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Neurodevelopmental correlates of proneness to guilt and shame in adolescence and early adulthood

Sarah Whittle[a,*], Kirra Liu[a], Coralie Bastin[a], Ben J. Harrison[a], Christopher G. Davey[a,b]

[a] Melbourne Neuropsychiatry Centre, Department of Psychiatry, The University of Melbourne and Melbourne Health, Vic., 3053, Australia
[b] Orygen, The National Centre of Excellence in Youth Mental Health, The University of Melbourne, Vic., 3053, Australia

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ABSTRACT

Investigating how brain development during adolescence and early adulthood underlies guilt- and shame-proneness may be important for understanding risk processes for mental disorders. The aim of this study was to investigate the neurodevelopmental correlates of interpersonal guilt- and shame-proneness in healthy adolescents and young adults using structural magnetic resonance imaging (sMRI). Sixty participants (age range: 15–25) completed sMRI and self-report measures of interpersonal guilt- and shame-proneness. Independent of interpersonal guilt, higher levels of shame-proneness were associated with thinner posterior cingulate cortex (PCC) thickness and smaller amygdala volume. Higher levels of shame-proneness were also associated with attenuated age-related reductions in thickness of lateral orbitofrontal cortex (lOFC). Our findings highlight the complexities in understanding brain–behavior relationships during the adolescent/young adult period. Results were consistent with growing evidence that accelerated cortical thinning during adolescence may be associated with superior socioemotional functioning. Further research is required to understand the implications of these findings for mental disorders characterized by higher levels of guilt and shame.

1. Introduction

Adolescence is a dynamic period of life characterized by marked changes across a number of domains, including physical maturation, drive for independence, increased salience of social and peer interactions, and brain development. There is an increasing recognition that changes in relational and social processes are key for adaptive functioning during adolescence and the emerging adult period (Smetana et al., 2006). The prosocial, and particularly negative moral emotions, guilt and shame, are thought to be of particular importance for the maturing adolescent, serving to maintain attachments, and acting as 'social regulators' that encourage a balance between one's self-interested motivations and the rights and needs of others. It has been suggested that increases in self-consciousness and concern with others' opinions during adolescence results in an increase in the frequency and intensity of the experience of negative moral emotions such as guilt and shame (Zeman et al., 2006). While developmental increases in the experience of guilt and shame may be normative, the tendency to experience guilt and shame inappropriately or excessively may be maladaptive and related to the increased incidence of psychopathology during adolescence and young adulthood (Muris and Meesters, 2014).

While we have learned a great deal about the developing brain during adolescence over the past two decades (particularly with regards to neuroanatomical development) (Giedd et al., 1999; Lenroot et al., 2007), we know very little about how adolescent brain development underlies, or is associated with, social functioning, and in particular, the propensity to experience negative moral emotions. Existing functional magnetic resonance imaging (fMRI) work has identified the experience of guilt to be associated with broad engagement of prefrontal cortical regions, including the ventral medial prefrontal cortex (vmPFC; extending to subgenual cingulate cortex [SGC]) (Basile et al., 2011a; Moll et al., 2011; Zahn et al., 2009a,b), dmPFC (Basile et al., 2011a; Michl et al., 2012; Morey et al., 2012), and lOFC (Wagner et al., 2011); insular cortex (Basile et al., 2011b; Zahn et al., 2009b); and posterior medial wall regions, including PCC and precuneus (Basile et al., 2011a; Kedia et al., 2008). Far less research has been devoted to the neural correlates of shame. Two studies in healthy population, however, have found shame to be associated with activation of the anterior cingulate cortex (ACC) and PCC (Michl et al., 2012;

* Corresponding author at: Melbourne Neuropsychiatry Centre, Department of Psychiatry, The University of Melbourne, 161 Barry Street, Carlton South, 3053, Vic., Australia. Tel.: +61 3 8344 1958.
E-mail address: swhittle@unimelb.edu.au (S. Whittle).

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Roth et al., 2014), dorsolateral PFC, dmPFC, and insula (Roth et al., 2014).

Structural brain imaging studies have been less informative. Only two studies have investigated the neuroanatomical correlates of guilt; one found a significant negative association between trait guilt and insula cortex volume (Belden et al., 2015), while a second study found a positive association between a behavioral measure of guilt (compensatory behavior during a pain administration task) and ACC volume (Yu et al., 2013). However, neither study investigated the specificity of their findings to guilt. Indeed, across the functional and structural literature, few studies have investigated the unique correlates of guilt and shame, an important endeavor given that the two emotions, although sharing common features, are notably distinct (Tangney et al., 1996). Namely, it has been suggested that guilt is associated with self-blame related to one's own behavior, whereas shame is associated with self-blame at a deeper level where the individual sees their global self as 'faulty' (Barr, 2004). Guilt is thought to be associated with feelings of regret and remorse, and is the counterpart to prosocial tendencies associated with empathy. Conversely, shame is thought to be associated with feelings of helplessness, and a desire to hide or escape (Barr, 2004), in addition to a preoccupation with worry about negative social-evaluation (Tangney et al., 1996). Further, few studies have investigated trait measures of guilt and shame (i.e., guilt- and shame-proneness), which may be more relevant for understanding risk for mental illness than state/behavioral measures (Ghatavi et al., 2002). Finally, no study to our knowledge has investigated the neuroanatomical correlates of guilt and shame using a *developmental framework*. Such work will be important for better understanding the neurodevelopmental mechanisms underlying guilt- and shame-propensity during the adolescent and young adult period. Measures of brain *development* have been shown to contribute unique information about psychological functioning during adolescence, often uncovering informative associations that would have been obscured if development had not been taken into account. Brain development during adolescence is characterized by, among other changes, cortical thinning that starts in primary sensory and motor areas and proceeds to association cortex (Shaw et al., 2008). Importantly, while studies of early onset psychopathology (e.g., childhood onset depression, schizophrenia and bipolar disorder) show exaggerated cortical thinning with age (Gogtay and Thompson, 2010; Luby et al., 2016), an attenuation of the normal pattern of cortical thinning during adolescence has been associated with indices of poor emotional and cognitive functioning, including relatively low IQ, attention problems, increased internalizing symptoms, depression risk, and lower temperamental effortful control (Ducharme et al., 2012, 2014; Papmeyer et al., 2014; Shaw et al., 2006; Vijayakumar et al., 2014).

In the current study, we sought to investigate the unique structural neurodevelopmental correlates of interpersonal guilt- and shame-proneness in a sample of healthy young people. Interpersonal types of guilt were the focus given the centrality of *social* relationships to adolescent development and functioning. We hypothesized that guilt and shame could be dissociated in terms of distinct neurodevelopmental correlates within social brain regions. Specifically, we hypothesized that guilt would be uniquely associated with the development of SGC/vmPFC, by virtue of the role of these regions in empathy (Zahn et al., 2009a), and anticipation of the social–emotional consequences (e.g., feeling guilty) in social decision-making (Grossman et al., 2010; Harrison et al., 2012; Moll et al., 2011). We also hypothesized that guilt would be associated with the development of the lOFC, given evidence for activation of this region when social cues initiate a change of current behavior (Blair and Cipolotti, 2000). Conversely, we hypothesized that shame would be uniquely associated with the development of the dmPFC, PCC and precuneus. We made this prediction based on the contribution of these regions to social-oriented self-referential processing (Harrison et al., 2008), which have direct links to theoretical definitions of shame as involving thinking about the self in relation to others. We also hypothesized that shame would be uniquely associated with development of the insula and amygdala, given evidence for their involvement in the experience of aversive feeling states (Craig, 2009) and social threat appraisal (Wolfgang and Miltnera, 2005). Given that excessive propensity to experience guilt and shame may be maladaptive, it was hypothesized that higher trait levels of these emotions would be associated with less an attenuation of the normal pattern of brain development (e.g., attenuated or reduced cortical thinning with age).

2. Materials and methods

2.1. Participants

Sixty-five healthy young people aged between 15 and 25 years participated in the study. They were confirmed to be without current or past diagnosis of a psychiatric or neurological disorder using a structured clinical interview (SCID-I non-patient version (First and Spitzer)). All participants (and their parents if <18 years of age) provided written, informed consent to complete this study after a complete description of its protocol, which was approved by the Melbourne Health Human Research Ethics Committee. Participants were excluded if they: had a medical or neurological condition; were being treated with psychoactive medication; had any history of Axis I psychopathology; were taking antidepressants (previously or currently); had experienced loss of consciousness for 5 min or more as a result of serious head injury; were pregnant; or had any other contraindications to MRI. After excluding participants for whom brain image segmentation was poor (see below), the final sample consisted of 60 participants (33 Female, M age 20.51, SD 2.99).

2.2. Measures and procedures

All participants completed an assessment that determined eligibility for the study, recorded details on demographics, medical and family history, and that included an MRI scan. Participants also completed the Quick Inventory of Depressive Symptoms-Self Report (QIDS-SR, Rush et al., 2003). In a follow-up assessment approximately 0.77 years (SD 0.36 years) post MRI scan, participants completed the Interpersonal Guilt Questionnaire-67 (IGQ-67) (O'Connor et al., 1997), and the Experience of Shame Scale (ESS) (Andrews et al., 2002).

The IGQ-67 was designed to measure trait levels of irrational guilt related to concerns about harming others. It comprises 67 statements that the participant must either agree or disagree with using a 5-point Likert scale (e.g., "I worry about hurting other people's feelings if I turn down an invitation from somebody who is eager for me to accept"). Fifteen items associated with 'self-hate' were excluded given the stronger theoretical association between self-hate and shame as opposed to guilt (Gibson, 2013). The ESS is a 25-item questionnaire that measures experiential, cognitive and behavioral components of trait shame, with questions aimed to uncover personal levels of shame experienced over the past year. Each item is rated on a 4-point Likert scale, from 1—not at all to 4—very much (e.g., "Have you worried about what other people think of you when you said something stupid?"). Total trait guilt and shame scores were obtained by summing scores on all items from the IGQ-67 (excluding self-hate items) and EES, respectively. These total scores were used as continuous interval-type data for all analyses as per prior literature (e.g., Andrews et al., 2002; O'Connor et al., 1997). In the current study, internal consistencies (Cronbach's