no relationship was observed for *posed* happiness in Chapter 6, is that posed happy stimuli have been used in previous studies of psychopathy. However I think this possibility is less likely because stimuli from Ekman's lab were used in 14 of the 22 studies included in the meta-analysis (including the PoFA in 8 studies; Dawel et al., 2012), and other results in Chapter 6 show that the PoFA happy faces are perceived as genuine.

A third reason, in this case related to results for emotion *experience*, is that studies have often focused on fear and threat, and have not tested reactions to happy or pleasant stimuli or experiences. For example, two studies by Blair and colleagues (Blair, Jones, Clark, & Smith, 1997; Blair, 1999) compared physiological reactivity (via SCR) to pictures of distressed people (crying faces), threatening pictures (snake, shark, angry man, gun, divers jumping into a waterfall), and neutral pictures (rolling pin, wicker basket, hairdryer, fork, book, umbrella, food, building). No happy or pleasant pictures were included. Thus, it is not that these studies have not found deficits in reactions to happy or pleasant stimuli, but that they *have not tested them*. There is however one recent study that did test emotional experience for the full range of 'basic' emotions. Marsh et al. (2011) found that in retrospective reports of emotional experience, adolescents with high psychopathic traits reported less frequent and weaker experiences of fear than compared to controls with typical levels. These fearful recollections were accompanied by less sympathetic arousal but there were no differences for other emotions, including happiness. Based on these results, Marsh et al. (2011) conclude for a distress-specific impairment. However there was a notable numerical trend in the same direction for happiness as for fear (see Table 2 and Figure 1 from Marsh et al., 2011). It may be that effects for happiness are weaker than those for fear, but are still present and would be revealed with more power. Another key difference in the present thesis is that reports of arousal were current, not retrospective as in Marsh et al. (2011).

So how can we overcome the power problem? Besides the obvious strategy of increasing participant numbers, there are some additional strategies that may maximize power within experimental tasks (e.g., including sufficient numbers of items and avoiding ceiling/floor performance). One strategy I advocate is the use of rating scales, such as that used in Chapter 6 of the present thesis. Rating scales are a more sensitive measure than forced-choice labeling because they provide a graded rather than a categorical score for each stimulus.

7.3.3.4 Further testing of happiness and general attention abnormalities

This thesis has demonstrated abnormal processing of happy expressions in three different tasks – emotion recognition, eye-gaze cueing, and self-reported arousal. It has also raised the possibility that deficits for happy expressions might be related to specific aspects of psychopathic or CU traits, such as social affiliation and cooperative behaviour. Of particular interest is whether high psychopathic or CU trait individuals find happy expressions less socially rewarding. This could be measured using a social learning paradigm (e.g., Heerey, 2014). Also of interest are judgments of facial approachability and trustworthiness, and physiological responsivity (e.g., EMG) to others' facial expressions of happiness. It will be interesting to see under what circumstances results for genuinely-felt and posed happy expressions might differ.

This thesis has also demonstrated evidence of general attention abnormalities in high CU adults from the general population, for the first time. This finding in particular needs to be substantiated via replication and with different paradigms. For example, using Baskin-Sommers et al.'s (2011) paradigm. Or, another way in which general attention abnormalities in high psychopathic or CU traits could be tested is via emotional and non-emotional versions of the attentional blink paradigm, which shows reliable individual differences (Dale & Arnell, 2011) and can be used in children (Lallier, Donnadieu, & Valdois, 2010). It will be important to choose tasks that allow emotional and non-emotional versions to be compared, and that are suitable for testing across a wide range of ages.

7.3.3.5 What other populations are important to test?

An important question is whether the findings of this thesis from individual differences in the adult general population extend to other populations. There are two populations of particular interest, the first being children and the second adults with pathological levels of psychopathic or CU traits.

In relation to children, early abnormalities in general attention and affective processing could have propagative or interaction effects and it is possible that the cognitive/affective profile of psychopathic and/or CU traits could change across the lifespan. To illustrate, it is possible that neural dysfunction in high CU children is restricted to the amygdala, but that, over time, this affects other brain regions (e.g., the orbitofrontal cortex) via connections between these two regions. To provide a fair comparison across age, it will be important to collect data from adults and children that is not confounded by things like substance abuse, medication and violent injuries, which are common in forensic settings and could also cause abnormalities in cognitive functioning. For this reason, it may be particularly helpful to collect data from general child and adult populations for comparison. Such an approach is supported by the dimensional nature of psychopathic traits (Edens, Marcus, Lilienfeld, & Poythress, 2006; Marcus, John, & Edens, 2004). The present thesis has adopted this approach in Chapters 5 and 6 by testing individual differences in psychopathic traits and CU traits in adults from the general population, with the aim of providing a baseline to be compared with child data in future studies.

Also, specifically in relation to emotion recognition deficits, I note there is no evidence from *young* children. The meta-analysis in Chapter 3 shows that the mean age of the youngest sample in which emotion recognition has been tested in relation to psychopathic or CU traits is 9.1 years (from Tables 1 and 2 of meta-analysis). It is of interest at what age affective processing deficits emerge. One way to test this would be to examine arousal levels or other behavioral responses to facial expressions, including for happy expressions. Another important developmental question is whether children with high CU traits show abnormalities in *general* attention, not just to the eyes as found by Dadds et al. (2006, 2008). Chapter 5 showed that *in adults* with high CU traits attention abnormalities also encompassed non-social stimuli (arrows). If general attention abnormalities do have an etiological role in the development of psychopathic and CU traits, then it would be helpful to understand how high-CU children's attention differs from attention in typical development. For example, perhaps selective attention matures faster in high-CU children?

The second population of interest is adults with pathological levels of psychopathic, including CU, traits, such as 'psychopaths' in forensic populations. Although psychopathic are dimensional in nature, it is possible that cognitive and affective abnormalities at the extreme end of the spectrum are not just more severe but are of a different type (e.g., because of propagative/interaction effects of abnormalities over time). Thus it is important to test empirically whether findings in the general population hold for populations with higher levels of these traits. I also note that high psychopathic/CU-trait populations are the most in need of intervention, so ascertaining what is happening at the pathological end of the spectrum is especially important.

7.3.4 Conclusion

The evidence presented in this thesis argues against a distress-specific account of the affective features of psychopathy, and instead finds processing of happiness is also impaired – in both recognition and experience. This implies problems with reward processes that have potential implications for social affiliation, attachment and cooperative behavior. The results of this thesis also argue for general attention abnormalities in high CU traits. An important avenue for future research is to examine general attention in high CU children.

More broadly, I suggest the general approach of this thesis – particularly that taken in Chapter 5 – can help to bridge the current gap between the childhood CU and adulthood psychopathy literatures. There is a lack of continuity between theorizing about CU in childhood (e.g., Dadds et al., 2006) and psychopathy in adulthood (e.g., Newman et al., 2010). Consequently, until now Dadds' (2006) attention-to-eyes theory has only been tested in youths, whilst Newman and colleagues' (2010) general-attention-abnormality approach has primarily been tested in adult psychopaths. Chapter 5 of the present thesis shows that Newman and colleagues' theorizing extends to adult CU traits. Unlike the disorder of 'psychopathy', CU traits can be measured in both children and adults, and also show stability between childhood and adulthood (Frick et al., 2013). Thus CU traits offer potential for bridging the gap between current theories of childhood CU and the later development of 'psychopathy'.

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