The role of social-emotional factors and lateralisation for emotion processing in adolescent facial emotion recognition

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Declaration of Authorship

I, Rachel J. Nesbit, hereby declare that this work was carried out in accordance with the regulations of the University of London. I declare that this submission is my own work, and to the best of my knowledge does not represent the work of others, published or unpublished, except where duly acknowledged in the text. No part of this thesis has been submitted for a higher degree at another university of institution.

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Abstract

The ability to accurately recognise facial displays of emotion is a fundamental skill, allowing individuals to successfully engage in their social environments. Previous research has found that social-emotional factors may impact facial emotion recognition (FER), and found links between stronger right-hemisphere (RH) processing for emotions and stronger FER. Importantly, these factors have not been looked at together in one study, and not in an adolescent sample. This thesis examines the role of social-emotional factors (social anxiety, depression) and the lateralisation for emotion processing on adolescent FER.

Chapter 3 describes the development and validation (Study 1) of stimuli to be used within the chimeric face test (a behavioural measure of emotion processing). Chapter 4 examines the role of social-emotional factors and lateralisation for emotion processing in FER using cross-sectional (Study 2) and longitudinal (Study 3) designs. Findings highlight the importance of social-emotional factors in adolescent FER. Further, with data from three time-points, findings demonstrate how changes in both social-emotional factors and the lateralisation for emotion processing impact later FER.

Chapter 5 examines group differences of individuals (primarily adolescents), high and low in social anxiety facets, high and low in depressive symptoms, RH dominant or bilateral (BL) in their processing of emotions. The aims were to assess if groups differed in their (1) recognition of, and (2) attention to (facial features and the eyes) facial emotions at varying levels of intensity (Study 4) and varying exposure time (Study 5). Findings highlight no group differences in FER when emotions were

presented at different intensity or for different exposure time. Some group differences were found in attention to facial features (depression) and the eyes (laterality, social anxiety) during FER. In Chapter 6, the findings are brought together, highlighting the independent roles of social anxiety (specifically sub-facets), depression and lateralisation for emotion processing in understanding adolescent FER.

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1 General Introduction

The ability to accurately recognise emotions is a fundamental skill that allows individuals to successfully engage and navigate in their social environments (Watling, Workman, & Bourne, 2012). Emotion recognition is critical to infer what another may be thinking or feeling (Cunningham & Odom, 2006; Kolb, Wilson, & Taylor, 1992; Lawrence, Campbell, & Skuse, 2015), which in turn can allow individuals to modify their behaviour accordingly (Gao & Maurer, 2009; Lawrence et al., 2015; Sorce, Emde, Campos, & Klinnert, 1985). Therefore, it is important to understand how emotion recognition skills develop through the lifespan, and to understand factors that may influence one's ability to recognise emotions.

Emotion recognition typically relies on the analysis of information across different modalities, including, facial expressions, body gestures and speech (Busso et al., 2004; Caridakis et al., 2007). This thesis will focus exclusively on the ability to successfully recognise facial affect. Facial emotion recognition (FER) is well-established as a critical way to ensure effective communication and as an important part of overall social understanding (Herba & Phillips, 2004; Simonian, Beidel, Turner, Berkes, & Long, 2001). It has been shown that emotion recognition is typically better in the visual domain (facial expressions) than in the auditory domain (voice; Pell & Kotz, 2011) and that during experiments where incongruent emotion information is presented visually and auditorily, information from the visual domain has been found to dominate emotion decisions (Collignon et al., 2008).

The majority of the literature has focused on the development of FER abilities in infancy and childhood (e.g., Durand, Gallay, Seigneuric, Robichon, & Baudouin, 2007; Herba & Phillips, 2004; Nelson, 1987), as well as the decline of FER abilities in older age (e.g., Isaacowitz et al., 2007; Sullivan & Ruffman, 2004). It has typically been shown that FER may reach adult-like levels between the ages of 10-11 years (e.g., Durand et al., 2007; Gao & Maurer, 2009, 2010). In older adults, there is evidence of decline in FER for both full intensity and low intensity emotional expressions (Orgeta & Phillips, 2008; Phillips, MacLean, & Allen, 2002; Sullivan & Ruffman, 2004). Importantly, examination of FER in adolescence has been largely ignored. This thesis focuses on filling the gaps through examining FER in adolescence. In addition to developmental changes, this thesis focuses on factors that may be related to FER. Specifically, this thesis will focus on the role of social-emotional factors (i.e., social anxiety, depression) and patterns of hemispheric brain lateralisation for emotion processing in adolescent FER. Researchers have shown relationships between FER and social-emotional factors in both childhood (e.g., social anxiety, Simonian et al., 2001; depression, Lenti, Giacobbe, & Pegna, 2000) and adulthood (e.g., social anxiety, Tseng et al., 2017; depression, Persad & Polivy, 1993), as well as links between FER and degree of lateralisation in children (Workman, Chilvers, Yeomans, & Taylor, 2006; see Section 2.2.3). Given that adolescence is a time of considerable change in social, emotional, and brain development, and a time where there is an increased prevalence of social-emotional problems, this thesis will examine how individual differences in FER may be explained by these factors.

In this Chapter, I will begin by providing an overview of adolescence – focussing specifically on developments in the brain, as well as social and emotional changes. Later in this Chapter I will provide an overview of the development of FER from infancy through adolescence, outlining potential explanations for developments. I will highlight what is currently known about FER in adolescence and why the developments in adolescent brain, behaviour and cognition make this an important time to study FER.

1.1 Adolescent Development

Adolescence is the developmental period from childhood to adulthood (Jaworska & MacQueen, 2015) that is characterised by physical, psychological and social changes (Blakemore, 2008; Spear, 2000). Adolescence marks the onset of puberty and has been typically referred to as spanning between the ages of 10-19 years (Sawyer et al., 2012); although, recently researchers argue that adolescence may be reflected by a longer period of transition spanning into the mid-twenties (Sawyer, Azzopardi, Wickremarathne, & Patton, 2018). Throughout adolescence there are a number of changes in social and emotional development and within the brain.

1.1.1 Social and Emotional Development in Adolescence

Adolescence is a period of considerable social change (Casey, Duhoux, & Cohen, 2010). Throughout adolescence peer relationships become increasingly important (Masten, Telzer, Fuligni, Lieberman, & Eisenberger, 2012) and adolescents spend considerably more time with peers than adults (Blyth, Csikszentmihalyi, & Larson, 2006). With peers and social acceptance becoming increasingly important, adolescents strive for independence from their caregivers (Casey et al., 2010).

Through aiming for independence, adolescence marks a time of increasing parent-child conflict (see Laursen, Coy, & Collins, 1998, for a review). Adolescents tend to use peers as their primary source of social support (Prinstein, 2007). This may lead to considerable concerns about how they may be viewed by others increasing self-focus and influencing their perceptions of the self and their behaviours (see Chapter 2).

1.1.2 Brain Development in Adolescence

Historically, researchers assumed that sensitive periods of brain development occurred postnatally, within the first few weeks of life (Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992). However, it is now widely acknowledged that the brain also undergoes dramatic changes and re-organisation throughout the adolescent period (Blakemore & Choudhury, 2006; Herba & Phillips, 2004; Schumann, 2004). Throughout adolescence there are considerable structural changes in the ratio of white matter and grey matter volume in the brain (Blakemore, 2008; Mills et al., 2016; Shaw et al., 2008). Grey matter volume (GMV) has been found to follow an inverted U shape pattern (Lenroot & Giedd, 2006), increasing throughout childhood and declining throughout adolescence (see Figure 1.1.; Gogtay et al., 2004; Herba & Phillips, 2004; Shaw et al., 2008). Reductions in GMV are thought to be the result of synaptic pruning, to improve functional connectivity and information flow across the brain (Blakemore, 2008; Mills, Goddings, Clasen, Giedd, & Blakemore, 2014). At the same time as the non-linear declines in GMV across adolescence, white matter volume (WMV) has been found to show linear increases across the cortex throughout childhood and adolescence (Mills et al., 2016; Sowell et al., 2003). Throughout adolescence the amygdala volume has been found to increase (Schumann et al., 2004). Importantly, this area has been widely implicated in emotion processing (see

Section 1.3.2). Additionally, there are changes in the connectivity between limbic regions and prefrontal regions (Scherf, Smyth, & Delgado, 2013; Spear, 2013; Supekar, Musen, & Menon, 2009), which are implicated in the recognition and processing of emotions (see Section 1.3.2). The restructuring of the brain and changes in connectivity throughout adolescence may have implications for how emotions are processed and recognised at this time (Blakemore, 2008; Thomas, Bellis, Graham, & LaBar, 2007).

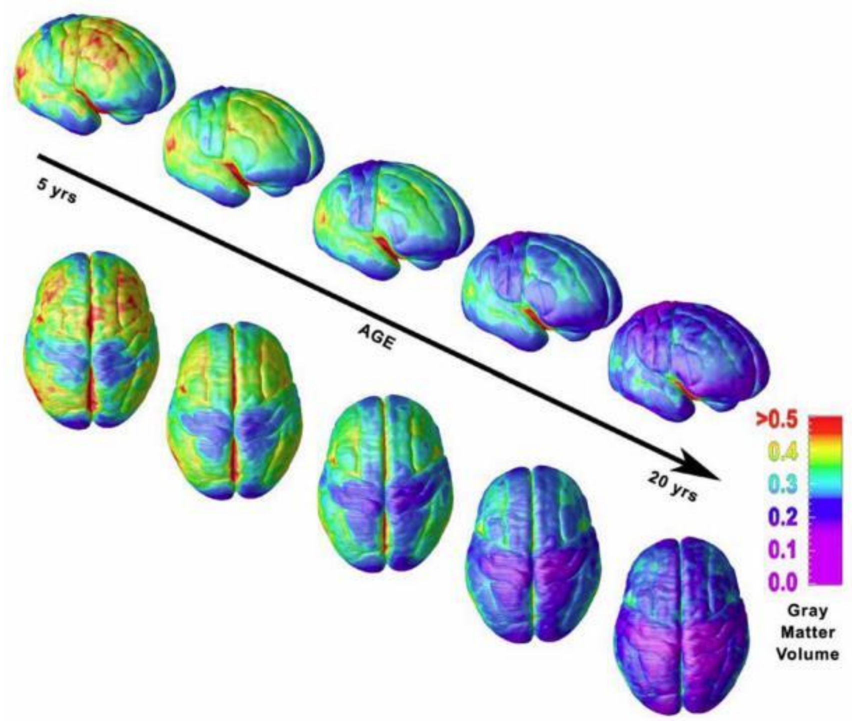

Figure 1.1. Grey matter maturation over adolescence. From Colver and Longwell, (2013, p.14).

As highlighted above, GMV has been found to decline throughout adolescence, and it has been found to follow a non-linear trajectory in the brain (Lenroot & Giedd, 2006), with limbic regions (including the amygdala) maturing before prefrontal areas (specifically the PFC; Lenroot & Giedd, 2006; Mills, Goddings, Clasen, Giedd, & Blakemore, 2014 ; see **Error! Reference source not found.**.). Differences in the maturation of these brain structures may have implications for emotion regulation in adolescents. The early maturation of limbic regions increases emotional reactivity, but it is not until the later maturation of the PFC that there are improvements in regulatory control. The dual systems theory (Casey, Getz, & Galvan, 2008; Steinberg, 2008) emphasises that adolescents may not be able to successfully regulate their emotions at this time, due to the mismatch between heightened emotional reactivity and underdeveloped cognitive control structures (see Figure 1.2.; Casey, Jones, & Hare, 2008; Mills et al., 2014; Powers & Casey, 2015; Steinberg, 2005). This has been argued as a core reason why adolescence may be a particularly vulnerable period for the onset of mental health disorders (Konrad, Firk, & Uhlhaas, 2013).

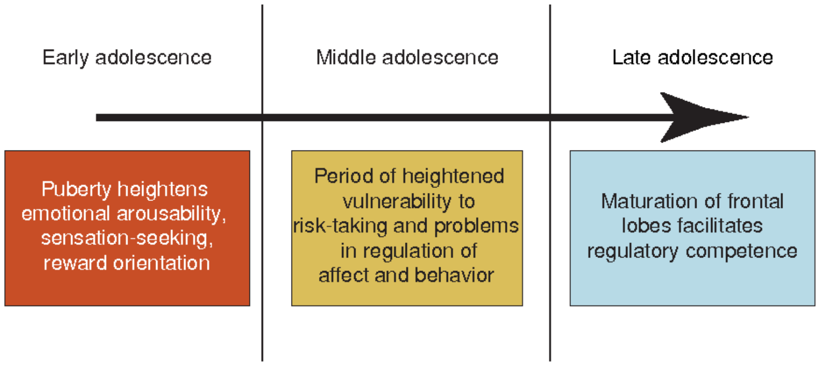

Figure 1.2. Visual representation of the 'mismatch' in adolescence. Early adolescence is a period of heightened emotional arousability, middle adolescence a period of vulnerability in regulation of affect and later adolescence is the period of maturation of PFC, facilitating regulatory control. From Steinberg, (2005, p.70).

In Chapter 2, I will explain how individual differences in social-emotional factors (specifically social anxiety and depression) may shed light on individual differences in FER. Importantly, researchers have found links between emotion regulation and FER (Harrison, Sullivan, Tchanturia, & Treasure, 2010; Harrison, Sullivan, Tchanturia, & Treasure, 2009), with difficulties in regulation associated with difficulties in recognition.

1.1.3 Summary

As can be seen from above, adolescence is characterised by a period of significant physical, social and psychological change (Blakemore, 2008; Spear, 2000). Taken together, changes in brain development, peer relationships and emotional reactivity mean that adolescents are increasingly vulnerable to the emergence of psychopathology at this time (Paus, Keshavan, & Giedd, 2008). Further, structural and connectivity changes in the brain throughout adolescence may have implications for how emotions are processed and recognised at this time. Adolescence is characterised as a period of increased emotional reactivity (Pine, 2007; Silvers et al., 2012; Steinberg, 2005). Adolescence has been characterised by the experience of more frequent and intense moods, (Larson, Moneta, Richards, & Wilson, 2002) and a time with increased hypersensitivity to peer influence and rejection (Kloep, 1999; O'Brien & Bierman, 1988), which may play a role in how adolescents navigate their social worlds. In this thesis, I will examine the role of social-emotional factors throughout adolescence and emotion processing in the brain in adolescent FER.

1.2 The Development of Facial Emotion Recognition (FER)

From an evolutionary standpoint, emotions are believed to have evolved to aid with communication, and survival (Darwin, 1872; Ekman, 1992). It has been suggested that there are six basic emotions – happiness, sadness, disgust, anger, fear and surprise – each of which are associated with innate neural substrates (Ekman, 1992) and distinct facial musculature patterns (Ekman, Levenson, & Friesen, 1983; Izard, 1992). There is evidence that these six emotions can be recognised cross culturally (Ekman & Friesen, 1971). Much of the research that investigates FER abilities does so with infant and child populations, exploring their recognition of these six 'basic' emotions (e.g., Durand, Gallay, Seigneuric, Robichon, & Baudouin, 2007; Herba & Phillips, 2004; Nelson, 1987). To understand how patterns of FER may develop in adolescence it is important to first understand how FER skills develop in childhood.

Figure 1.3. The six ‘basic’ emotions. Images from the Pictures of Facial Affect (Ekman & Friesen, 1971). From top left to right faces represent anger, fear and disgust. From bottom left to right faces represent surprise, happy and sad.

1.2.1 Facial Emotion Recognition (FER) in Infancy and Childhood

Several studies have demonstrated that infants as young as 3-4 months are able to discriminate between different facial expressions of emotion (Barrera & Maurer, 1981; Montague & Walker-Andrews, 2001; Nelson, 1987; Young-Browne, Rosenfeld, & Horowitz, 1977). For example, Montague and Walker-Andrews (2001) had an experimenter play a peekaboo game with 4-month-olds whereby they systematically changed the typical happy/surprised expression with either a sad, angry or fear expression. They found that infants changed their looking time as a function of the emotion, demonstrating that infants can discriminate between different emotions. Further, researchers have demonstrated that 7-month-olds can discriminate happy faces from fear and anger (Kestenbaum & Nelson, 1990), and by the end of the first year of life, they are able to use social referencing to adapt their behaviour in response to others’ facial expressions (e.g., Sorce et al., 1985; Klinnert, Emde, Butterfield, & Campos, 1986).

Researchers have established that there is a gradual increase in FER (e.g., recognition and identification) from 4-11-years (e.g., Durand et al., 2007; Herba & Phillips, 2004; Tremblay, Claire, Kirouac, Giles, Dore, 2001). Cunningham and Odom (1986) suggest that children developmentally recall information from the mouth followed by the eyes and the nose. Similarly, Kestenbaum (1992) demonstrated that whilst children were good at recognising global categories (i.e., positive versus negative expressions), with age children become better at recognising discrete categories from facial features (i.e., eyes only, nose only, mouth only). Related studies have examined how emotional intensity may play a role in children's accuracy in identifying different emotions at adult-level. Gao and Maurer (2009, 2010) found that children were able to comparably recognise happiness and sadness at similar low intensity to adults, while for the emotions of fear, anger, surprise and disgust they showed a dissimilar pattern to adults, with younger children being less likely to recognise these emotions at lower intensities. As such, a developmental trend has been established – as children develop, they become more competent in accurately identifying emotions and are able to recognise them at a lower emotional intensity (Gao & Maurer, 2009, 2010).

Importantly, much of this work has explored each of the six basic emotions developmental trajectory independently and thus is not believed to reflect a distinct stage of development (Camras & Allison, 1985; Herba & Phillips, 2004). There is general consensus that happiness is the earliest emotion recognised, followed by sad or angry facial expressions, later by fearful and surprise facial expressions and later still by disgust (Camras & Allison, 1985; Herba & Phillips, 2004). Within this order, researchers have identified the ages at which the recognition of each emotion reaches an adult level. Durand et al. (2007) compared children aged 5-12 years with an adult sample on their recognition of different emotions and found that whilst the accuracy in recognition of happiness and sadness was comparable to the adults at 5-6 years of age, fear was comparable at 7-years, anger at 9-years and disgust at 12-years.

Research supports the idea of developmental changes in the recognition of emotions throughout infancy and childhood, with much research pointing towards FER accuracy reaching adult levels before adolescence (e.g., Durand et al., 2007; Tremblay et al., 2001). However, inconsistent patterns of development in FER abilities have been found throughout development (Thomas et al., 2007). More recently, researchers argue that the evidence demonstrates that FER abilities may continue to develop throughout late childhood and adolescence (Lawrence et al., 2015; Thomas et al., 2007). In fact, it may be that differences have not been detected previously due to the task demands; for example, some tasks traditionally used are prone to ceiling effects in performance (Thomas et al., 2007) and may use oversimplified stimuli, such as schematic faces (Gross & Ballif, 1991).

1.2.2 Facial Emotion Recognition (FER) in Adolescence

As highlighted earlier, much research assumes that adult-like levels of FER ability are reached by middle childhood (e.g., Durand et al., 2007; Watling et al., 2012), however, there are several reasons to believe that this may not be the case. Adolescence is a key time for social and emotional development and a time of reorganisation of face processing structures in the brain (Scherf, Behrmann, & Dahl, 2012). As such, continuation of FER development is expected throughout adolescence. It is evident that the anatomical and functional brain changes throughout adolescence appear contrary to the behavioural literature that suggests that FER abilities reach maturity in late childhood (Thomas et al., 2007). Further, there is evidence that the neural substrates involved in facial emotional processing reach adult-like levels in early adolescence (e.g., Batty & Taylor, 2006).

In recent years, researchers have begun to examine the development of FER that occurs in late childhood and into adolescence. Findings suggest that the recognition of some emotions (e.g., fear, disgust) may show a more gradual change than has been reported elsewhere (e.g., Lawrence et al., 2015; Thomas et al., 2007). For example, Lawrence et al. (2015) examined the relationship between chronological age, pubertal stage and gender on FER abilities in individuals aged 6-16 years. Participants were required to view a computerised version of the Ekman and Friesen Pictures of Facial affect test and select the emotional label that they thought corresponded to the emotion, selecting from the six basic emotions plus an additional neutral option. Happiness was found to be accurately named by even the youngest participants (6-year-olds were 92% accurate), supporting previous research that happiness can be accurately identified from early childhood (Durand et al., 2007). Sadness and anger showed little or no change in accuracy across childhood through adolescence, with young children performing at similar levels to adolescence, suggesting no developmental change from childhood to adolescence. Contrary to previous findings, the recognition of fear, disgust and surprise showed linear improvements across childhood and through adolescence, with 16-year-olds performing significantly better than 10-year-olds on the recognition of fear and disgust. It thus appears that there is a continuation in the development of FER skills throughout childhood and into adolescence. Given that the stimuli used in this study were of high emotional intensity, it may be expected that there may be greater differences when examining the recognition of more subtle emotional expressions. Further, Lawrence et al. (2015) demonstrated that pubertal stage, independent of age, influenced the recognition of disgust and anger, with significant increases in accuracy from mid to late-stage puberty.

Interestingly, Thomas et al. (2007) provided evidence of late developmental changes in FER skills throughout adolescence, parallel to brain changes that occur at this time. In their study participants (aged 7-13, 14-18 and 25-57 years) viewed three different emotional morph types (i.e., neutral-anger, neutral-fear, fear-anger). The morphs were incremental across a continuum, with each expression shown at increasing emotional intensities (e.g., from 22.22% - 77.77% intensity; 6 morph increments per morph type). Participants viewed a face and were required to judge which of two emotions the face was showing (e.g., neutral or anger). For each different emotional morph type the average detection sensitivity of the emotion was calculated. It was found that across all three morph types that adults were more sensitive to changes in emotional expression than children and adolescents, and that children and adolescents were equivalent in their sensitivity for detecting changes in emotional expressions (Thomas et al., 2007). This study demonstrated that individuals improve in their ability to recognise more nuanced expressions of emotion later in adolescence and into adulthood.

1.3 Theoretical accounts of Facial Emotion Recognition (FER)

1.3.1 Social factors

From a social-constructivist perspective (see Averill, 1980), the development of children's FER skills can be explained through being 'trained'. The social constructivist model argues that through observing and imitating adults over time, children acquire increasingly sophisticated skills and behaviours. Over repeated social interactions and parents decreasing involvement, children become increasingly self-sufficient in their FER skills (Averill, 1980; McClure, 2000).

Ample research highlights the importance of social experiences in the development of emotion skills (Halberstadt, 1986; McClure, 2000; Pollak & Sinha, 2002).

Halberstadt's (1986) socialisation hypothesis proposes that an individual's family environment plays a crucial role in children's development of FER and social understanding. For example, a positive relationship has been found between mothers' levels of emotional expressivity and children's developing FER skills (Camras et al., 1990). Indeed, it has also been demonstrated that when compared to typically developing children, physically abused children (Pollak & Sinha, 2002), as well as children exposed to high levels of parental hostility (Pollak et al., 2009), show earlier recognition of anger. These findings highlight the effect of early experience of children's non-verbal decoding skills and provide support for the perceptual learning of emotional expressions (Pollak et al., 2009).

Taken together, social learning has been highlighted as important for the development of FER skills. Although, it provides little information about how emotions are processed and how this might impact FER. It is therefore important to examine emotion in the brain and how brain structures and development may support FER.

1.3.2 Emotion in the Brain

Whilst it is beyond the scope of this thesis to examine in depth the neural architecture that may support emotion processing, understanding how core areas implicated in emotion processing may develop throughout adolescence may be particularly important. In particular, this section will highlight how changes during the adolescent period may be involved with further development in FER at this time.

It is believed that facial emotional processing relies on a complex network of brain areas (Phan, Wager, Taylor, & Liberzon, 2002; Thomas et al., 2007), including both cortical and subcortical regions (Batty & Taylor, 2006). Researchers have found that the prefrontal cortices (PFC), insula, amygdala and fusiform gyrus are all involved in the perception of and recognition of facial effect (Batty & Taylor, 2006). The fusiform gyrus is a brain area found to be specialised in the perception and extraction of emotional information (Batty & Taylor, 2006; Breiter et al., 1996; Kawasaki et al., 2012). The role of the amygdala in emotion processing remains unclear, but much research finds evidence that the amygdala is activated in fear processing (Breiter et al., 1996; Morris et al., 1996; Phan et al., 2002; Whalen et al., 2001); although, it has been implicated in the processing of other emotions, such as anger, disgust, sadness, happiness, as well as in the processing of neutral expressions (Adolphs, 1999; Fitzgerald, Angstadt, Jelsone, Nathan, & Phan, 2006; Graham, Devinsky, & LaBar, 2007). As mentioned in Section 1.1.2, there are sizeable age-related changes in amygdala volume throughout adolescence (Schumann, 2004). With the amygdala being a key structure found to be involved in emotion processing (Thomas et al., 2007), these changes in volume provide support for the notion that there may be continued developments in FER at this time.

The PFC is believed to play an important role in the processing of facial expressions (Nakamura et al., 1999; Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998). As highlighted in Section 1.1.2, the PFC is one of the latest brain areas to mature (Casey, Galvan, & Hare, 2005; Casey, Giedd, & Thomas, 2000) and undergoes dramatic synaptic reorganisation throughout adolescence (Steinberg, 2008). Throughout adolescence there is functional re-organisation of the reciprocal connections from the PFC to other regions of the brain, including limbic regions, implemented in emotion processing (Batty & Taylor, 2006). Taken together, it has been suggested that brain structure changes in the brain may link to changes in the development of FER in adolescence (Blakemore & Choudhury, 2006).

As well as examining structural changes in the brain in relation to FER, some researchers have looked more broadly in terms of hemispheric specialisation. The right-hemisphere (RH) is largely believed to play a dominant role in emotion processing (Nakamura et al., 1999; Phan et al., 2002; Workman et al., 2006; see Section 2.2.1.3), and researchers have found associations between degree of laterality to the RH and FER (Barth & Boles, 1999; Watling & Bourne, 2013; Workman et al., 2006). Importantly, to my knowledge no research to date has examined hemispheric specialisation for emotion processing in adolescence, which this thesis aims to address. The role of lateralisation for emotion processing and links to FER will be discussed in more depth in Chapter 2.

1.4 Face scanning and Facial Emotion Recognition (FER)

As highlighted in Section 1.2.1, children developmentally recall information from the mouth, eyes and then nose (Cunningham & Odom, 1986). Researchers have consistently shown that individuals follow an inverted triangle pattern during face scanning (Walker-Smith, Gale, & Findlay, 1977; Yarbus, 1967); they preferentially attend to salient features (the eyes, nose and mouth; (Eisenbarth & Alpers, 2011; Yarbus, 1967) and spend little time viewing non-features (Manor et al., 1999; Walker-Smith et al., 1977; Yarbus, 1967). It has been found that different regions of the face may be more or less informative in the recognition of specific emotions (Eisenbarth & Alpers, 2011; Kestenbaum, 1992; Schurgin et al., 2014). In particular, researchers have highlighted the eyes as a critical source of emotional information

(Baron-Cohen, Wheelwright, Spong, Scahill, & Lawson, 2001; Emery, 2000; Spezio, Huang, Castelli, & Adolphs, 2007). Indeed, it has been shown that the majority of fixations are directed to the eye region (Lundqvist, Esteves, & Öhman, 1999; Wegrzyn, Vogt, Kireclioglu, Schneider, & Kissler, 2017) and research with both children and adults has shown that the eyes are the dominant feature in the recognition of sadness (Eisenbarth & Alpers, 2011; Schurgin et al., 2014), fear (Eisenbarth & Alpers, 2011; Kestenbaum, 1992; Schurgin et al., 2014), anger (Schurgin et al., 2014) and surprise (Kestenbaum, 1992). The mouth has also been highlighted as an important feature in facial recognition, it is believed that happiness and disgust recognition, may rely primarily on information from the mouth region (Eisenbarth & Alpers, 2011; Kestenbaum, 1992).

As highlighted above, specific facial features may be necessary in the identification of different facial emotions, with researchers emphasising the eyes and mouth as the core diagnostic features for FER (Eisenbarth & Alpers, 2011; Kestenbaum, 1992; Schurgin et al., 2014). Given, the importance of specific features in the recognition of facial affect (particularly the eyes and mouth), it is not surprising that researchers have found that scanning of different features may be related to the successful identification of facial expressions (Adolphs et al., 2005; Kestenbaum, 1992; Schurgin et al., 2014; Wong, Cronin-Golomb, & Neargarder, 2005). Adolphs et al. (2005) examined a patient who showed poor fear recognition following amygdala damage. Using eye-tracking it was shown that this individual was not making use of the information from the eyes during FER. Importantly, when the patient was instructed to look at the eye region, it was found that their recognition of fear improved. These findings highlight how scanning of specific regions may be critical in the decoding of facial expressions.

Much of what is known about the relationship between face scanning and FER has been informed by research on clinical populations, who have often been shown to demonstrate atypical face scanning (Bal et al., 2010; Dalton et al., 2005; Loughland, Williams, & Gordon, 2002). Specifically, relationships have been found between the amount of time spent viewing salient features and FER accuracy across a range of patient groups, such as in autism (Bal et al., 2010; Nacewicz et al., 2006), in schizophrenia (Loughland et al., 2002), and in Huntington's disease (Kordsachia, Labuschagne, & Stout, 2017). Researchers have also found positive relationships between the amount of time spent looking at the eyes and FER in control groups of healthy adults (Bal et al., 2010).

In healthy populations, female advantage in FER has been linked to differences in face scanning. Hall, Hutton, and Morgan (2010) showed that females spent significantly longer looking at the eyes during FER than males, and that the amount of time spent looking at the eye region was positively correlated with better FER. Additionally, Sullivan, Ruffman, and Hutton (2007) found that age related declines in FER have been attributed to differences in the scanning of faces; for example, younger adults compared to older adults were found to be significantly more accurate in their FER, and showed increased time spent examining both the eyes and mouth when decoding facial expressions. As well as this, across a variety of groups, researchers have demonstrated that FER can be improved through redirecting attention to salient features of the face (Frommann, Streit, & Wölwer, 2003; Marsh, Luckett, Russell, Coltheart, & Green, 2012). Taken together, these findings highlight that visual scanning of facial regions may be of paramount importance in the ability to accurately recognise emotions and that any differences in FER may be in part explained by differences in the attention to faces, specifically in the scanning of facial features which may be important for the accurate identification of facial affect.

1.4.1 Sex differences in Facial Emotion Recognition (FER)

Research suggests a sex difference exists in the ability to recognise emotions (e.g., Hoffmann, Kessler, Eppel, Rukavina, & Traue, 2010; McClure & Nowicki, 2001; Montagne, Kessels, Frigerio, De Haan, & Perrett, 2005). Hoffmann et al. (2005) found that females are significantly better than males at recognising subtle emotions; however, at 100% intensity findings indicate that males and females do not differ in their FER accuracy. In support of this, Montagne et al. (2005) examined sex differences in the sensitivity of FER accuracy. Participants were required to view video clips of subtle emotions that morphed into full-blown emotions (100% intensity). Participants were required to signal when they first noticed a particular emotion. Females were more sensitive and accurate at identifying emotions in comparison to males. Taken together, in a meta-analysis, McClure's (2000) found that sex differences exist, with females showing stronger FER; although, the analysis also found that the effect size of these sex differences was small.

1.5 Summary

This chapter introduces evidence that FER develops throughout infancy and childhood, as well as throughout adolescence. This is supported by research evidencing continued brain development during adolescence, specifically in brain areas that may be particularly important in facial emotion processing (i.e., PFC, amygdala). As well as developments within the brain during adolescence, it has been highlighted that adolescence marks a time of change in social and emotional development and a time of increasing prevalence and onset of social-emotional problems that may impact how emotions are processed and recognised.

Researchers have highlighted that specific facial regions contain important emotional information for successful FER (Eisenbarth & Alpers, 2011; Kestenbaum, 1992); in particular, the eyes and the mouth are important for FER. Importantly, difficulties in the recognition of facial emotions have been linked to differences in attention to faces (see Section 1.4). As such, findings highlight that through examining attention to facial features researchers may gain greater insight into FER.

Given that adolescence is a period of risk for the emergence of psychopathology, this thesis will examine the role of social-emotional factors and lateralisation for emotion processing in the ability to recognise facial affect at this time. Whilst above, the development of FER has been summarised, it is widely acknowledged that there may be individual differences in the ability to recognise facial affect throughout the lifespan. In Chapter 2, I will focus specifically on the role of individual differences in explaining FER. Specifically, I will focus on the relationship between social emotional factors (social anxiety, depression) and the lateralisation for emotion processing with FER, including how these factors may relate to attention to emotional faces during decoding of emotional expressions.

2 Factors influencing Facial Emotion Recognition (FER)

In Chapter 1, I provided background on the typical development of facial emotion recognition (FER). Importantly, there are a number of factors that may influence an individual's ability to recognise emotions throughout the lifespan. In this Chapter, I will provide an overview on some of the key factors that may influence FER during adolescence. Specifically, and consistent with the primary aim of this thesis, social-emotional factors (social anxiety and depression) and patterns of hemispheric brain lateralisation for emotion processing may influence adolescent FER. In this Chapter, I will introduce each of these factors in turn, summarise previous literature in these areas, and outline their potential relationship to FER.

2.1 Social-emotional factors

Social skills deficits are often reported as a core characteristic in many neuropsychiatric disorders (Feinberg, Rifkin, Schaffer, & Walker, 1986; Kornreich & Philippot, 2006; Walker, Marwit, & Emory, 1980).Specifically, deficits in FER have been found in a range of clinical groups, including those with psychotic disorders (e.g., schizophrenia; see Mandal, Pandey, & Prasad, 1998 for review), mood disorders (e.g., depression; see Bourke, Douglas, & Porter, 2010 for review), anxiety disorders (Attwood et al., 2017; Simonian et al., 2001), and neurodevelopmental disorders (e.g., autism; see Uljarevic & Hamilton, 2013). This thesis focuses on understanding the relationship between those higher in feelings of social anxiety and depression (both of which are often first diagnosed in adolescence), and their relationship with FER.

2.1.1 Social Anxiety

Social anxiety disorder (SAD) is a specific type of anxiety disorder, characterised by an intense fear in social situations (American Psychiatric Association [APA], 2013). In fact, it is often seen as a multifaceted disorder (Moscovitch, 2009), with researchers often distinguishing between subjective components (fear of negative evaluation; FNE) and behavioural components (social avoidance; La Greca & Stone, 1993) of social anxiety (SA). Whilst subjective components reflect subjective experiences (i.e., intense fear of social situations), behavioural components reflect actual behaviours that individuals with social anxiety may engage in (i.e., social avoidance).

Social anxiety has been reported as the most common anxiety disorder (Kessler et al., 1994). In the DSM-5 there are seven criteria that distinguish whether an individual will receive a diagnosis of social anxiety (see Table 2.1). The median age of onset for social anxiety is 13 years in the USA, with 75% of these individuals receiving a diagnosis between the ages of 8-15 years, and rarely is the first onset of the disorder in adulthood (APA, 2013). The prevalence of SAD is estimated between 7% and 12% (NICE, 2013), with it being identified as the most prevalent mental health diagnosis in adolescence (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003). Rates of social anxiety have been found to rise during the preadolescent and early adolescent years (Beesdo et al., 2007; Chavira & Stein, 2005; Kessler et al., 2005; Mancini, Ameringen, Bennett, Patterson, & Watson, 2005). Importantly, it is believed that the estimate of the prevalence of SAD is likely to be conservative in respect to those who actually have the disorder, as there is evidence that large proportions of individuals with high levels of social anxiety do not seek professional support (Katzelnick & Greist, 2001).

Social anxiety tends to have considerable stability from adolescence into adulthood if left untreated (Schneier, Johnson, Hornig, Liebowitz, & Weissman, 1992; Wittchen, Stein, & Kessler, 1999). It is associated with many functional consequences, including decreased well-being, elevated rates of school dropout, socioeconomic status and quality of life (APA, 2013). Individuals with social anxiety have also been found to suffer from intense emotional distress and significantly impaired social interactions skills (Simonian et al., 2001), which may be related to how they perceive and identify the emotions of others.

Table 2.1. Diagnostic criteria for social anxiety disorder (APA, 2013, p.202-203)

Criterion A	In children the fear of anxiety must occur in peer settings and not just during interaction with adults
Criterion B	The individual fears that he or she will act or appear in a certain way or show anxiety symptoms, such as blushing, trembling, sweating, stumbling over one's words, or staring, that will be negatively evaluated by others
Criterion C	The social situations almost always provokes fear of anxiety
Criterion D	The individual will avoid the feared social situations. Alternatively, the situations are endured with intense fear or anxiety
Criterion E	The fear or anxiety is judged to be out of proportion to the actual risk of being negatively evaluated or to the consequence of such negative evaluations
Criterion F	The duration of the disturbance is typically at least 6 months
Criterion G	The fear, anxiety, and avoidance must interfere significantly with the individual's normal routine, occupational or academic functioning, or social activities or relationships, or must cause clinically significant distress or impairment in social, occupations or other important areas of functioning

2.1.1.1 Models of social anxiety

Researchers has proposed that socially anxious individuals show a range of biases across a number of cognitive processes, such as attention, memory, imagery and interpretation (Spokas, Rodebaugh, & Heimberg, 2007). Cognitive theories of anxiety emphasise that cognitive biases are related to both the development and the maintenance of anxiety disorders (Clark & Wells, 1995; Rapee & Heimberg, 1997; Spokas et al., 2007; Wieser, Pauli, Weyers, Alpers, & Mühlberger, 2009). There are two key models of social anxiety: Clark and Wells' (1995) cognitive model and Rapee and Heimberg's (1997) cognitive-behavioural model. Both are outlined below.

Clark and Wells (1995) Model

Clark and Wells' (1995) cognitive model of social anxiety proposes that socially anxious individuals hold negative assumptions, including high self-standards for their social performance, intense fear of how others in their environment will evaluate them and negative views about their own social competency. When entering into a social situation, socially anxious individuals are believed to shift their attention internally and consequently ignore external cues, using their negative assumptions to guide how they may be perceived by others. It is believed that socially anxious individuals may engage in safety behaviours as a way to minimise fear and anxiety in social situations, such as avoiding eye contact (Clark & Wells, 1995). Such safety behaviours are thought to increase self-focussed attention. With increased self-focused attention, socially anxious individuals may experience somatic and cognitive symptoms, which are interpreted as signs of failing desired standards, which consequently leads to increased fear and anxiety (Clark & Wells, 1995; see *Figure 2.1*).

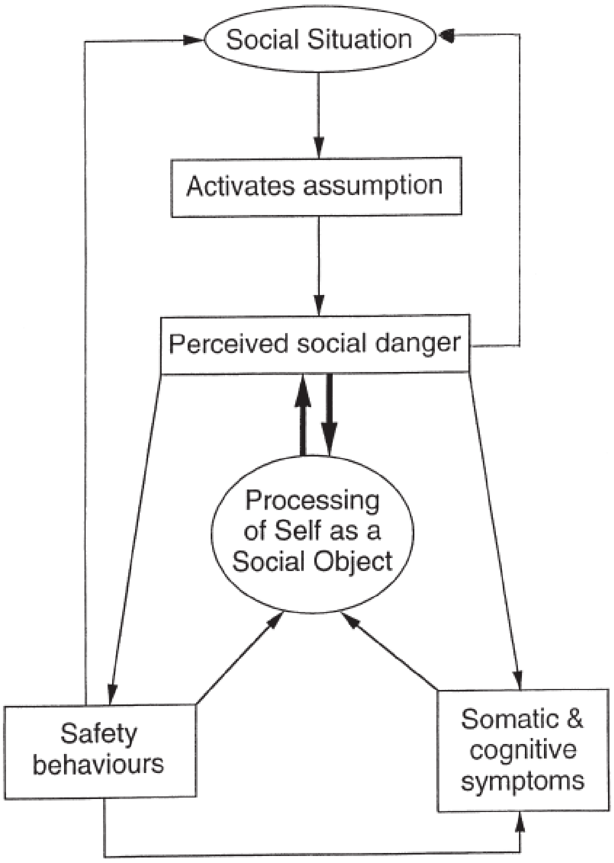

Figure 2.1. Cognitive Model of Social Anxiety Disorder, Clark and Wells (1995)

Rapee and Heimberg's (1997) Model

Rapee and Heimberg's (1997) model is similar in many ways to Clark and Wells' (1995) model. The model assumes that socially anxious individuals hold the assumption that others are overtly critical of their social performance and are likely to negatively evaluate them. Similar to Clark and Wells model, the belief is that socially anxious individuals mentally represent their behaviour and appearance and focus internally. Rapee and Heimberg's (1997) model, however, emphasises that as well as increased self-focussed attention, socially anxious individuals are also sensitive to external cues that may signify threat, and they therefore monitor their external environment for signs of threat and disapproval. Socially anxious individuals 'multi-task' between self-monitoring and looking out for external cues of threat. They tend to interpret how they may be viewed by others based on their own high expectations of their performance and their predicted performance; the difference between these is believed to determine the likelihood of further negative evaluation and social consequences, which leads to increasing anxiety (Rapee & Heimberg, 1997; see Figure 2.2).

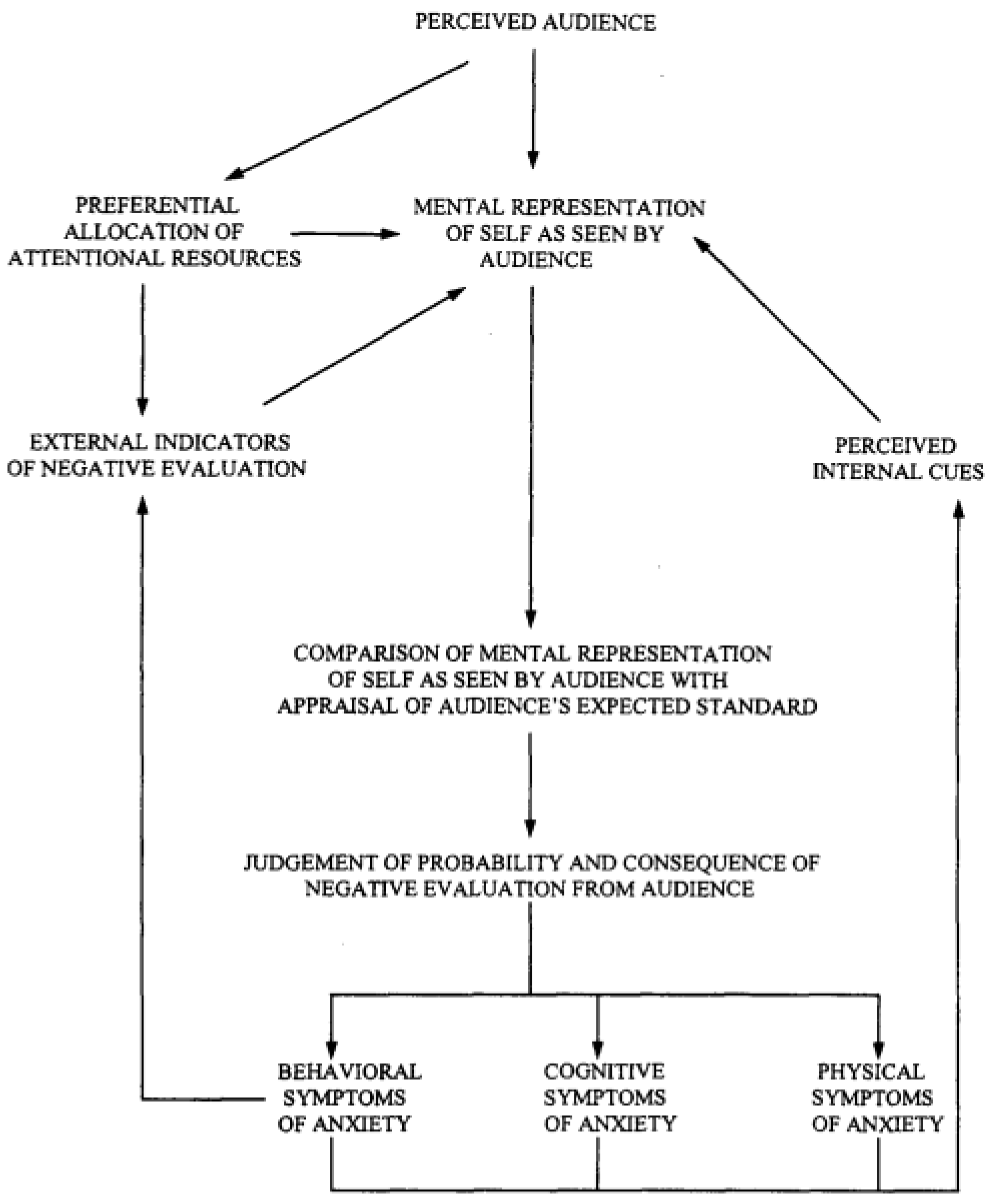

Figure 2.2. Rapee and Heimberg's (1997) cognitive-behaviour model of anxiety in social phobia.

2.1.1.2 Social Anxiety and Facial Emotion Recognition (FER)

Individuals with social anxiety are often referred to as having poor interpersonal skills, specifically in the domain of social interactions (e.g., Beidel & Turner, 1997; Simonian et al., 2001). FNE may play a role in how individuals interpret their social environments, and consequently this may lead them to avoid social situations or to feel distressed within them. Beidel and Turner (1997) suggested that early social isolation may result in the inability to successfully acquire the appropriate social skills necessary to engage in successful social exchanges.

The ability to accurately decode facial expressions of emotion is an important component of social competency, which due to avoidance behaviours and poor inter-personal skills may be underdeveloped in socially anxious individuals. As highlighted in Section 1.3.1, social experiences are believed to play a critical role in the development of emotion skills (Halberstadt, 1986; Pollak, Messner, Kistler & Cohn, 2009; Pollak & Sinhan, 2002). Difficulties in the recognition of facial affect have been found to negatively impact interpersonal relations (Knapp & Hall, 1992). Thus, it may be that there is a bidirectional relationship between poor interpersonal skills and FER accuracy – poor social skills impact negatively on peer relations and peer relations may be important for the development of these skills.

Individuals with heightened levels of social anxiety, both at the clinical and non-clinical level, have been shown to perform differently than their non-socially anxious counterparts on FER (Arrais et al., 2010; Montagne et al., 2006; Simonian et al., 2001; Tseng et al., 2017). Findings relate to their accuracy in identifying emotions and to their biases. The evidence for these are outlined below.

Recognition Accuracy

Some researchers have found that individuals with social anxiety may show difficulties in the ability to recognise facial affect (Simonian et al., 2001; Tseng et al., 2017). For example, Simonian et al. (2001) required a group of socially anxious children and adolescents and a group of non-socially anxious controls to recognise the six basic emotions. Children and adolescents with social anxiety disorder (SAD) were significantly less accurate and made more errors in their FER than the non-socially anxious control group. Specifically, this was found to be the case for happy, sad and disgust expressions. This research suggests that individuals with social anxiety may be characterised by impairments in the recognition of a range of emotional expressions.

Further research has highlighted that socially anxious individuals may be characterised by difficulties in the recognition of other emotions. For example, Tseng et al. (2017) compared adults with SAD and controls in their recognition of emotion. It was found that compared to the controls, adults with SAD were overall poorer in their FER than non-socially anxious controls and they spent more time on FER. Differences between the two groups were primarily driven by significantly lower accuracy and slower reaction times in the recognition of fear by the socially-anxious individuals in comparison to the individuals in the control group. Additionally, the authors measured self-reported levels of social anxiety (using the Liebowitz Social anxiety scale; Fresco et al., 2001) and found that poorer sad recognition was associated with higher avoidance symptoms in the SAD group. Together, this work shows that in both clinical SAD participants and non-clinical high social anxiety groups FER performance is poorer.

Above, evidence supports that socially anxious individuals tend to have more difficulties in FER (e.g., Simonian et al., 2001; Tseng et al., 2017), yet other evidence suggests that those who are more socially anxious may show increased sensitivity in FER for some emotions. Arrais et al. (2010) compared socially anxious adults and control participants in their judgements of emotional expressions at varying levels of emotional intensity. No differences were found in the number of correct responses or reaction times; however, the socially anxious females (not males) required less emotional intensity to recognise happy, fear and sad emotional expressions than controls. These findings suggest that socially anxious individuals may be hyper sensitive to subtle emotional expressions in others. Additionally, Gutierrez-Garcia and Calvo (2017) found that undergraduate students with clinical levels of social anxiety (compared to non-socially anxious controls), demonstrated an increased ability to detect anger and disgust at low intensity during an emotion categorisation task. These findings are in line with cognitive models of social anxiety which argue that socially anxious individuals may be sensitive to signs of disapproval and threat in their social environments (Rapee & Heimberg, 1997). Notably, some researchers have demonstrated that individuals with social anxiety may show overall better FER (Hunter, Buckner, & Schmidt, 2009), which may be explained by socially anxious individuals' vigilance to scan for social cues, resulting in increased accuracy on these tasks.

In contrast to findings that supports hypersensitivity to FER by those with social anxiety, Montagne et al. (2006) found the opposite. They examined sensitivity at recognising the six basic emotions for individuals with SAD and matched controls who viewed video clips, whereby a neutral face gradually morphed into an emotive face. The intensities of the emotions ranged between 20-90%. Participants were required to identify, using a forced choice paradigm, the emotion that the end face displayed. The authors calculated the sensitivity (the lower % intensity that all subsequent trials were recognised) for each emotion. They found no significant difference in the sensitivity of FER for positive stimuli, but a significant difference in sensitivity for negative emotions. For anger and disgust individuals with SAD required higher emotional intensity to successfully recognise the emotions. These findings suggest that social anxiety may be characterised by a reduced sensitivity in the identification of negative emotions.

It should be noted that some researchers have failed to find evidence of differences in FER for individuals differing in their level of social anxiety. For example, Philippot and Douilliez (2005) compared performance on an emotional facial expression task for participants with social anxiety, with another anxiety condition and with a control group. Participants were required to decode the emotions of 40 faces that varied in intensity and emotional expression. There were no differences between the groups with regards to decoding accuracy, misclassification and self-reported task difficulty.

Given the conflicting evidence, within this thesis I set out to understand what factors may explain the link between adolescent FER and their levels of social anxiety. To do this, I am exploring their recognition at different intensities to assess if there is increased, decreased, or no differences in sensitivity. Further, much of the research above, did not assess biased responding (i.e., where an individual may over attribute an emotional label to more than one face; outlined below); this will be considered within this thesis (Study 4 and 5).

Negative Biases

Individuals with social anxiety have been characterised by negative processing biases (Spokas et al., 2007). Specifically, much research has documented that socially anxious individuals may interpret others facial expressions more negatively (Pozo, Carver, Wellens, & Scheier, 1991), and interpret ambiguous social events more negatively (Amin et al., 1998). These biases may not be picked up in research that just explores accuracy.

Researchers who account for response bias may find that there are no differences in accuracy of FER for those who are socially anxious in comparison to those who are not, but instead find differences in the types of misclassification errors made on these tasks. For example, Bell, Bourke, Carter, Frampton and Porter (2011) compared FER accuracy for socially anxious adults and non-socially anxious controls. They demonstrated that although the two groups were equally accurate on their FER and on the amount of errors made, the high socially anxious adults were more likely to judge that neutral stimuli were displaying anger than controls did. Similarly, Yoon and Zinbarg (2007) demonstrated that compared to low socially anxious controls, adults with higher levels of social anxiety were significantly more likely to misinterpret neutral faces as threatening. In children, Battaglia and colleagues (2012) showed that social anxiety scores were associated with higher misidentifications; they were more likely to classify angry faces as disgust. These findings highlight that levels of social anxiety may be associated with negative biases when identifying emotional stimuli.

In addition to looking at overall feelings of social anxiety, researchers have examined how different facets of social anxiety may be related to the ability to detect negative emotions in others (e.g., Veljaca & Rapee, 1998; Winton, Clark, & Edelmann, 1995).

As highlighted earlier, a core feature of SAD is an individual's intense fear of being negatively evaluated by others in social situations (Heuer, Rinck, & Becker, 2007; APA, 2013). Winton et al. (1995) examined whether individuals low or high on FNE would show discrepancies in their ability to attribute negative emotions to others. Participants completed Leary's (1983) FNE scale and were required to view images of neutral and negative emotions under restricted viewing times (i.e., the image could be viewed for 60ms). Following the presentation of each emotion, participants were required to identify the emotion that had been displayed. It was found that the high FNE group was significantly better at identifying negative facial expressions compared to low FNE participants and significantly poorer in their recognition of neutral emotional expressions. To distinguish whether individuals high on FNE were generally more accurate at recognising negative emotions or whether a negative response bias existed, a signal detection analysis was carried out. Results showed that individuals in the high FNE condition had a lower criterion for identifying negative expressions (i.e., high FNE subjects showed a bias towards identifying others expressions as negative regardless of stimuli presented). The authors concluded that the higher FER accuracy of negative facial expressions and the lower accuracy in detecting neutral expressions was an artefact of the high FNE subjects' bias towards identifying other's expressions as negative. These findings may therefore reflect that individuals with high levels of social anxiety may show an overall negative response bias in their identification of facial affect and may have a more 'liberal' response criterion in identifying negative emotions in others.

Veljaca and Rapee (1998) further examined whether individuals with social anxiety show a response bias in identifying negative affect in others. They had participants give a speech and to indicate detection of positive and negative behaviours from their audience. Similar to the findings of Winton et al. (1995) with FER, it was found that the socially anxious individuals had a more liberal criterion in detecting negative behaviours and a more conservative use of detecting positive audience behaviours (i.e., they showed a bias away from positive response). These findings suggest that socially anxious individuals may be characterised by a response bias – socially anxious individuals may be more likely to attribute negative affect to others and less likely to attribute positive emotion.

Recently, Yoon, Yang, Chong and Oh (2014) aimed to examine whether socially anxious individuals show a response bias or a sensitivity bias in detecting positive and negative facial expressions. Firstly, participants high and low in feelings of social anxiety were required to view a continuum of neutral to happy and neutral to anger morphs and to detect when the emotion 'appeared' and 'disappeared' (assessing sensitivity bias). Secondly, in a separate task, participants were required to respond "yes" or "no" whether the face was happy in neutral to happy trials or angry in neutral to angry trials (assessing response bias). It was found that (1) socially anxious individuals were more sensitive in recognising anger and (2) socially anxious individuals showed a negative response bias (i.e., were more likely to identify emotions as negative). These findings support that individuals with social anxiety may interpret stimuli more negatively and that this may reflect a sensitivity bias and/or a response bias.

Speed of Facial Emotion Recognition (FER) and Exposure time

In addition to interpretation biases, researchers have found evidence that individuals with social anxiety may show differences in their speed of FER (e.g., Melfsen & Florin, 2002; Silvia, Allan, Beauchamp, Maschauer, & Workman, 2006). In a reaction time study, Silvia et al. (2006) examined the links between levels of social anxiety and the recognition of happy, sad and angry facial expressions. Adult participants viewed images of faces and chose whether the face was portraying a happy, sad or angry emotion, as quickly as they could. The results supported previous research that there was an overall recognition advantage for happy faces (e.g., Leppänen & Hietanen, 2004), with significantly faster recognition of happiness in comparison to sad and angry faces. While those higher and lower in social anxiety did not differ on their accuracy of facial emotions or on their reaction times for negative facial expressions of emotion, those higher in social anxiety were significantly slower at recognising happy faces than those lower in social anxiety. These findings suggest that adults who report greater feelings of social anxiety are slower to respond to positive emotions. This may be explained through theories of retrieval of conceptual knowledge influencing FER (Silvia et al., 2006). For example, it is thought that the retrieval of conceptual knowledge of happiness is harder for those who are more socially anxious than those who are not. In fact, individuals with SAD have been found to more readily recall information related to negative evaluations than positive evaluations (Spokas, Rodebaugh, & Heimberg, 2007).

Given the evidence that individuals with social anxiety may take longer to respond on FER tasks (Melfsen & Florin, 2002) and may inspect emotional stimuli for longer (Wieser et al., 2009), it would be expected that their FER would also be affected by restricted viewing times. Heuer, Lange, Isaac, Rinck and Becker (2010) compared low and high socially anxious adults in their identification of facial emotions at different viewing speeds. Participants viewed video clips of neutral faces morphing into happy, angry and disgust expressions. They were required to indicate as soon as they could identify an expression. Under free-viewing conditions, participants were able to move through the progress bar of the 100s clip to make their decision. In a restricted viewing condition, participants viewed the 100s clip without the ability to move back and forth. No group differences were found in the free viewing condition; however, under restricted viewing condition, those who were higher in feelings of social anxiety showed a threat bias, while those who were lower in feelings of social anxiety showed a positivity bias. These findings highlight that under restricted viewing times, socially anxious individuals may be more likely to show bias towards threat.

Summary

As highlighted above, there is ample evidence to suggest that individuals who are higher in level of social anxiety may show differences in their recognition of facial affect; specifically, this may become evident in accuracy (Simonian et al., 2001; Tseng et al., 2017), sensitivity (Arrais et al., 2010; Gutierrez-Garcia & Calvo, 2017; Montagne et al., 2006), speed (Melfsen & Florin, 2002; Silvia et al., 2006; Wieser et al., 2009) and the types of errors made (Bell et al., 2011). To date, little research has examined how social anxiety in adolescence may impact FER skills at this time. This thesis aims to examine the role of social anxiety in adolescent FER.

2.1.1.3 Attention in Social Anxiety

As highlighted in the cognitive and cognitive-behavioural models of social anxiety (Section 2.1.1.1), it is believed that socially anxious individuals may shift their attention internally when in a social situation (Clark & Wells, 1995; Rapee & Heimberg, 1997), and that they may show reduced processing of external cues (Clark & Wells, 1995). This is supported by findings that socially anxious individuals have poorer memory when recalling social interactions (Mellings & Alden, 2000). In fact, researchers have documented patterns of attentional avoidance in individuals who experience social anxiety (Chen & Mansell, 2002; Mansell et al., 1999; Weeks et al., 2013). For example, Chen and Mansell (2002) compared a group of individuals with social phobia with a control group on a dot probe task. Within the dot probe task, participants were presented simultaneously with non-social (household objects) and social objects (emotional faces of positive, negative and neutral valence). A probe replaced the location of one of the objects on the screen. Participants were instructed to press a button corresponding to the location that the probe appeared. It was found that individuals with social phobia were significantly faster at detecting the probe in the location of the non-social object (household object) compared to the social object (emotional faces). This effect was found regardless of the valence of the emotional face presented. In contrast, the control participants showed no bias to either the social or non-social objects during this task. These findings highlight that socially anxious individuals may show avoidance of emotional stimuli, which is consistent with models of social anxiety (see Section 2.1.1.1) that emphasise a shift in attention internally at the cost of ignoring external cues.

Rapee and Heimberg's model (1997) also emphasises that socially anxious individuals may monitor their social environments for cues of threat. When examining the literature, there is evidence to support that socially anxious individuals may show a bias for threat detection. In a masked-priming task Mogg and Bradley (2002) briefly presented pairs of emotional faces (neutral and negative) followed by a visual probe whereby individuals had to respond in the location of the probe. It was found that compared to the controls, socially anxious individuals were significantly faster to respond in the location of negative stimuli (threat) than to the neutral faces. These findings support an automatic capture of attention to threat cues in socially anxious individuals. Importantly, similar findings have been found for both positive and negative stimuli under conditions of social threat (Sposari & Rapee, 2007), suggesting that social anxiety may be characterised by increased vigilance to emotional stimuli more generally.

From above, it can be seen that patterns of avoidance and vigilance to emotional stimuli have been found in socially anxious individuals. Whilst some researchers have documented avoidance of emotional stimuli (Chen & Mansell, 2002), other researchers have found evidence of vigilance to threat (Mogg & Bradley, 2002) and to emotional stimuli more generally (Sposari & Rapee, 2007). These findings highlight one factor that may be of interest when examining FER in individuals differing in their level of social anxiety – attention. In Study 4 and 5, I will examine how individuals differing in their level of social anxiety may attend to emotional stimuli.

Scanning of Emotion Faces in Social Anxiety

The majority of the research examining attention in social anxiety has often used paradigms of competing emotional stimuli (i.e., presenting multiple emotional faces simultaneously) to primarily examine how emotional faces may capture attention in social anxiety (Chen & Mansell, 2002; Mogg & Bradley, 2002). Despite this, little research to date has examined how individuals with high levels of social anxiety may attend to faces when presented one at a time, which is important for decoding of emotional expressions.

One of the most ubiquitous findings in social anxiety is the avoidance of eye contact (Chen & Clarke, 2017; Schneier et al., 2011). Avoidance of eye contact has been put forward as a core safety behaviour in socially anxious individuals (Clark & Wells, 1995). Eye contact can signal the start of a social exchange or can signal threat

(Driver et al., 1999; Emery, 2000), and it may trigger feelings of FNE. Socially anxious individuals report that they experience increased avoidance of and fear of making eye contact; this finding has been linked to symptom severity (Moukheiber, Rautureau, Perez-Diaz, Jouvent & Pelissolo, 2012; Schneirer, et al., 2011). Indeed, socially anxious individuals have been found to make less eye-contact across a range of social situations (Daly, 1978; Farabee, Holcom, Ramsay, & Cole, 1993). Avoidance of the eye contact in social anxiety may be a maintenance factor in social anxiety, as it will impact the maintenance and quality of peer interactions (lead to negative evaluations). In fact, Larsen and Shackelford (1996) found individuals who avoided eye contact to be more negatively evaluated by peers. Further, Clark and Wells (1995) model emphasises that safety behaviours may increase self-focussed attention and increase fear and anxiety. Researchers have found that socially anxious individuals exhibit greater eye gaze avoidance than controls when viewing both positive and negative stimuli (Weeks et al., 2013).

Some researchers have examined how socially anxious individuals may scan faces. For example, Horley, Williams, Gonsalvez and Gordon (2003) compared a group of adults diagnosed with social phobia with a control group in a free viewing of neutral, happy and sad faces for 10 seconds. It was found that socially phobic individuals made fewer fixations and spent less time fixating to features (eyes, nose, mouth), which was particularly the case when viewing sad and neutral expressions. In particular, the socially phobic individuals, when compared to the controls, showed reduced fixations to the eye region during viewing of faces. In a second study, Horley and colleagues (2004) compared adults with social phobia with a control group in their viewing of angry, sad, happy and neutral faces. It was found that the social phobic individuals spent less time looking at features and showed greater eye avoidance compared to the controls; this was particularly evident for angry expressions. These findings highlight that social anxiety may be associated with differences in the scanning of emotional faces, which may subsequently affect FER.

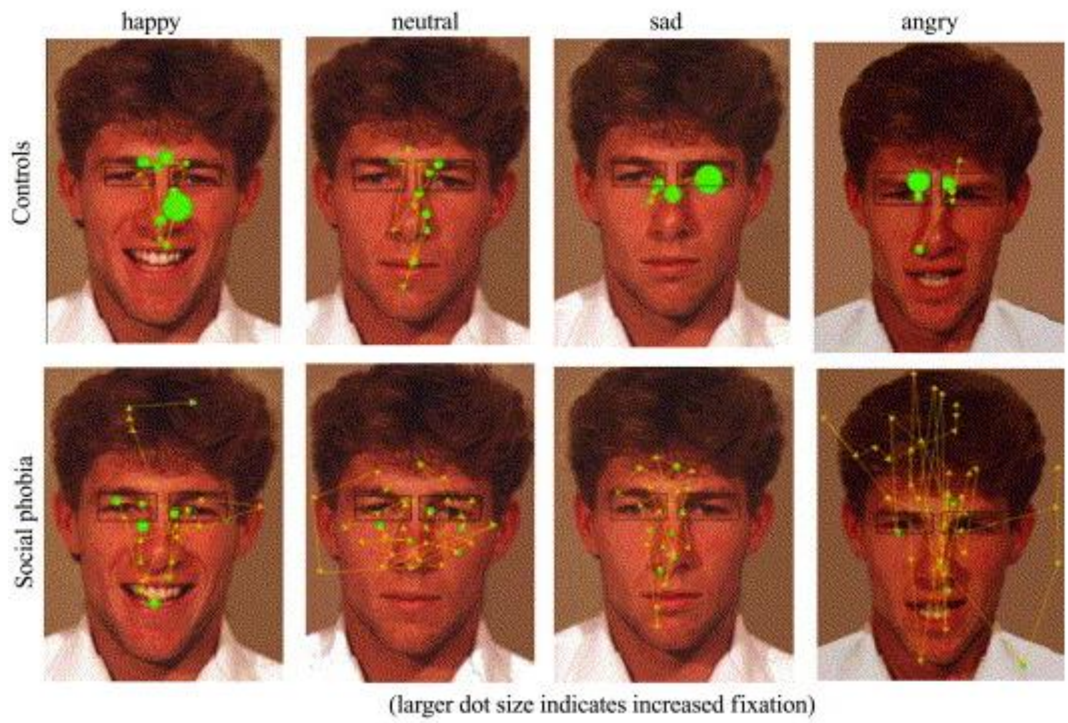

Figure 2.3. A visual scan path of a high social phobia participant and a low social phobia participant viewing happy, neutral, sad and angry faces respectively (image from Horley et al., 2004).

As well as research with adults, researchers have examined how shyness may be related to face scanning in children (e.g., Brunet, Heisz, Mondloch, Shore & Schmidt, 2009). While persistent shyness is not equivalent to social anxiety, it has widely been seen as empirically and conceptually related, and is similarly associated with both avoidance tendencies and social withdrawal (Biederman et al., 1990; Schwartz, Snidman & Kagan, 1999; Young & Brunet, 2011). Brunet et al. (2009) examined face scanning patterns of children with stable shyness in comparison to controls and found that shyness was associated with increased dwell times of the eyes and mouth. These findings are in contrast to findings in socially anxious adults, where researchers have typically found avoidance of the eyes during passive viewing of emotional stimuli (e.g., Horley et al., 2003, 2004). Findings suggest that there may be differences in patterns of attention for children and adolescents. To my knowledge, no research to date has examined how adolescents with higher levels of social anxiety may scan emotional faces, and whether they may be more likely to show similar patterns to children or adults. It may be that those in early adolescence show similar patterns to children and that those in late adolescence show similar patterns to adults. Thus, this will be explored within this thesis.

Time course of attention in social anxiety

Whilst there is evidence of avoidance (Chen & Mansell, 2002) and also of vigilance (Mogg & Bradley, 2002) to emotional faces in those who experience social anxiety, the vigilance-avoidance hypothesis aims to consolidate these findings by accounting for the time course of attention. In particular, the vigilance-avoidance hypothesis (Mogg & Bradley, 2004) suggests that socially anxious individuals may initially attend to threat and then over extended viewing show avoidance (Wieser, Pauli, Weyers, Alpers, & Mühlberger, 2009). In fact, Gamble and Rapee (2010) compared adults with social phobia with a control group in their viewing of happy and angry stimuli paired with neutral stimuli or with non-social objects. Biases in viewing only occurred within the social condition: it was found that the social phobia group showed vigilance for angry faces when paired with neutral stimuli during the first 500ms of exposure compared to the control group. There were no group differences in relation to happy-neutral pairings, nor across the remaining exposure time (i.e., up to 5000ms). This suggests that socially phobic individuals may be characterised by early vigilance to social cues, particularly those that may signal signs of social disapproval (Gamble & Rapee, 2010). In a similar design, Wieser et al. (2009) had participants view pairs of emotional faces (angry and happy) with neutral faces, whilst their eyes were tracked. It was found that those high in FNE were more likely to initially fixate to the emotional face and then show avoidance during longer exposure (1000-1500ms). These findings suggest that socially anxious individuals may show differences in their allocation of attention over time, with initial vigilance and later avoidance. Despite this, the majority of this research has focussed on attention to competing emotional stimuli and as such it is not known whether these same patterns of vigilance and avoidance may be present when scanning faces in singular.

Summary

Above it was noted, that individuals with social anxiety may show differences in their scanning of emotional faces. However, the research does not appear to examine scanning behaviours when participants make FER decisions (e.g., Horley et al., 2003, 2004), which would be important when evaluating how attention patterns may differ when assessing emotion in others. Importantly, much research places importance on eyes as a critical source of emotional information in FER (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). It could therefore be asserted that this may be one of the factors that influence an individual’s ability to accurately recognise facial affect. In fact, scanning behaviours in FER have been linked to recognition accuracy (see Section 1.4 ; e.g., Hall et al., 2010); for example, a positive relationship was found between dwell times and the total number of fixations to the eyes and the accuracy in decoding facial expressions of emotion (Hall et al., 2008). Given that the eyes appear a critical source of social information (Emery, 2010) and that individuals with SAD appear to show avoidance of the eye-regions, this thesis will examine how individuals differing in their levels of social anxiety attend to facial features and the eyes during FER.

2.1.2 Depression

Depression or Major Depressive Disorder (MDD) is a common mood disorder, characterised by low mood and by diminished interest and pleasure in most or all activities (APA, 2013). The diagnosis of depression is characterised by the presence of five or more symptoms (see Table 2.2) present during the same two-week period. For children and adolescents, irritable mood has also been included as a core diagnostic symptom (APA, 2013). The diagnostic criteria for depression includes that the symptoms must cause significant impairment in one or more areas of functioning, including social, occupational or other important areas and that these symptoms should not be attributed to the effects of another medical condition or substance abuse (APA, 2013). Depression is one of the most prevalent psychiatric disorders, with a lifetime prevalence estimated at 16% (DeRubeis, Siegle, & Hollon, 2008). Rates of depression in prepubescent children are typically low (1-2%; Egger & Angold, 2006), but have been found to markedly increase throughout the adolescent period (Avenevoli et al., 2015; Paus, Keshavan & Giedd, 2008).

Table 2.2 Diagnostic criteria for Depression (APA, 2013 p.156).

Depressed mood most of the day, nearly every day, as indicated by either subjective report (e.g., feels sad, empty, hopeless) or observation made by others (e.g., appears tearful). Note in children/adolescents, can be irritable mood.
Markedly diminished interest or pleasure in all, or almost all, activities most of the day, nearly every day (as indicated by either subjective account or observation)
Significant weight loss when not dieting or weight gain (e.g., a change of more than 5% of body weight in a month), or decrease or increase in appetite nearly every day
Insomnia or hypersomnia nearly every day
Psychomotor agitation or retardation nearly every day (observable by others, not merely subjective feelings of restlessness or being slowed done)
Fatigue or loss of energy nearly every day
Feelings of worthlessness or excessive or inappropriate guilt (which may be delusional) nearly every day (not merely self-reproach or guilt about being sick)
Diminished ability to think or concentrate, or indecisiveness, nearly every day (either by subjective account or observed by others)
Recurrent thoughts of death (not just fear of dying), recurrent suicidal ideation without a specific plan, or a suicide attempt or a specific plan for committing suicide.

2.1.2.1 Cognitive models of Depression

Cognitive models of depression have highlighted that individuals with depression show a range of biases in information processing (Beck, 1967; see Foland-Ross & Gotlib, 2012, for review), which are believed to play a role in the development and maintenance of the disorder (Beck, 1967, 1987, 2008). Cognitive models of depression emphasize that individuals with depression hold negative internal representations or schemas about themselves, the world and their future (Beck, 1967). These schemes then influence how information is processed in their environment.

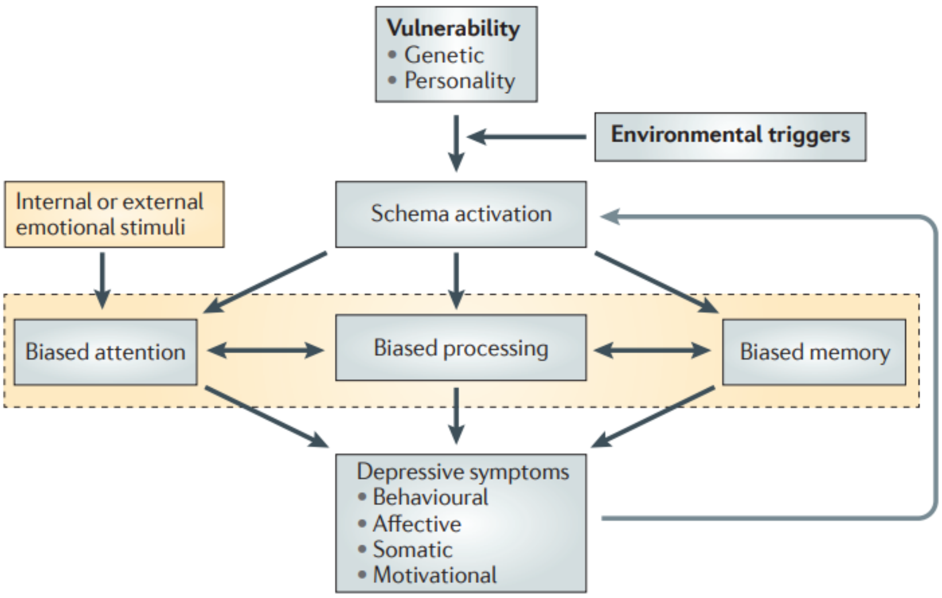

Figure 2.4. Information processing in the cognitive model of depression (from Disner et al., 2011, p.469).

Negative processing biases have been found for memory as well as attention (Matt, Vazquez, & Campbell, 1992). For example, individuals with depression have been shown to preferentially recall negative over positive information (Lyubomirsky, Caldwell, & Nolen-Hoeksema, 1998) and to interpret ambiguous social situations more negatively (Butler and Mathews, 1983). Individuals with depression have also been characterised by biases in attention to emotional stimuli (Disner et al., 2011). It is therefore expected that the way that information is processed in depression may play a role in FER.

2.1.2.2 Depression and Facial Emotion Recognition (FER)

Individuals with mood disorders (including depression) are often characterised by emotional dysfunction (Gur et al., 1992), which may in turn influence their ability to recognise emotional expressions. In fact, research has demonstrated that individuals with depression show overall poorer recognition of all types of facial expressions (Mikhailova et al., 1996) and show negative bias in interpretation of facial affect (Gur et al., 1992). These will be explored below.

Recognition Accuracy

Patterns of FER are well-documented in depression (Bourke et al., 2010) and are believed to play a critical role in both the development and maintenance of the disorder (Beck, 1987; Gotlib & Joormann, 2010). Researchers have documented a global deficit in the ability to detect facial affect across all emotional expressions in depression (e.g., Asthana, Mandal, Khurana, & Haque-Nizamie, 1998; Csukly et al., 2009; Dalili et al., 2015; Persad & Polivy, 1993). For example, Persad and Polivy (1993) found that compared to non-depressed controls, both highly depressed and clinically depressed adults made significantly more errors on an FER task across all emotion categories.

As well as general impairments in FER, some researchers have suggested that depressed individuals may show impairments in the recognition of specific emotions (see Bourke et al., 2010, for review). In particular depression may be characterised by mood-congruent impairments in FER (Bourke et al., 2010), in which those emotions impacted may be those most relevant to depression (i.e., sadness and happiness). Specifically, impairments in the recognition of sadness have been consistently documented in depressed individuals (Bediou et al., 2009; Bourke et al., 2010; Rubinow & Post, 1992) and have been found to improve after remission (Mikhailova, Vladimirova, Iznak & Tsusulkovskaya, 1996). Researchers have also documented a reduced ability to recognise happiness in depressed individuals (Bourke et al., 2010; Harmer et al., 2009; Joormann & Gotlib, 2006; Rubinow & Post, 1992), which is believed to reflect a lack of positivity bias characteristic of those with depression (McCabe & Gotlib, 1995). For instance, depressed individuals were both less accurate than healthy controls in their recognition of happiness and reported lower confidence in identifying happy expressions (Zwick & Wolkenstein, 2017). Further, when viewing happy faces depressed individuals have less brain activation in P300 (Cavanagh & Geisler, 2006); this has been put forward as evidence that depressed individuals have reduced ability to process positive stimuli.

In children and adolescents, there has been a lack of research examining how the level of depression may affect FER. Although, as with adult research, there is evidence in childhood and adolescence, depression is related to poorer FER. In fact, researchers have demonstrated that children and adolescents with depression show impaired recognition of facial affect, primarily due to poorer recognition of fear (Lenti et al., 2000), and of anger in females (Mendlewicz, Linkowski, Bazelmans, & Philippot, 2005). However, these findings are not consistent as research has also found no FER differences depending on depression level in children (Smoller & Brosgole, 1993).

Negative Biases

Similar to those with social anxiety, it has been found that depressed individuals may show negative biases in the recognition of emotions (Punkanen, Eerola, & Erkkila, 2011). Depressed individuals have been found to judge ambiguous facial expressions more negatively (Gollan et al., 2008; Gur et al., 1992); for example, they tend to identify neutral expressions as sad (Gollan et al., 2008**)** and happy expressions as neutral (Gur et al., 1992; Surguladze et al., 2004). The degree of negative emotion perceived in schematic faces has further been associated with both later (3 and 6 months later) depression severity (Hale, 1998) and with depression relapse (Bouhuys et al., 1999).

In addition to research with negative biases, researchers have found evidence that depressed individuals may be poorer at recognising emotion when presented at low emotional intensities (e.g., Csukly et al., 2009; Gollan, McCloskey, Hoxha, & Coccaro, 2010). Gollan et al. (2010) compared adults with major depression with controls on their recognition of faces displaying expressions between 10% and 80% emotional intensity. Compared to the controls, depressed individuals were significantly impaired in their recognition of all emotional expressions (with the exception of sad, where they were better), and this finding was more pronounced when detecting the more subtle displays of emotion.

As well as overall impairments in the recognition of subtle emotions in depression, some researchers have found that depressed individuals may require significantly greater intensity to recognise happiness (Gollan et al., 2008, 2010; Bannerman, Milders & Sahraie, 2010) and less emotional intensity to recognise sadness (Gollan et al., 2008, 2010; Bannerman et al., 2010). These findings have been supported with children and adolescents who were at risk of depression (i.e., have depressed mothers), where they were found to require significantly greater intensity to recognise sad expressions (Joormann, Gilbert, & Gotlib, 2010). Interestingly, children and adolescents who perceived the intensity of an angry facial expression as greater than it actually was had higher depression scores; further, for the girls but not boys, those who perceived the intensity of a happy facial expression as greater than it actually was had lower depression scores (Beek & Dubas, 2008).

Speed of Facial Emotion Recognition (FER) and Exposure time

There has been very little research to date examining the influence of exposure time on FER in depression. One study that did explore this demonstrated that depressed adults have difficulties in recognising emotions under short exposure times (100ms), but are no different from healthy controls under extended viewing times (2000ms; Surguladze, 2004). This would be important to investigate further within adolescents.

These findings indicate that, similar to those with social anxiety, it is important to understand how FER differs overall but also by emotion. Further, as with social anxiety, it is clear that FER may be affected for those with depression by negative biases in FER, the intensity of the emotion presented, and possibly exposure (or viewing) time. These factors will be considered within the current thesis.

2.1.2.3 Attention in Depression

As previously highlighted, individuals with depression are often characterised by biases in information processing (Beck, 1967). Importantly, depressed individuals have been found to show biases to emotional stimuli (Eizenman et al., 2003;

Sanchez, Vavquez, LeMoult, & Joormann, 2013). Many researchers have demonstrated that depressed individuals typically spend longer looking at dysphoric stimuli than non-depressed controls (e.g., Eizenman et al., 2003; Koster et al., 2011; Sears et al., 2011) and may have difficulty in engaging from depressive-like stimuli (Sanchez et al., 2013). Individuals with depression have also be found to spend less time looking at positive stimuli in comparison to non-depressed individuals (Isaac et al., 2014); although, this is not the case for children with depression. Instead, children with depression have been show to spend less time viewing sad stimuli, but to show preferential attention towards happy stimuli compared to non-depressed peers (see Armstrong & Olatunji, 2012, for a review).

Scanning of Emotion Faces in Depression

In relation to scanning of faces, some researchers have found evidence that depressed individuals show reduced fixation to features (eyes, nose, mouth) when passively viewing happy, sad and neutral expressions compared to healthy controls (Loughland et al., 2002). Whilst passive viewing can inform about information we may attend to generally, it is important to understand what information individuals attend to within the face when deciding what emotion is shown (i.e., decoding of the emotional expressions). Wu et al. (2012) asked students who were low or high in depressive symptoms to verbally label emotional expressions shown on a computer screen whilst their eye movements were recorded during a self-paced task. Whilst no significant differences in accuracy were found between the two groups, those high in depressive symptoms spent significantly less time examining features compared to those low in depressive symptoms. Further, those high in depressive symptoms, compared to low, were quicker in their recognition. These findings suggest that those high in depressive symptoms are not characterised by difficulties in FER, but that they do show differences in their scanning of emotional faces and in their decision making time. It must be noted that in this study the stimuli used were of high emotional intensity, which may have masked any potential differences between the two groups.

Time course of attention in Depression

Some researchers have argued that biases in attentional processing for those higher in depression may operate at later, more voluntary stages of processing (Kellough et al., 2008; Mogg & Bradley, 2005). In fact, whilst some researchers have found evidence of attentional biases for dysmorphic stimuli in depression (Eizenman et al., 2003; Koster et al., 2011; Sears et al., 2011; Siegle et al., 2000), some have found that these may not be apparent under short exposure times (Bradley, Mogg, & Lee, 1997). For example, Bradley et al. (1997) showed that depressed mood was correlated with vigilance to negative stimuli at 1000ms but not at 500ms, providing evidence that attentional biases in depression may operate at different time courses. There is little research to date examining the impact of exposure time on attention in depression. One aim of this thesis is to examine the role of exposure time in adolescents and evaluate if differences exist depending on their level of depressive symptoms during FER.

Summary

As highlighted above, depression has often been associated with differences in the allocation of attention to competing emotional stimuli (Eizenman et al., 2003; Sanchez et al., 2013). Specifically, depressed individuals may show preference in viewing dysphoric stimuli (e.g., Eizenman et al., 2003; Koster et al., 2011; Sears et al., 2011; Siegle et al., 2000). Little research to date has examined how individuals with depression may scan faces presented in singular and during emotion decoding. One study demonstrated that in adults, individuals higher in their level of depressive symptoms showed avoidance of facial features compared to those low in depressive symptoms (Wu et al., 2012). To my knowledge, there is no research to date that has examined how adolescents who vary in their level of depression attend to emotional faces during a FER task. This will be explored within Study 4 and 5.

2.2 Lateralisation for Emotion Processing

Thus far in this chapter, I have explored social-emotional factors that have been found to be related to FER performance (specifically social anxiety and depression); however, it is also important to explore biological factors that may play a role. Researchers have argued that like other cognitive functions, such as language (Groen et al., 2013) and spatial ability (Vogel et al., 2003), that the two hemispheres of the brain may play independent roles in the processing of emotions (Davidson 1992; Killgore & Yurgelun-Todd, 2007). Tasks assessing hemispheric lateralisation for emotion processing in the brain typically take advantage of the cross organisation of the visual pathways in the brain, whereby information viewed in an individual's left visual field is primarily processed in the RH and information presented in the right visual field is primarily processed in the LH (see Figure 2.5).

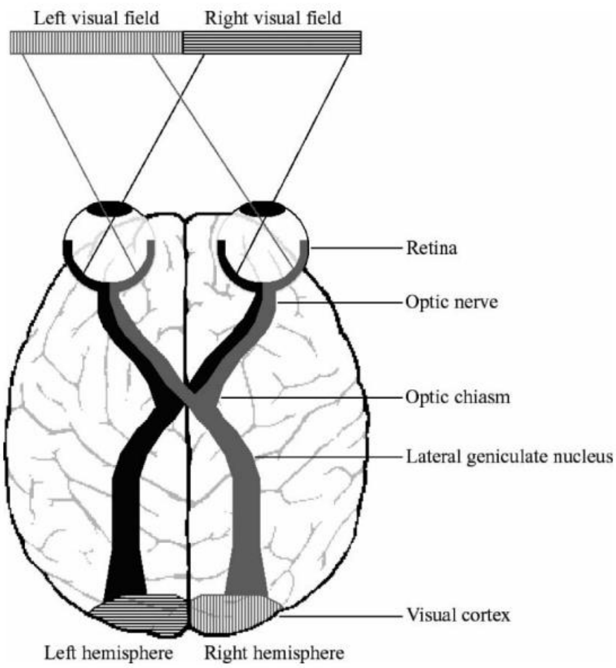

Figure 2.5. A visual representation of the neuroanatomical organisation of the visual pathways. Taken from Bourne (2006, p.374). Information presented in the left-visual field is primary processed in the RH, whereas information presented in the right-visual field is primarily processed in the LH.

Three prominent theories have been put forward to explain how emotion perception might be organised in the brain: the valence hypothesis, the approach-withdrawal hypothesis and the RH hypothesis. In this section, firstly, I will evaluate theories of lateralisation for emotion processing; secondly, I will provide some background on the development of lateralisation for emotion processing; thirdly, I will introduce the Chimeric Face Test (CFT) – a behavioural measure of emotion processing – to evaluate the research exploring individual differences in lateralisation for emotion processing, including links with social anxiety and depression. Importantly, at the end of this section I will provide an overview of what is currently known about lateralisation for emotion processing as a factor that may relate to FER.

2.2.1 Models of Lateralisation for Emotion Processing

2.2.1.1 The Valence Hypothesis

The valence hypothesis (Davidson, 1992) posits that emotional stimuli with a positive valence (happiness and surprise) are processed in the left hemisphere (LH), whereas emotional stimuli with a negative valence (sadness, anger, disgust, and fear) are predominantly processed in the right-hemisphere (RH). There is some evidence to support this hypothesis. For example, Adolphs et al. (2001) presented participants with two faces side by side in the participants' left and right visual fields. It was found that the discrimination of happy faces from neutral faces was better when the happy face was located in the viewers' right visual field, providing support for LH processing of positive emotions. Furthermore, for sad faces, discrimination was better when the sad face was presented in the left visual field, indicating RH processing of emotions of a negative valence. Evidence from patients with unilateral brain damage has also been put forward in support of the valence hypothesis. Borod et al. (1992) demonstrated that patients with LH damage showed impairments in their recognition of positive emotional stimuli, whereas those with damage to the RH showed difficulties in their recognition of negative emotional stimuli (Borod et al., 1992; Mandal et al., 1991).

2.2.1.2 The Approach-Withdrawal Model

The approach-withdrawal model is an evolutionary model that suggests that emotions associated with approach behaviours are predominantly processed in the LH (happiness, surprise, anger) and that emotions associated with withdrawal behaviours are predominantly processed in the RH (disgust, fear, sadness; Davidson, 1992). There is some evidence in support of the approach-withdrawal model. For example, Davidson et al. (1990) asked participants to watch videos designed to either elicit approach behaviours (happiness) or withdrawal behaviours (disgust). EEG data showed that in comparison to happiness, the disgust video was associated with a shift towards right frontal activity, thus supporting the notion of differences in the lateralisation for processing of approach and withdrawal behaviours. The approach-withdrawal model is similar to the valence account of emotion processing, with primarily withdrawal behaviours being negative (right-hemisphere) and approach behaviours being positive (left-hemisphere). One fundamental difference is in the classification of anger. In the valence hypothesis anger is categorised as a negative emotion, while in the approach-withdrawal model anger is categorised as an approach emotion, as it is believed to guide the individual to act (Alves, Fujusima, & Aznar-Casanova, 2009).

2.2.1.3 The Right-Hemisphere Hypothesis

The right-hemisphere (RH) hypothesis states that emotional stimuli are perceived more efficiently by the RH than by the LH, irrespective of the valence of the emotional stimuli (Borod, 1992; Smith & Bulman-Fleming, 2005; Watling, Workman, & Bourne, 2012). There has been ample research in support of a RH dominancy in the processing of emotions in both child (e.g., Bava, Ballantyne, & Trauner, 2005; Workman, Chilvers, Yeomans, & Taylor, 2006) and adult samples (e.g., Bourne, 2005; 2010; Nakamura et al., 1999; Spence et al., 1996). However, to my knowledge there is currently no research with adolescent populations.

Lesion studies have provided convincing evidence in support of the RH hypothesis of emotion processing (Adolphs, Damasio, Tranel & Damasio, 2018; Borod, 1992). Borod (1992) carried out a lesion analysis on participants with focal brain damage. Participants were required to choose which label best represents the facial expressions, which included the six basic emotions (i.e., happiness, sadness, disgust, fear, surprised and anger). It was found that FER performance was negatively correlated with damage to the RH regions (specifically, the mesial anterior infracalcarine cortex and right inferior parietal cortex). Importantly, patients with lesions in the LH did not show impairments in their FER. These findings support that cortical systems of the RH are important in the processing of facial emotions (Adolphs et al., 2006). Further, Batty and Taylor (2006) assessed children's event related potentials when viewing facial expressions of emotion and found evidence of greater RH compared to LH activation, providing support of RH processing of emotions in children.

2.2.1.4 Integrating models of Emotion Processing

More recently, some researchers have proposed a more integrated approach of understanding how emotions are processed in the brain. Some evidence suggests that theories of emotion processing – specifically, the RH and the valence hypotheses – may not be mutually exclusive. Killgore and Yurgelum-Todd (2007) found that when emotional faces were presented in the left visual field, irrespective of valence, that there was more activation in the RH than LH. However, when examining specific emotions, the strength of activation was stronger for negative than positive emotions (particularly sad relative to happy). Similarly, Bourne (2010) examined adults' patterns of facial emotion processing using a chimeric face test for each of the six basic emotions. Across all emotions, RH dominancy was found, supporting the RH hypothesis; however, when examining the effects of emotional valence, it was found that negative emotions showed reduced lateralisation to the RH than positive emotions. These findings are contradictory to the valence hypothesis that suggests that negative emotions show RH processing. Together these studies highlight the role of the RH in the processing of emotions but suggests that the degree of and strength of lateralisation may in part depend on the valence of the stimuli – negative emotions may be lateralised to a greater extent to the RH.

2.2.2 The Development of Emotion Lateralisation

Like FER, there are developmental trends found in children's becoming more RH specialised (more strongly lateralised) for facial emotion processing throughout childhood (see Watling, Workman & Bourne, 2012, for review). Watling et al. (2012) and Watling and Damaskinou (2018) both note that children show similar trends in the development of FER and in the developing strength of lateralisation for emotion processing. Like with FER, developmental trends in the processing of emotions have been found to differ depending on the emotion in question (Chiang et al, 2000; Workman et al., 2006). Workman and colleagues (2006) explored developmental trends in lateralisation for emotion processing in 5- to 11-year-olds. It was found that children became increasingly RH dominant throughout childhood. Lateralisation of happiness and sadness (5-6 years) were the first emotion to show RH processing, followed by surprise, disgust and anger (7- 8 years) and later by fear (10-11 years). These are similar trends to when FER reaches adult levels in childhood (Watling et al., 2012).

Importantly, as it has been shown that there is continued development of FER throughout adolescence, it would be important to understand how this relates to any developments in patterns of hemispheric lateralisation for emotion processing. To my knowledge, lateralisation for emotion processing has not been examined in adolescence. It may be expected that adolescents may become more strongly RH dominant at this time.

2.2.2.1 Behavioural Measures of Emotion Processing

The Chimeric Face Test (CFT) is a well-established free-viewing behavioural task that has been widely used as a measure of hemispheric lateralisation for emotion processing (Bourne, 2008; Levine & Levy, 1986; Levy, Trevarthen, & Sperry, 1972; Workman et al., 2006). A chimeric face is created by splicing an emotive and neutral face down the centre and then reconfiguring to merge one emotive half face with one neutral half face, thereby splicing it together to create a chimeric image. The mirror image is taken, so there are two chimeras. Typically, one chimera image is placed on the top and the second chimera on the bottom (mirror images of each other). Within the task, faces with the emotive half on the left appear on top in half the trials (with faces with the emotive half on the right appearing below), and in half the opposite was true (see Figure 2.6 for example).

In the CFT tasks, participants are typically asked which of the two chimeras looks more emotive (happier, sadder, etc.). If the individual selects the face with the emotion on the left-side of the image (left visual field) as more emotive then this is believed to reflect RH processing, whereas if the individual selects the face with the emotion on the right side of the image (right visual field) as more emotive then this is believed to reflect LH processing (Beaumont, 1983; see Figure 2.5).

Figure 2.6. Example of Chimeric Faces, Top left, emotion in left visual field, bottom on right side. From Watling, Workman and Bourne (2012, p.393).

There is a considerable amount of evidence to support the CFT as a valid measure of lateralisation for emotion processing (Bava, Ballantyn, May, & Trauner, 2005; Bourne, 2006, 2010; Coronel & Federmeirer, 2014; Damaskinou & Watling, 2018; Killgore & Yurgelun-Todd, 2007; Kucharska- Pietura & David, 2003). For example, evidence with unilateral brain damage patients has shown that patients with LH brain damage show a left visual field bias on CFTs (indicating RH dominancy), whereas those with unilateral RH brain damage show reduced left visual field bias (indicating reduced RH processing; Kurcharska- Pietura & David, 2003). Similar patterns have also been demonstrated in children with unilateral brain damage (Bava, Ballantyn, May, & Trauner, 2005). Further, the chimeric face test has also been validated with EEG. Damaskinou and Watling (2018) demonstrated that adults showed patterns of greater amplitude within the RH than LH when chimeras displayed the emotion in the left visual field; in contrast, chimeras with the emotion displayed in the right visual field showed patterns of greater activation within the LH compared to the RH. Therefore, findings support that whilst this task is a centrally presented task, and not using the traditional divided visual field format, it is a task that indicates a pattern of lateralisation (supported by the neurological and neurophysiological evidence, as well as the behavioural findings).

Whilst there is evidence that the CFT task is a task of laterality, some researchers have critiqued it. One critique is that the finding that left visual field (indicative of RH processing) is considered to be more emotive may be the result of default scanning biases (Heath et al., 2005; Vaid & Singh, 1989). In fact, Vaid and Singh (1989) tested whether scores obtained from the CFT were the result of left-ward scanning biases by comparing three groups who differed on how they read text (left-ward, right-ward and bidirectional). It was found that the group who tended to read left to right showed a greater left visual field bias. However, it may not be as clear as this. Other researchers have shown that differences in default scanning biases cannot entirely account for left visual field biases found in CFT. For example, Coronel and Federmeirer (2014) tracked eye movements whilst participants looked at chimeric faces. It was found that task instruction altered visual scanning – the authors concluded that participants' responses to the CFT were not due to default scanning.

2.2.2.2 Individual Differences in the degree of Emotion Lateralisation

Whilst there is increasing evidence to suggest a RH dominancy in emotion processing (see Section 2.2.1.3), like FER, individual differences have been found in the degree of the lateralisation for emotion processing across the lifespan (see Bourne & Watling, 2015, for review). Researchers have found evidence that sex (Bourne, 2005, 2008; Bourne & Todd, 2004) and handedness (Bourne, 2008; Hellige et al., 1994; Ida, 1998) may impact degree of lateralisation for emotion processing.

Typically, males have been found to display stronger patterns of RH dominance for facial emotion processing than females (Bourne, 2005, 2008; Bourne & Todd, 2004), with females often reported as showing weaker dominancy or being more BL in their processing of emotions (Bourne, 2005, 2008; Bourne & Maxwell, 2010). As well as biological sex, males higher in masculinity traits have been shown to have stronger patterns of lateralisation (Bourne & Maxwell, 2010). In support of these CFT findings, in adolescence males have been shown to display stronger RH amygdala activation than females (Schneider et al., 2011).

Furthermore, researchers have found evidence of RH emotion processing differences using the CFT for left and right handers (Harris, Almerigi, Carbary, & Fogel, 2001). The degree of RH dominance has been found to be significantly weaker in left-handed participants (Heillige et al., 1994). In fact, strength of handedness has been found to be related to lateralisation for emotion processing. Bourne (2008) found that adults who were more strongly right-handed were also more strongly lateralised to the RH in the processing of emotions; this was particularly the case for males.

Of particular relevance for this research, there is evidence that hormones may influence the degree of lateralisation for emotion processing throughout the lifetime (Bourne, 2014; Bourne & Gray, 2009; Watling et al., 2012). Researchers have found that there are fluctuations in patterns of hemispheric processing of emotions across the menstrual cycle (Hausmann & Gunturkun, 2000). Despite this finding, there is a research gap where research has not explored lateralisation for emotion processing in adolescence, a time when hormones are known to fluctuate and may affect patterns of lateralisation for emotion processing.

2.2.2.3 Emotion Processing and Social Anxiety

Researchers have found that the degree of lateralisation for emotional processing may differ for adults with feelings of social anxiety (e.g., Bourne & Watling, 2015; Kolassa & Miltner, 2006; Mogg & Bradley, 2002). Much of the research in this area supports the notion that individuals who are socially anxious (or those with greater feelings of social anxiety) tend to demonstrate stronger patterns of lateralisation towards the RH (Bourne & Watling, 2015; Cooney, Atlas, Joormann, Eugence, & Gotlib, 2006; Kolassa and Miltner, 2006; Mogg & Bradley, 2002). Research by Kolassa and Miltner (2006), with event related potentials, found that social phobic individuals were characterised by increased activation in early visual areas (N170) in the RH when viewing angry faces. Importantly, a recent review concluded that social anxiety is associated with hyperactivity of the RH (specifically PFC) across a wide range of emotion tasks (see Engel et al., 2009, for review). Similarly, Cooney et al. (2006) found evidence that socially anxious individuals showed increased activation of the right amygdala during the viewing of neutral facial stimuli, while control-group individuals showed left amygdala activation in the same task. These findings support that socially anxious individuals interpret ambiguous social stimuli more negatively, as has been highlighted earlier (see Section 2.1.1.1), and that this may be related to patterns of hemispheric lateralisation.

Some researchers have examined how lateralisation for emotion processing may be related to specific facets of social anxiety (Bourne & Vladeanu, 2011; Bourne & Watling, 2015). Bourne and Watling (2015) demonstrated that the female participants but not males who scored higher on FNE (one facet of social anxiety) tended to be more strongly lateralised to the RH, particularly in the processing of anger, sadness, happiness and fear. In contrast, Bourne and Vladeanu (2011) found that for males, but not females, that social anxiety was associated with a reduced RH processing of emotions, or even showed LH lateralisation. Whilst these findings are opposite to those of Bourne and Watling (2015), it must be noted that the relationship between social anxiety and lateralisation for emotion processing differed in Bourne and Vladeanu's study across different aspects of social anxiety. Bourne and Vladeanu used the Brief Social Phobia scale (Davidson, 1997), which splits social anxiety into FNE, social avoidance and distress and physiological symptoms. Physiological symptoms within this scale measure how often individuals experience physical symptoms in social situations, such as sweating and palpitations. In particular, the relationship only existed for physiological aspects of social anxiety, but not for FNE or social avoidance aspects of social anxiety.

From above, it can be seen that the relationship between social anxiety and lateralisation for emotion processing may be complex, and that the findings may differ depending on what aspects of social anxiety are being investigated (e.g., Bourne & Watling, 2015, found with FNE a positive relationship, while Bourne & Vladeanu, 2011, found with physiological aspects a negative relationship). Given that social anxiety is a multifaceted disorder (Moscovitch, 2009), I argue that different components of social anxiety may lead to differing results when exploring the role of the RH in the processing of emotions; this is why it is important to explore independent relationships with all three facets of social anxiety (i.e., FNE, social avoidance and distress to general situations and social avoidance and distress to new situations).

2.2.2.4 Emotion Processing and Depression

As in findings with social anxiety, there is also research to suggest that depression may be characterised by different patterns in hemispheric lateralisation (see Bruder, Stewart, & McGrath, 2017, for review). Researchers have found evidence that depressed individuals show a pattern of hyperactivity of the RH (Grimm et al., 2009; Schaffer et al., 1983; Trinkl et al., 2015). For example, Grimm et al. (2009), with fMRI, found that depressed individuals, compared to healthy controls individuals, were characterised by a reduced activation in the left dorsolateral prefrontal cortex (DLPFC) and increased activation of the right DLPFC. Further, depression severity was found to be associated with hyperactivity in the RH. These findings highlight the role of depression and RH processing in the brain.

As well as evidence of increased RH processing in depression, there is evidence to support that depression may be associated with reduced RH, or even showing LH processing of emotions (Bourne & Vladeanu, 2013; Kucharska-Pietura & David, 2003; Lai, 2014). In a meta-analysis that included clinically depressed individuals, depression was associated with increased activation of left limbic regions during the viewing of emotional faces (Lai, 2014). Additionally, Kucharska-Pietura and David (2003) demonstrated that depressed individuals showed reduced left visual field bias (reduced RH processing) when viewing chimeric faces; interestingly, this group's performance was similar to a group of patients with unilateral RH brain damage. This suggests that the RH functioning for emotion processing may be diminished in depressed individuals. In line with this, Bourne and Vladeanu (2013) found that females who scored higher in depressive symptoms were less strongly lateralised to the RH (specifically for anger, disgust and fear); albeit, as previously highlighted (see Section 2.2.2.2), females tend to be less strongly lateralised to the RH than males so being more BL does not necessarily indicate that we would expect impaired performance.

Whilst the majority of the literature has examined processing of emotions in adults with depression or who had higher depressive symptom scores (Bourne & Vladeanu, 2013; Grimm et al., 2008; Kucharska-Pietura & David, 2003), one study examined lateralisation of emotion processing in adolescence. Trinkl et al. (2011) demonstrated that compared to a control group of adolescents, depressed adolescents exhibited increased RH activation (measured through electroencephalography [EEG]) on an emotional go/no go task. These findings highlight that depression may be related to lateralisation for emotion processing and it therefore is important to control for depression when examining the independent effects of lateralisation for emotion processing on FER.

2.2.3 Emotion Processing and Facial Emotion Recognition (FER)

As highlighted above there is ample research that has examined the topics of FER and lateralisation for emotion processing independently. Despite this, there is considerably little research examining how these two factors might be related to one another, and to my knowledge no research has examined this in adolescence. As highlighted earlier (Section 2.2.2), developmental trends in lateralisation for emotion processing appear in parallel to trends in the development of FER abilities (Watling, Workman, & Bourne, 2012), with increasing RH dominancy for emotions occurring at a similar time of increasing FER accuracy.

One study that has attempted to examine the relationship between lateralisation for emotion processing and the recognition of emotions provided evidence of a positive correlation between a child's left visual field bias on the CFT (demonstrating RH dominance) for processing of happy faces and the ability to identify the emotions of happiness, sad and angry expressions (Barth & Boles, 1999). Similarly, Workman and colleagues (2006) explored the relation between children's lateralisation for emotion processing (with CFT) with their performance in an emotion in the eyes test and in a situational cartoon task (individuals were required to attribute emotional states on others). They found that increasing hemispheric lateralisation to the RH was positively correlated with both a child’s ability to recognise emotion in the eyes and the ability to attribute emotional states on others in the situational cartoon task (Workman et al., 2006). More recently, Watling and Bourne (2013) demonstrated that children who more strongly lateralised for their processing of emotions on a CFT had better accuracy on an emotion discrimination task; however, this pattern was found for boys but not girls, further demonstrating potential sex differences in these relationships. Together, these findings are some of the first to show a relationship between patterns of hemispheric lateralisation for emotion processing with children’s FER skills, but no research to date has explored these relations within adolescent populations.

One concern with previous research is the reliance on cross-sectional designs. Longitudinal design would allow a more in-depth exploration of how developing lateralisation for emotion processing relates to emotion skills. One study has recently examined longitudinal associations between children’s lateralisation for emotion processing and FER skills. Watling and Damaskinou (2018) found that children’s degree of lateralisation for emotion processing predicted emotion discrimination ability one year later and that changes towards becoming more RH dominant for emotion processing predicted emotion matching skills one year later. Taken together these findings highlight the relationship between developing FER skills and developing lateralisation for emotion processing.

As highlighted earlier, to our knowledge no research has explicitly examined how adolescents’ strength of laterality for emotion processing may relate to facial emotion skills at this time – this is one of the aims of the current thesis. It is expected, given that there is evidence of further developments of FER skills developing throughout the adolescent period that there may be an increasing shift towards the RH for facial emotion processing throughout the adolescent years. As well as this, hormonal fluctuations that are known to occur throughout adolescence may impact how emotions are processed in the brain at this time. Importantly, it is known that social-emotional factors, which are highly prevalent during adolescence, may impact both the lateralisation for emotion processing and FER at this time; therefore, this will be considered throughout this thesis.

2.2.3.1 Summary

Above, it was demonstrated that there are individual differences in the degree of laterality for emotion processing throughout the lifespan. Importantly, I provided a summary of the developmental trajectory of lateralisation for emotion processing, showing similarities with developments in FER skills. Importantly to my knowledge, no research to date has examined how degree of laterality for emotion processing may link to FER in adolescents, which will be explored within this thesis. In Section 2.2.2.3 and 2.2.2.4, it was shown that degree of laterality for emotion processing may differ as a function of both social anxiety and depression. This highlights the importance of accounting for these factors when examining the independent relationship between degree of lateralisation for emotion processing and FER skills, which will be considered within the current work.

2.3 Current thesis and aims

2.3.1 Summary

The research presented within this chapter builds on that in chapter one, highlighting developments in FER and how these may be impacted by social-emotional factors and patterns of hemispheric processing in the brain. As can be seen from above, individuals with social anxiety have been found to show differences in their ability to recognise facial affect, including being less accurate (Simonian et al., 2001; Tseng et al., 2017) as well as show increased (Arrais et al., 2010; Gutierrez-Garcia & Calvo, 2017) or decreased (Montagne et al., 2006) sensitivity. Similar findings have also been reported in depression (see Section 2.1.2.2). Importantly, research examining how social-emotional factors may impact FER in adolescence is scarce. Given, that the onset of both social anxiety and depression often occurs in adolescence (Paus et al., 2018), it is important to examine how social-emotional factors may relate to FER during this time.

As well as examining FER in social anxiety and depression, researchers have also shown that these groups may be characterised by differences in the allocation of attention to emotional stimuli. Socially anxious individuals have been characterised by patterns of vigilance (Mogg & Bradley, 2002), as well as avoidance (Chen & Mansell, 2002; Horley et al., 2003, 2004), and these patterns may differ depending on the time course of attention (Gamble & Rapee, 2010; Wieser et al., 2009). In depression, researchers have found that depression may be associated with increased time looking at dysphoric stimuli (Eizenman et al., 2003; Koster et al., 2011; Sears et al., 2011; Siegle et al., 2000), as well as difficulties in disengaging from depressive-like stimuli (Sanchez, Vavquez, LeMoult, & Joormann, 2013).

Specifically, in relation to faces, individuals with social anxiety when viewing emotional faces have been found to show eye avoidance and show hyper scanning of non-features (Horley et al., 2003, 2004). In depression little research has examined the scanning of faces, but a recent study suggests that depressed individuals may show avoidance of features (Wu et al., 2012). To date, little research has focused on adolescence; in particular, how levels of social anxiety and depression may relate to the scanning of faces (i.e., in the amount of time spent looking at features and eyes). Through examining individual differences in adolescents' attention to faces, this may shed light on some of the recognition differences that characterise these groups. This thesis will examine how individuals high and low in social-emotional factors may differ in their scanning of faces, specifically in the amount of time spent fixating to features, and the eyes during FER.

Lateralisation for emotion processing is another factor that may relate to FER however, to date there is very little research examining the two alongside one another, and none in adolescents. Importantly, research studies exploring lateralisation for emotion processing have been shown to link with social anxiety and depression, which may affect how emotions are processed in the brain. The current thesis will therefore examine the role of social-emotional factors (namely, social anxiety and depression) and the lateralisation for emotion processing on the ability to recognise facial affect in groups of adolescents.

Importantly, many of the findings in the aforementioned areas have not accounted for this known comorbidity between depression and social anxiety. This may add to the contrasting past findings. This work will assess the independent contribution of the three facets of social anxiety, of depression, and of laterality for emotion processing to explain the variability in FER.

2.3.2 Aims and research questions

The main aim of this thesis is to examine the role of social-emotional factors and degree of lateralisation for emotion processing on adolescent FER. In Chapter 3, I will introduce the development of the stimuli that will be used throughout this thesis to assess FER and patterns of lateralisation for emotion processing. Within Chapter 3, I include a validation study of a new NimStim Chimeric Face Test (CFT) as a measure of lateralisation for emotion processing (Study 1).

Moving forward, in Chapter 4, I will use both cross-sectional and longitudinal designs to address: (1) whether social-emotional factors and lateralisation for emotion processing can predict FER in adolescence (Study 2); and, (2) whether changes in social-emotional factors and degree of lateralisation for emotion processing predict later FER in adolescence (Study 3).

In Chapter 5, I will use a combination of behavioural and eye-tracking measures to address whether adolescents high and low in the three facets of social anxiety and in depression, as well as those who are more RH dominant compared to BL, differ in their ability to recognise emotions and what may impact their FER. Specifically, I will evaluate the groups FER at different levels of intensity (Study 4) and at different exposure times (Study 5). I will also examine the groups' attention to facial features and the eyes in both of these studies; specifically, I will examine with eye-tracking whether the groups differ in their scanning of faces, specifically in the amount of time spent fixating on the facial features and then more specifically the eyes at different levels of intensity (Study 4) and different exposure times (Study 5).

In Chapter 6, I will bring together the findings from the thesis to address the research questions set out. I will draw upon some limitations and provide suggestions for future work in this area.

3 Stimuli Development

As highlighted in Chapter 2, the aims of this thesis are to examine the role of social-emotional factors and lateralisation for emotion processing in adolescent facial emotion recognition (FER). As such, throughout this work, FER and patterns of hemispheric laterality for facial emotion processing will be assessed in all studies. In this chapter, I will provide details on the stimuli that will be used throughout this thesis. Firstly, I will provide details on development of stimuli for the FER task, and secondly, I will explain the development of the stimuli for the chimeric face test (CFT) that will be used as a measure of lateralisation for facial emotion processing throughout this thesis. At the end of this chapter, I will provide details on the validation of the NimStim CFT (Study 1).

3.1 Facial Emotion Recognition Task

The Pictures of Facial Affect (POFA; Ekman & Friesen, 1976) have been popularly used to assess FER in much of the literature (e.g., Ekman & Friesen, 1971; Lawrence, Campbell, & Skuse, 2015; Thomas, Bellis, Graham, & LaBar, 2007; Workman, Chilvers, Yeomans, & Taylor, 2006). Despite this, the POFA have often received criticism (e.g., Erwin et al., 1992; Phillips et al., 1998; Winston, Strange, O'Doherty, & Dolan, 2002), such as that the POFA are only available in black and white, may contain too few stimuli (Winston et al., 2002) and there is a lack of ethnic and racial diversity (Phillips et al., 1998). One stimulus set that has been developed to address some of the concerns of the POFA is the NimStim facial stimulus set (available at www.macbrain.org/resources.htm; Tottenham et al., 2009). The NimStim facial stimulus set contains 672 coloured photographs from 43 (25 male) professional actors posing eight emotional expressions (the six basic emotions, plus neutral and calm). This stimulus set is available in colour and uses a range of ethnic and racial diversities. In the development of the NimStim facial stimulus set, Thomas and colleagues (2009) have also provided evaluation of both the reliability and validity of this stimulus set. Validity was tested by asking participants to view and label all 672 photographs using a forced choice paradigm (participants chose from six basic emotions, calm, neutral and none of the above) and the proportion of individuals who correctly labelled the intended expression were recorded. In order to account for agreement that may have occurred by chance, Cohens kappa (κ, Cohen, 1960) was calculated. After a short break, participants were asked to repeat the labelling task, and the proportion of agreement between the two sets of ratings was calculated as a measure of reliability. In all instances the values obtained for these measures ranged from 0-1 and can be found for each model and emotional expression in supplementary materials provided by Thomas and colleagues (2009).

3.1.1 Stimuli Selection

Two male and two female models were selected for each of the six basic emotions based on the following criteria: (1) the reliability, validity and Cohen's kappa all were greater than .80 (2) models must have a neutral face that also met this criterion (3) a range of racial and ethnic diversity was included. Based on these inclusion criteria, it was not possible to select individual models for each emotion category; as such, some models were selected to display several emotions, although for each of the six emotions there were two male and two female models selected (see Table 3.1). Neutral faces were also included in the FER, using the neutral expression of all models included in the model selection (14 models in total, 8 females, 6 males; see Appendix 2, Table 7.1 for reliability, validity and kappas for selected models).

Table 3.1. Model selection for each of the 6 basic emotions for the FER task.

	Happy	Sad	Anger	Fear	Disgust	Surprise
Face 1	6^{+}	**1**$^{+}$	13*	**14***	**13***	10^{+}
Face 2	**11***	18$^{\bullet}$	**11***	10^{+}	16$^{\bullet}$	**14***
Face 3	36^{+}	**26**$^{+}$	36^{+}	36^{+}	23^{+}	**36**$^{+}$
Face 4	**43***	40*	**38***	**43***	**36**$^{+}$	43*

Note: Shaded = male stimuli; Ethnicities: $^{+}$ Caucasian (European-American), * African-American, $^{\bullet}$Asian-American. All of these models were used in the FER task for Studies 2, 3 and 4. Models in **Bold** refer to models used in Study 5.

3.1.1.1 Creating different emotion intensities

In the design of studies, I considered that FER tasks with children and adolescents often rely on participants judging which emotion a face is showing at 100% intensity, which may lead to ceiling effects in performance (Thomas et al., 2007) and may mask any development in FER throughout the adolescent period. As discussed in Chapter 2, individuals varying in their level of social anxiety and depression have been found to show differences in their sensitivity to different emotional expressions. As well as this, lateralisation for emotion processing may be more closely related to task performance when the task is more difficult (Watling & Damaskinou, 2018). As highlighted in

Chapter 1 (see Section 1.2.1)**,** with age children become increasingly competent in recognising emotional expressions at a lower intensity. Some researchers have suggested that whilst happiness can be recognised at 20% emotional intensity, other emotional intensities may not be recognised until 50% intensity (Calvo, Avero, Fernández-Martín, & Recio, 2016). Despite this, Gao and Maurer, (2010) demonstrated using the NimStim facial set (Tottenham et al., 2009) that the threshold for detecting happiness, sadness and anger was below 30% intensity for children over the age of 10, given this, the choice was made to use three emotional intensities throughout this thesis, referring to low (30%), mid (50%) and high (70%) emotional intensities.

To create different intensity of emotional expressions, Abrosoft FantaMorph 5 was used to create facial morphs of different increments, by blending an emotive face (e.g., happy, sad, angry) with the same models' neutral face (see Figure 3.1). Morphs were created and images were saved at 30%, 50% and 70% emotional intensity. Adobe Photoshop (CC 2015) was used to place an oval mask around the face to remove hair and ensuring faces were of similar shapes (see Figure 3.2).

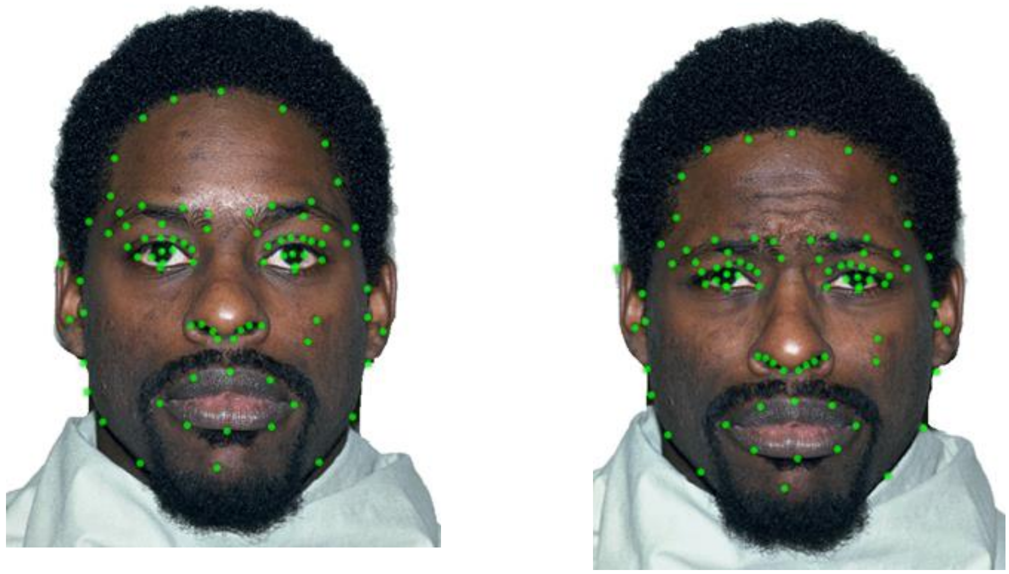

Figure 3.1. Example of morphing software mapping to create sad emotional expressions. Dots were placed on the neutral and sad face to map up key features (Model 40).

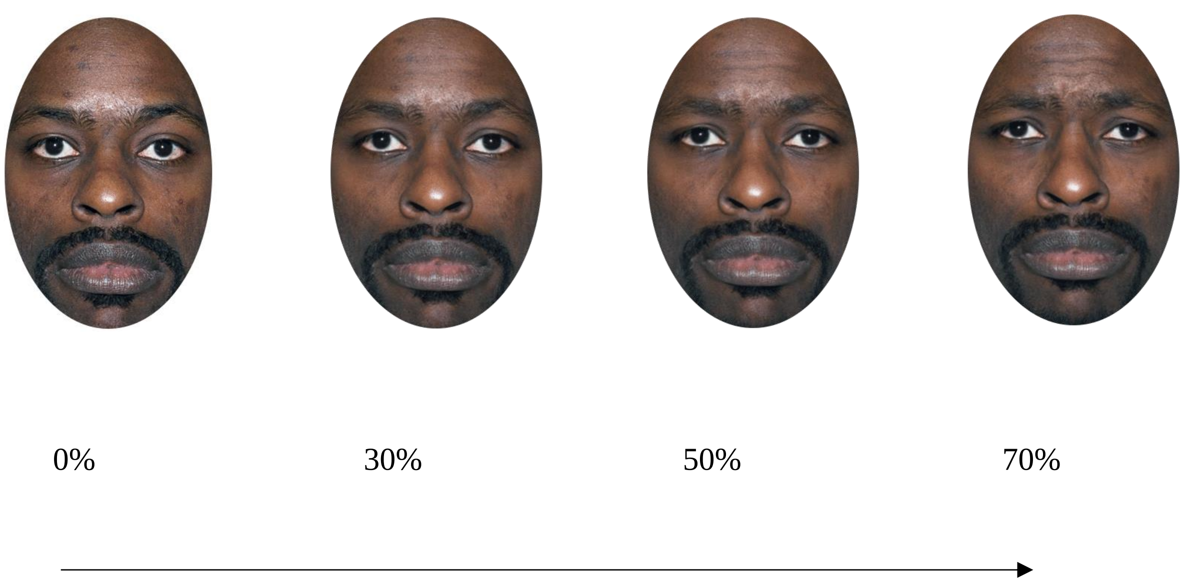

Figure 3.2. Example of sad emotional expression (Model 40) at neutral, 30%, 50% and 70% emotional intensity.

In total there were 36 male and 36 female emotional faces created (two of each at the three intensity levels for each of the six emotions). As highlighted above, 14 neutral faces were included, of these eight were female and six were male. This was due to a greater number of female models available that met the criteria for the different emotions (some male models were used for the creation of several emotional morphs). As can be seen from Table 3.1, I used a mixture of ethnicities in the creation of the stimuli, of the 14 models used, six were European-American, six were African-American and two were Asian-American. The final set of stimuli created consisted of 86 images, 24 images for each intensity level (four per emotion – two female, two male) and 14 neutral faces, corresponding to all models used in the creation of morphed expressions.

3.2 The NimStim Chimeric Face Test (CFT)

As highlighted in Chapter 2 (see Section 2.2.2.1), the Chimeric Face Test (CFT) is a well-established behavioural method to assess lateralisation for emotion processing, with converging evidence to support the CFT as a valid measure of laterality (e.g., EEG, Damaskinou & Watling, 2018; fMRI, Killgore & Yurgelun-Todd, 2007). Similar to the FER tasks, much work using the CFT has used images created from the POFA (e.g., Bourne & Maxwell, 2010; Bourne & Vladeanu, 2013; Drebing, Federman, Edington, & Terzian, 1997; Innes, Burt, Birch, & Hausmann, 2016; Watling & Bourne, 2013; Workman et al., 2006), typically containing one male and one female model (see Workman et al., 2000 for development of POFA CFT). Importantly, considering that I will be using the NimStim stimuli set to measure FER, it was considered important to create a new CFT measure that also addresses some of the limitations of the previously used POFA. In developing the NimStim CFT, instead of one male and female used in previous CFTs, here I select two males and two females for each of the six basic emotions, further given critiques of the POFA, a range of racial and ethnic diversities were included in this task.

3.2.1 Stimuli Selection

Two male and female models were selected for each of the six emotions, an attempt was made to select different models than used for the FER task, but this was not always possible given the limited amount of stimuli that met the criteria for inclusion (identical criteria was used as to the FER task above; see Section 3.1.1). Nine models were selected for the development of the NimStim CFT, some of which overlapped with the models selected for the development of the FER task. The overlap here is not considered to be problematic given the difference in task demands between the two tasks (i.e., judging emotion versus judging which of two faces looks more expressive). Further, chimeras were created by using the full-blown emotional expression (see Section 3.2.2) whereas the FER used morphing to produce less intense emotional expressions (see Section 3.1.1.1), meaning that the stimuli were not identical in nature. Importantly, the order of the two emotion tasks (FER and CFT) was counterbalanced for participants throughout the set of studies within this thesis, so is unlikely to have had an effect of judgements within these set of tasks. Individual models were included if: 1) the reliability, validity and Cohen's kappa all were greater than .80 (2) models had a neutral face that also met this criterion (3) a range of racial and ethnic diversity was included. Based on this inclusion criteria, it was not possible to select individual models for each emotion category, and as such, some models were selected in the creation of different emotion chimeras (see Table 3.2). In total 14 models were used (six male, eight female) and 16 images (two male, two female for each emotion) were selected (see Appendix 2; Table 7.1, for reliability, validity and kappas for selected models).

Table 3.2. Model selection for emotion for the development of the NimStim CFT.

	Happy	Sad	Anger	Fear	Disgust	Surprise
Face 1	1^{+}	**1**$^{+}$	3¨	**10**$^{+}$	16$^{\bullet}$	7^{+}
Face 2	14*	3¨	17$^{\bullet}$	**14***	19$^{\bullet}$	**14***
Face 3	20^{+}	20^{+}	20^{+}	**36**$^{+}$	20^{+}	**36**$^{+}$
Face 4	33^{+}	27^{+}	34^{+}	**43***	**36**$^{+}$	**43***

Note: Shaded grey refers to male stimuli; Ethnicities: $^{+}$ Caucasian (European-American), * African-American, $^{\bullet}$Asian-American. ¨Latino-American. All of these models were used in the CFT for all studies. Bold refers to models also selected for the FER task.

3.2.2 Creating Chimeric Faces

We used a similar procedure to create the stimuli as early work in this area (see Levine & Levy, 1986; Workman et al., 2006). For each image created, a model 100% intensity emotion expression image and the same models' neutral face image were vertically split in half at the nose (see Figure 3.3); this yielded 4 facial half images. Using the facial half images, two chimera images were created by taking each half of an emotive facial image (left and right side) and splicing it with the opposite half of the neutral facial image (i.e., right and left side, respectively) to create a 'full face' (the nose was used as the main matching point, see Figure 3.4).

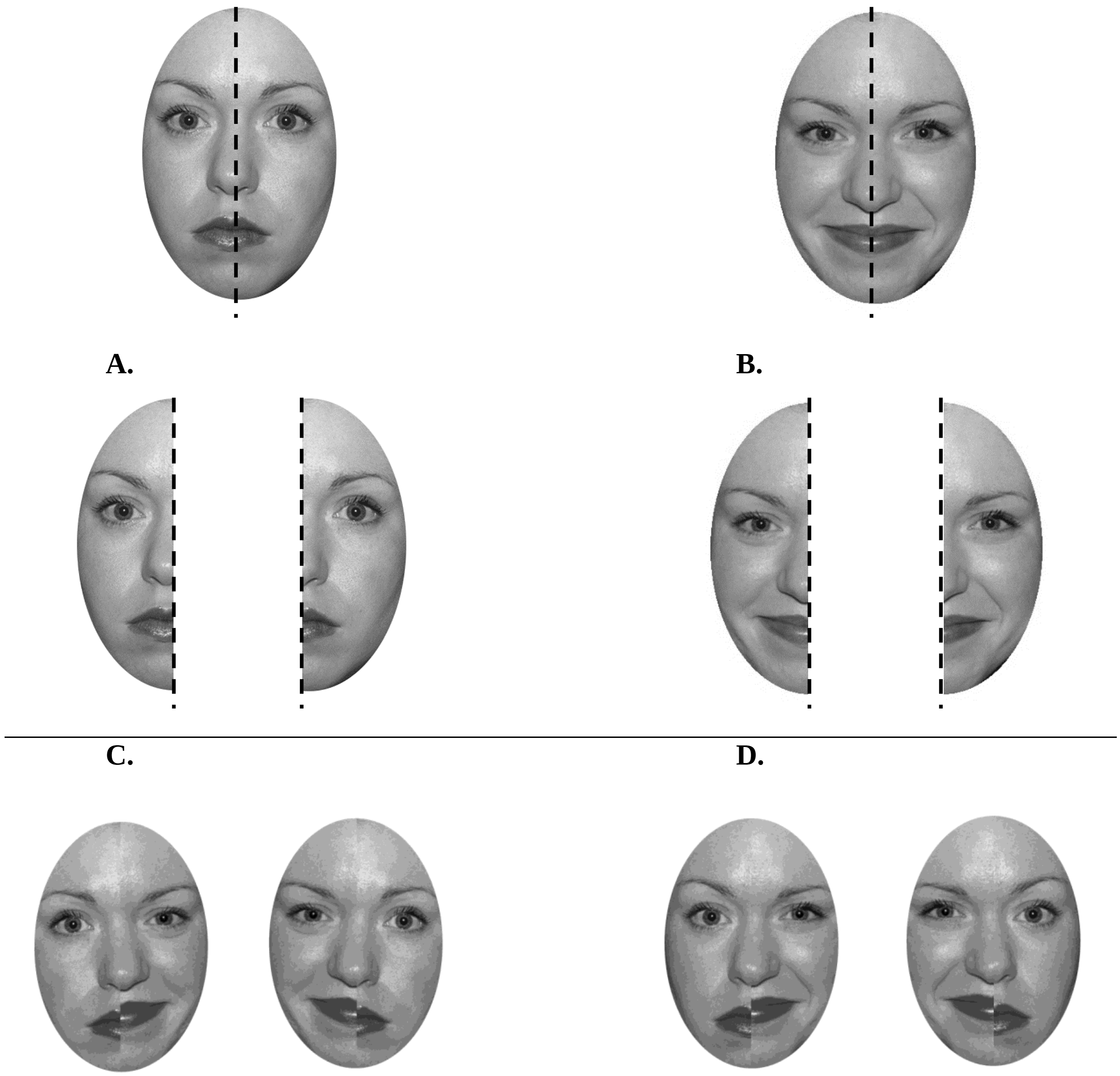

Figure 3.3. Creation of chimeras

For each of the two chimera images, a mirror image was created so to have an identical image, with the emotion and neutral sides swapped (i.e., where the image had the emotion on the left side of the face and neutral on the right, the mirror image had the emotion on the right side of the face and neutral on the left; see Figure 3.3). Using Adobe Photoshop (CC 2015) an oval mask was placed around the face to remove hair and ensuring faces were of similar shapes and sizes. Further, to ensure consistency with the previous POFA CFT, chimeras were saved as greyscale. For each emotion, there were four chimeric images in total per model, for a total of 16 chimeras per emotion. In total, for the six basic emotions, there were 96 chimeras created. In Study 1, I validate these stimuli, to assess if patterns of lateralisation for emotion processing are similar to when the POFA stimuli are used.

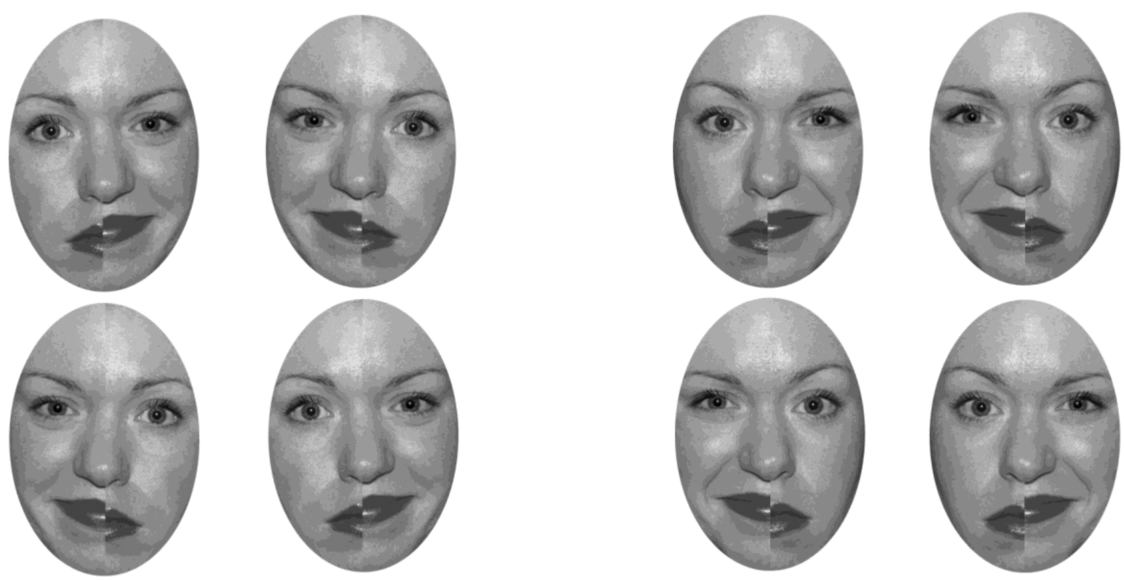

Figure 3.4. Example pairs of chimeras created, with mirror image chimera placed on top for all four possible combinations of chimeras created.

3.3 Study 1: Validating the NimStim Chimeric Face Test (CFT)

As highlighted in Chapter 2 (see Section 2.2.2.1), researchers have consistently demonstrated an overall pattern of left-visual field bias on CFTs, believed to reflect right-hemisphere (RH) processing, as well as for individual emotions more specifically (e.g., Bourne, 2010; Workman et al., 2006). In order to demonstrate the concurrent validity of the NimStim CFT as a valid measure of laterality, participants completed both the traditional Workman et al., (2006) task using the POFA CFT stimuli set and the newly created NimStim CFT, developed for the use in this thesis, for each of the six basic emotions (i.e. happy, sad, angry, fear, surprise, disgust). Internal reliability was assessed by examining the inter-correlations in the emotion laterality quotients obtained from both tasks. Given that the CFT should provide general patterns of lateralisation, it is expected that participants' patterns of lateralisation on the two tasks will be similar.

3.3.1 Method

3.3.1.1 Participants

The sample consisted of 50 participants (M_{age} = 22.12, *SD* = 3.26; range 18 – 32, males = 15), recruited from Royal Holloway, University of London. Participants took part for course credit. Participants were asked to self-report handedness (left, right, ambidextrous), strength of handedness was further assessed through the Dorthe, Blumenthal, Jason, and Lantz (1995) handedness measure, which required participants to respond to 14 statements, indicating the extent to which they used their left or right hand for a variety of activities. Participants responded on a 7-point Likert scale that ranged from "Always with Left" (-3) to "Always with Right" (+3). Responses were totalled to get a score from - 42 to + 42 whereby a score of 0 would be indicative of no dominancy (equal use of left of right hand), a negative score would indicate left-hand dominancy and a positive score would be indicative of right-hand dominancy. Five participants identified as left-handed, this was supported by the handedness measure (M= -13.40). No participants identified as ambidextrous. To be consistent with past research in our validation of the stimuli, individuals who identified as being left-handed were removed from further analyses; previous researchers have found differences in patterns of lateralisation for left and right handers (e.g., Bourne, 2008; Burton & Levy, 1989; Hellige et al., 1994 see Section 2.2.2.2). The mean handedness score for participants who identified as right-handed was 32.96 (*SD* = 7.47). The final sample consisted of 45 participants (M_{age} = 22.44, *SD* = 3.27, range 18 – 32; males = 12).

3.3.1.2 Materials and measures

Participants completed a measure of handedness (Dorthe et al., 1995; see Section 3.3.1), reported above. Further, participants completed two Chimeric Face Test (CFT) tasks, one using the POFA stimuli and one developed using the NimStim facial set (see Figure 3.5 and Figure 3.6). The two CFTs were programmed using E-Prime 2.0, which was used for stimuli presentation. Participants took part on a laptop and made responses using the keyboard.

3.3.1.3 POFA Chimeric Face Test

The Emotion CFT, using the POFA stimuli was created by Workman and collegues (2006). As highlighted earlier the CFT stimuli were created using one male and female model for each of the six basic emotions. These stimuli were created in a similar way to the NimStim CFT created in this study (see Workman et al., 2000 for details). All images were show in greyscale. In total there were eight images per emotion (four original chimeras and a mirror image for each; 48 images in total), each with the emotion presented either on the left or right of the chimera face, with neutral emotion on the other half of the face. Trial presentation included two chimeras (an original and the mirror image), one on the top and one on the bottom (see Figure 3.5 for example). There were eight trials per emotion as per the original task (four with the original chimera on the top and mirror image on the bottom, and four with the mirror image on the top and original chimera on the bottom). Trials were blocked by emotion (six blocks in total) and were randomised within each block. Cronbach's alpha indicated a good level of internal consistency on this task ($\alpha = .85$).

3.3.1.4 NimStim Chimeric Face test

The task is identical to the POFA CFT task with two exceptions. First, I have used the newly created NimStim chimeric images rather than the POFA images. Second, given there are four models for each emotion, allowing for the creation of eight original chimeras, there are 16 trials per emotion (96 trials in total). Cronbach's alpha indicated an excellent level of internal consistency on this task ($\alpha = .90$).

Figure 3.5. Examples of the POFA chimeras, used in previous research (e.g., Workman et al., 2006). From left to right faces represent anger, sadness, fear, disgust, happiness and surprise

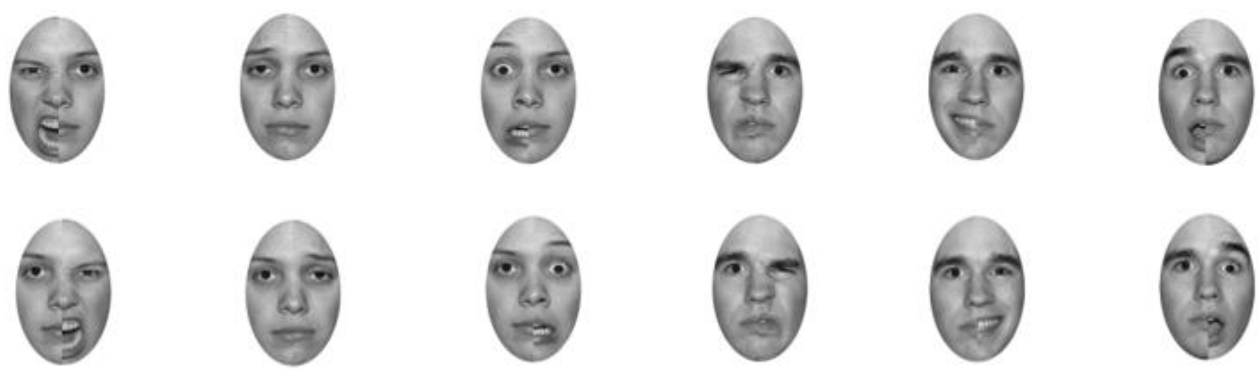

Figure 3.6. Examples of the NimStim chimeras created. From left to right faces represent anger, sadness, fear, disgust, happiness and surprise.

3.3.1.5 Procedure

Participants were seated individually in a quiet room. Following reading the information sheet, and having the opportunity to ask questions, they completed a consent form and completed the handedness measure using pen and paper. Following this, participants completed both CFT tasks on a 15-inch Lenova laptop at a viewing distance of approximately 50cm. E-Prime 2.0 was used for presentation of both CFTs, half of the participants started with the POFA CFT (Workman et al., 2006) and half of participants started with the NimStim CFT.

As highlighted above, the order of the two CFT tasks were counterbalanced. The emotion blocks within each task were randomised, as well as the trials within each emotion block through E Prime 2.0. Within each emotion block, participants were first instructed to read the block instructions before the trials begun. Participants were instructed to “decide which of the two faces look [happier, sadder, angrier, more scared, more disgusted, more surprised]”. In each trial, the instructions were followed by the automatic presentation of the mirrored chimera images (presented centrally on light grey background with one above the other). Participants responded using the up and down arrow corresponding to the face they believed looked more emotive (up arrow indicating the top face was more emotive, down arrow indicating the bottom face was more emotive). This was a free-viewing task whereby faces remained on screen until a decision was made, but participants were instructed to decide as quickly as possible. The task in total took 20 minutes to complete. Participants were fully debriefed on completion of the task as to the purpose of the study.

Scoring

Responses were recorded and summed separately for the amount of times participants responded that the image with the emotion presented on the left side (left-visual field) was more emotive (indicative of a RH processing) and for the amount of times participants responded that the image with the emotion presented on the right side (right-visual field) was more emotive (indicative of a LH processing). To calculate a laterality quotient for each participant, we used the formula from Bourne (2008b, see Equation 3.1). This resulted in a calculated score for each emotion block from -1 to +1, whereby -1 indicated a LH processing bias, 0 indicated no-hemispheric bias, and +1 indicated a RH processing bias. An overall laterality quotient was calculated for each of the two CFT stimulus sets by averaging the scores of the six emotion blocks.

Equation 3.1. Equation used to calculate Laterality Quotient from Bourne, (2008b), for each emotion for each of the two CFTs separately[1].

$$\frac{(\boldsymbol{Number\ of\ LVF\ choices} - (\boldsymbol{Total\ number\ of\ trials} - \boldsymbol{Number\ of\ LVF\ choices}))}{\boldsymbol{Total\ number\ of\ trials}}$$

[1] Two participants missed one trial on the POFA CFT, there were no missing data for the NimStim CFT, in the instance of missing trials the total number of trials for the POFA for the emotion block = 7 (8 trials for POFA CFT and 16 trials for NimStim CFT per emotion block)

3.3.2 Results

The mean laterality quotient for the POFA CFT was .28 (range = -.38 to +.88; SD = 0.34) and for the NimStim CFT mean = .18 (range = -.48 to +.92; SD = 0.35). Two one-sample t-tests were carried out to assess whether the overall laterality quotients for each stimulus set significantly differed from 0 (indicating no hemispheric dominance). The t-tests revealed that for both the POFA chimeras, t (44) = 5.58, p <.001, and for the NimStim chimeras, t (44) = 3.46, p =.001, that participants showed a left visual field bias (indicative of a RH processing). The overall laterality quotients from the two tests were strongly correlated, r = .84, p < .001.

A second set of one sample t-tests were completed for each emotion within each CFT task to assess if there was a laterality bias (significantly greater or lesser than 0 – indicating no bias). In line with typical protocol in this area (see Bourne, 2009; Indersmitter & Gur, 2003; Watling & Damaskinou, 2018), a Bonferroni correction was not applied when comparing each emotion laterality to zero. For the POFA CFT, all emotions showed significant left visual field bias and were significantly different from 0, *p*s ≤.010, indicating a RH bias. For the NimStim CFT, all laterality quotients apart from anger (p = .082) were significantly different from 0, *p*s <.050, indicating a RH bias. Means and standard deviations for each task by emotion type are presented in (Table 3.3).

Laterality quotients obtained for each emotion from both stimuli sets were compared to one another with separate paired sampled t-tests, with Bonferroni corrections applied to control for multiple comparisons (α = .008). For anger and surprise, but no other emotion, there was a significant difference in the laterality quotients obtained from the two CFT tasks, in both instances the laterality quotient from the POFA CFT was significantly higher than the NimStim CFT (see Table 3.3).

3.3.2.1 Inter-correlations

I also examined the inter-correlations between each emotions laterality quotient within each CFT task, to understand how strength of lateralisation on one emotion might relate to strength of lateralisation on another, as well as to the overall laterality quotient obtained from that CFT (see Table 3.4 and Table 3.5). Given that the CFT is measuring emotion processing, I would expect that the laterality quotients for each emotion should be correlated. The POFA CFT correlations between emotion laterality quotients were primarily moderate – strong (moderate, r = .30 to .50, strong r > .50); although, some correlations with the sad laterality quotient were not significant p > .050. Individual emotion laterality quotients were strongly correlated with the overall laterality quotient, apart from sad, which was moderately correlated. For the NimStim CFT all correlations between emotion laterality quotients were moderately – strongly correlated (see Table 3; ps < .001 for all comparisons). Individual emotion laterality quotients were all strongly correlated with the overall laterality quotient (r > .70).

Table 3.3. Mean laterality quotients (range -1 to +1) for each emotion block for the POFA and the NimStim CFT. T-tests show significant differences between the two tasks.

	POFA	NimStim	t	*p*
Happy	.300 (.502)$^{+}$	.194 (.458)$^{+}$	1.816	.076
Sad	.133 (.322)$^{+}$	.175 (.371)$_{+}$	0.639	.526
Anger	.389 (.393)$^{+}$	.122(.460)	-4.981	<.001**
Fear	.350 (.450)$^{+}$	.219 (.436)$^{+}$	-2.196	.033
Surprised	.327 (.499)$^{+}$	.150 (.464)$^{+}$	2.810	.007*
Disgust	.200 (.499)$^{+}$	.250 (.390)$^{+}$	0.746	.459

Note: $^{**}p \leq .001$; $^{*}p \leq .008$. Bonferroni correction applied $\alpha = .008$. $^{+}$ Indicates a laterality quotient significantly greater than 0 (RH processing).

Table 3.4. Inter-correlations between POFA CFT stimulus emotions

	Sad	Angry	Fear	Surprised	Disgust	Overall LQ
Happy	.344*	.511***	.656***	.596***	.612***	.839***
Sad		.231	.395**	.179	.175	.461***
Angry			.489**	.462***	.586***	.719***
Fear				.697***	.554***	.844***
Surprised					.618***	.813***
Disgust						.809***

Note: $^{***}p \leq .001$; $^{**}p \leq .050$.

Table 3.5. Inter-correlations between NimStim CFT stimulus emotions.

	Sad	Angry	Fear	Surprised	Disgust	Overall LQ
Happy	.675***	.757***	.699***	.547***	.616***	.874***
Sad		.611***	.645***	.404**	.536***	.771***
Angry			.575***	.724***	.688***	.893***
Fear				.629***	.436**	.802****
Surprised					.584***	.801***
Disgust						.782***

Note: All correlations are significant $^{***}p \leq .001$; $^{**}p \leq .050$.

3.3.3 Discussion

The primary aim of this study was to validate a new CFT to assess the lateralisation for emotion processing using the NimStim facial stimulus (Tottenham et al., 2009), which will be used throughout this thesis. I compared participants' patterns of hemispheric lateralisation for facial emotion processing on the newly developed CFT with a previously established and widely used CFT that had used the POFA stimuli to establish the validity and reliability of the newly established measure. Consistent with previous research in the area, there is evidence of an overall left visual field bias (RH) in the processing of emotions for both of the CFT measures. These findings are consistent with those widely documented in the literature (e.g., Workman et al., 2000b; Watling et al., 2012). As well as this, I show that the laterality quotients obtained from the NimStim CFT are strongly correlated to responses on a previously well-used CFT, using the POFA. These findings highlight that both tasks appear to be measuring the same thing.

Similar to previous work, for the POFA CFT, it was found that patterns of hemispheric emotion processing for all emotions tended to show RH processing (laterality quotients significantly different from 0). The findings in this study support the findings of previous work that demonstrates a RH processing of emotions (e.g., Bourne, 2010; Watling, Workman, & Bourne, 2012; Workman et al., 2006; Levine & Levy, 1986). For the newly developed NimStim CFT, the findings were similar to those with the POFA: laterality quotients obtained from each emotion were significantly different from 0 (indicating RH processing). However, there was one difference in that for anger only, the laterality quotient scores did not significantly differ from 0, although this was approaching significance (p = .082). In general, these findings indicate that the newly designed CFT with the NimStim stimuli set has a consistent pattern of findings as when using the POFA stimuli set.

Importantly, I expected that there would be relationships between laterality quotients for facial emotion processing. When examining the inter-correlation between the laterality quotients for each emotion, all emotions (including anger) significantly and positively correlated with the overall laterality quotient for both the POFA CFT and the NimStim CFT. When examining the inter-correlations between laterality quotients for the different emotions, for the POFA CFT it was found that laterality quotients obtained for sad expressions did not significantly correlate with anger, surprise and disgust laterality quotients. In fact, when looking at the relation with the overall laterality quotient, sad was the only emotion that showed moderate instead of strong correlations. For the NimStim CFT, all laterality quotients for each emotion correlated with all other emotion laterality quotients. These findings indicate that laterality quotients of each emotion for the NimStim CFT are more strongly related to one another than the POFA CFT.

When comparing laterality quotients obtained on both CFTs, there were some differences that emerged; for instance, the new NimStim CFT typically showed less hemispheric dominance than the POFA CFT (although all apart from anger showed significant RH dominancy). These differences were significant for anger and surprise laterality quotients, with the POFA CFT laterality scores significantly higher (i.e. more RH dominant). It may be that scores on the NimStim CFT may provide a more conservative estimate (less strongly lateralised to the RH) due to the added racial diversity of the models included in trials. In fact, there is evidence that individual’s show more pronounced hemispheric asymmetry for own raced faces (Correll et al., 2011).

Whilst data on ethnicity was not collected from the sample, regardless of participant ethnicity the mix of racial and ethnic diversity of the NimStim CFT may affect emotion judgements and is likely to result in differences in laterality quotient from the two measures. In contrast, the POFA contained only Caucasian models. According to the findings from Correll et al. (2011), it would be expected that using a combination of Caucasian and other ethnic stimuli would result in a lower overall laterality quotient score for all participants. Although beyond the scope of this thesis, future research is needed to examine how participant ethnicity may impact laterality quotient obtained for racially diverse stimuli.

3.3.3.1 Conclusion

In conclusion, in this study I find evidence that the newly developed NimStim CFT is a valid measure of laterality for emotion processing and is comparable to the POFA CFT used in previous research (Workman et al., 2000b, 2006; Bourne, 2010a, 2010b, 2011). Findings support that there is a relationship between the strength of lateralisation for the six emotions and that the scores obtained from the NimStim CFT are highly correlated with the POFA CFT, which has been widely used within the literature. Importantly, I have noted that scores on the newly developed NimStim measure may provide a more conservative estimate of hemisphere dominance, given the inclusion of racial diversity, arguably a more ecologically valid measure of emotion processing.

4 Facial Emotion Recognition (FER) in Adolescence: Influences of socio-emotional factors and lateralisation for emotion processing

4.1 General Introduction

The ability to accurately recognise emotions is a fundamental skill that allows individuals to successfully engage in their social environments. However, this skill varies amongst individuals. As highlighted in Chapter 1, it is well established that facial emotion recognition (FER) abilities develop throughout infancy and childhood, with some researchers suggesting that children aged 10 can make comparable judgements to adults. More recently researchers have argued that FER abilities may continue to develop throughout late childhood and adolescence. Specifically, researchers have demonstrated linear trajectories in the development of some emotions (i.e., happiness, surprise, fear, disgust) from 6-16 years. These continued developments are believed to be the result of brain changes; there is evidence of continued development and reorganization of face processing structures in the brain throughout adolescence (Scherf, Behrmann, & Dahl, 2012).

As outlined in Section 1.1, adolescence is a key period for social and emotional development and marks a vulnerable period for the onset and heightened prevalence of psychiatric disorders (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003; Fiedd, Keshavan & Paus, 2008; Steinberg, 2005). It is therefore of paramount importance to understand the factors that might influence the ability to recognise emotions at this time. The following set of studies will examine whether social-emotional factors (social anxiety and depression) and patterns of hemispheric brain lateralisation for facial emotion processing can predict FER in adolescents. Firstly, I will assess whether these factors can predict FER in adolescent male and females (Study 2). Secondly, I will assess if changes in these factors over time can predict later FER at six and 12 months (Study 3).

Due to variability in FER across the lifespan, research (primarily with adult participants) has sought to examine factors that might influence an individual's ability to detect facial affect. It is well known that poor emotion recognition of facial affect is a central component of many psychiatric disorders including mood and anxiety disorders. Of these, a growing number of studies have examined FER in those with clinical depression and social anxiety disorder (SAD; see Section 2.1.1.2).

As previously highlighted in Chapter 2 (Section 2.1.1), SAD is characterised by a marked fear of social situations, encompassing fear of being negatively evaluated by others (APA, 2013) and has been associated with poor social interpersonal skills (Simonian et al., 2001). Social anxiety (SA) onset often occurs in the early-mid teen years (Rapee & Spence, 2004) and has been reported to be prevalent in 5.5% of 13- to 18-year-olds (Merikangas et al., 2010); although, rates are expected to be higher given reports of as little as 5% of individuals with SAD seek professional help (Keller, 2003). Previous research examining the relationship between SA and FER skills has often produced mixed findings. There is evidence that individuals with high levels of SA in both clinical and non-clinical samples may be less accurate and less sensitive in their FER (Simonian et al., 2001; Tseng et al., 2017; Montagne et al., 2006), display negative interpretation biases (Bell et al., 2011; Frampton & Porter, 2011), and show slower processing of some emotions (Melfsen & Florin, 2002; Silvia et al., 2006). In contrast, some researchers have found no differences in FER between low and high socially anxious participants (Philippot & Douilliez, 2005), and in some instances have found an increased ability to recognise facial affect (Hunter, Buckner, & Schmidt, 2009) or an increased sensitivity at detecting subtle emotions (Arrais et al., 2010).

One explanation for the inconsistencies in findings could be due to measuring different facets of SA or the use of aggregate scores on SA measures (Silvia et al., 2006); yet, SA is multifaceted (Moscovitch, 2009). In fact, researchers have distinguished between subjective and behavioural aspects of SA (La Greca & Stone, 1993). Fear of negative evaluation (FNE) has previously been described as a form of social-evaluative anxiety, whereas behavioural aspects of SA may be more closely linked with avoidance and distress behaviours (La Greca & Stone, 1993); supporting previous work that has viewed FNE and social avoidance and distress as conceptually distinct (Watson & Friend, 1969). Researchers have also distinguished generalised social avoidance and distress from avoidance and distress specific to new situations and with unfamiliar peers, with the belief that these two types of social avoidance may lead to different social experiences (La Greca & Stone, 1993). Given the distinctions made, it may be that different facets of SA may influence FER in different ways.

Past findings linking SA to FER have been mixed, which may be the result of not considering the effect of the different facets of SA. This thesis examines the independent ability of different facets of SA to predict FER. In order to achieve this, within Study 2 and Study 3, the Social Anxiety Scale for Children (SAS-C-R, La Greca & Stone, 1993) will be used as it assesses the multifaceted nature of SA. This measure consists of three sub-scales, assessing subjective components of SA (FNE), as well as behavioural components (generalised social avoidance and distress, and avoidance and distress specific to new situations).

In acknowledging that there are different facets of SA, and with the idea that it is through exploring these that we may be able to understand the conflicting results previously found, it is expected that there will be different relationships found between each facet and FER. One common facet of SA is FNE, which has often been associated with hypervigilance to emotional stimuli in adults. For example, individuals high on FNE have been found to be hypersensitive to cues of social evaluation and show attentional biases for facial expressions (e.g., Rossignol, Campanella, Bissot, & Philippot, 2013). In fact, research has shown that individuals high on FNE may show an enhanced ability to recognise negative affect, possibly due to a negative response bias (Winton et al., 1995). It is therefore expected that after considering other facets of SA, FNE will be positively related to FER ability.

The second and third facet of SA relate to social avoidance and distress, specifically for general and for new social situations. Whilst these two are explored as different facets, both involve social avoidance and distress. Social avoidance and distress may negatively influence FER due to a propensity to have increased number of avoidant behaviours. Researchers propose that an individual’s exposure to emotional faces (i.e., social experience) over time leads to perceptual learning of emotion over time (Gauthier & Nelson, 2001). In fact, young children exposed to high levels of hostility and parental anger have been found to recognise anger at a lower intensity (Pollak et al., 2009). Given exposure influences emotion recognition, lack of exposure would be expected to weaken the perceptual learning of emotional expressions and thus result in poorer FER ability. In fact, individuals with social phobia show poorer recognition of facial affect (Simonian et al., 2001) and preadolescent children who are higher on general social avoidance and distress are poorer at decoding nonverbal emotion in voices (McClure & Nowicki, 2001). With the enhanced importance of friendships and socialiszing during adolescence, it is believed that avoidance may lead to long-term negative consequences (Albano, DiBartolo, Heimberg, & Barlow, 1995). It is therefore predicted that adolescents' levels of social avoidance and distress will negatively predict FER ability.

Depression is another common socio-emotional disorder emerging during adolescence and is characterised by low mood and by diminished interest and pleasure in most or all activities (APA, 2013). Adults with clinical depression have been shown to be less accurate (Asthana et al., 1998; Mikhailova et al., 2005; see Bourke, Douglas, & Porter, 2010, for review) and less sensitive (Csuky et al., 2009; Gollan et al., 2013) in their ability to recognise emotions. Individuals with depression have also been found to demonstrate negative interpretative biases in their recognition of facial emotions (Golan et al., 2008; Gur et al., 1992; Leppanen et al., 2004). As highlighted in Section 2.1.2.2, research examining the relationship between depression and FER in children and adolescents is limited. Lenti, Giacobbe and Pegna (2000) found children and adolescents with major depressive disorder showed poorer recognition of fear than non-depressed peers, which may be a consequence of differences in amygdala activation in depressed individuals (see Sheline et al., 2001). Given the literature with adults, it is predicted that adolescents' levels of depression will negatively predict their FER.

As well as links between socio-emotional factors and FER, one's degree of laterality for facial emotion processing has also been related to emotion recognition (Watling & Bourne, 2013; Watling & Damaskinou, 2018; Workman et al., 2006; see Section 2.2.3). Developmental trends in the lateralisation for emotion processing show similar developmental trends as those for the development of emotion recognition abilities, with increasing right-hemisphere (RH) dominancy for emotion processing occurring at a similar time of increasing emotion recognition accuracy (Watling et al., 2012). Despite this, to date, very little research has looked directly at the relationship between the degree of laterality for facial emotion processing and FER performance.

As discussed in Section 2.2.3, Barth and Boles (1999) and Watling and Bourne (2013) found that children more strongly lateralised for the processing of emotions within the RH, had greater ability to identify and discriminate between facial expression of emotions. Similarly, Workman and colleagues (2006) found that children more strongly lateralised for the processing of emotions within the RH, had greater ability to recognise emotion in the eyes. More recently, Watling and Damaskinou (2018) found in children that their initial degree of laterality for emotion processing predicted emotion discrimination skills one year later. Whilst patterns of laterality for emotion processing have been linked to emotion skills in children, research is yet to examine if there is a relationship between increased RH dominancy for emotions in adolescents and their development of FER skills. In the following set of studies, it will be examined whether patterns in the degree of hemispheric brain lateralisation for facial emotion processing predicts FER skills in adolescents.

Social anxiety, depression and lateralisation for emotion processing have independently been linked to emotion recognition ability (for more information see Chapter 2); however, together these factors are also interlinked. Researchers have found in adults that there are links between SA and laterality for processing of facial expressions of emotion (e.g., Bourne & Vladeanu, 2011; Bourne & Watling, 2015; Cooney, Atlas, Joormann, Eugence & Gotlib, 2006; Kolassa and Miltner, 2006; Mogg & Bradley, 2002; see Section 2.2.2.3), and between depression and laterality for processing of facial expressions of emotion (e.g., Bourne & Vladeanu, 2013; Grimm et al., 2008; Kucharska-Pietura & David, 2003; Lai, 2014; Schaffer et al., 1983; Trinkl et al., 2015; see Section 2.2.2.4). Bourne and Watling (2015) found in females that adults higher on FNE tended to be more strongly lateralised to the RH. Research with adults also demonstrates that depressed patients show attenuated left visual field bias in the processing of emotional faces (indicating less RH processing) and may show a RH dysfunction (Kucharska-Pietura et al., 2003), both which may impact emotion recognition abilities. Some researchers have also found opposite patterns, with adults higher in feelings of SA showing weaker lateralisation to the RH (Bourne & Vlaedeanu, 2011), and adolescents higher in depression having stronger RH processing (Trink et al., 2011). Given that degree of laterality and SA and depression may be interrelated, in the following set of studies both lateralisation for emotion processing and social-emotional factors will be included in one model; this will allow examination of which variables may independently predict FER, after accounting for the variance of other factors.

4.2 Study 2

4.2.1 Introduction

As highlighted thus far throughout the thesis, little is known about developments in FER in adolescence. This study sets out to understand what factors may be associated with individual differences in adolescent FER. It is known that levels of SA, depression and strength of lateralisation for emotion processing have previously been linked to FER skills. However, work examining these factors in adolescence is lacking. Specifically, this study will examine whether variance in FER may be accounted for by each of the potential influencers (i.e., the three facets of SA, depression, and strength of lateralisation for emotion processing).

In addition to examining how SA, depression and lateralisation for emotion processing may link to FER in adolescents, this study will examine whether these relationship patterns are similar for males and females. Indeed, there are known sex differences in all of these predictors (see Section 4.1). For example, previous research has demonstrated a female advantage in emotion recognition (Montagne, Kessels, Friferio, de Haan, & Perret, 2005), which may be specific to more subtle emotional expressions (Hoffman, 2010) or to specific emotions (Connolly, Lefevre, Young, & Lewis, 2018). It is also well established that SAD and depression have higher prevalence in females than males (APA, 2013) and that for both SA and depression these sex differences are more pronounced throughout adolescence (APA, 2013). Whilst data shows that for SA, there are similar onsets for males and females, there is evidence that for females only, advancing puberty is associated with increased symptomology in early adolescence (Deardorff et al., 2007). Data from the Early Developmental Stages of Psychopathology Study, examining adolescents 14-25, indicated that females had higher prevalence of SAD, 9.5% compared to 4.9% for males (Wittchen et al., 1999; see also Asher, Asnanni & Aderka, 2017, for review). It is also noteworthy that there are sex differences in the comorbidity of SA with other disorders. For females, SA is more likely to be related to internalising disorders (i.e., depression), whereas for males SA tends to be related to externalising disorders (Xu et al., 2012). Importantly, girls who are higher in SA, but not boys, have been rated by parents as having poorer social skills (Ginsburg, La Greca & Silverman, 1998), suggesting that the relationship between social-emotional factors and social skills may differ by sex. It therefore warrants investigation as to whether these factors are able to explain variance in the ability to recognise emotions in both male and female adolescents or whether adolescent boys and girls patterns of relationships may differ.

Sex differences have also been reported in patterns of hemispheric laterality for emotion processing; for instance, research with adults has shown that males are more strongly lateralised for facial emotion processing (e.g., Bourne, 2005, 2008; Bourne & Todd, 2004; Bourne & Maxwell, 2010; Schneider et al., 2011). As well as this, some researchers have found evidence in children that for boys, but not girls, hemispheric laterality for facial emotion processing is related to FER (Watling & Bourne, 2005). It may therefore be that some factors may be more important in predicting FER for males and females.

This study will examine to what extent FER in male and female adolescents can be predicted from social-emotional factors (SA, depression) and lateralisation for emotion processing. As highlighted in Section 1.2.2, developments in FER may not have been previously detected in adolescence, which may be a consequence of task demands, specifically the use of high intensity emotional expressions (Thomas et al., 2007). As discussed in Chapter 3, the FER task used within this thesis will examine the recognition of more subtle emotional expressions (30%, 50% and 70% intensity) to avoid ceiling effects.

4.2.2 Aims and hypotheses

This study aims to evaluate to what extent FER in males and females can be predicted from their age, social-emotional factors – specifically FNE, social avoidance (general social avoidance and avoidance and distress for new situations), depression – and strength of laterality for emotion processing. It is expected that:

1. Given recent evidence of continued brain maturation, specifically in brain areas associated with FER (Batty & Taylor, 2006), it is predicted that age will significantly predict FER.

2. Previous research suggests that exposure is important for the development of FER skills, it is therefore predicted that social avoidance and distress will negatively predict FER. In contrast, given findings that FNE may be linked to hypervigilance to emotional stimuli, it is predicted that after accounting for other facets of SA that FNE will be a significant positive predictor of FER.

3. Although there is lack of research examining the relationship between depression and FER in adolescence, given the research with adults, it is predicted that depression will negatively predict FER.

4. Given evidence of increasing FER skills at this time, and evidence that developing hemispheric lateralisation for facial emotion processing may develop in parallel to these skills, it is predicted that degree of lateralisation will predict FER.

4.2.3 Method

4.2.3.1 Participants

The sample consisted of 541 adolescents aged 11 – 17 years (M_{age} = 14.21 years, *SD* = 1.76). The sample was predominantly female (85.8%, *N = 464)* and predominately White Caucasian (see Appendix 3, *Table 7.2* for participant descriptives and demographics by sex). Participants were recruited from secondary schools and a sixth form college in the south of England, including from an all-girls independent school (*n*= 357; index of multiple deprivation[2] [IMD] = 9), mixed grammar school (n=65; IMB = 2), a state school (n=62; IMB = 7) and a sixth form college (n= 57; IMD = 6). Eighty-five percent of the sample identified as being right-handed, 11% as left-handed, and 3% as ambidextrous. Handedness was missing from 2% of the sample. This data was collected given that previous work has found differences in laterality for emotion processing depending on handedness. Given that the research question is assessing predictors of FER not laterality, all participants were included within the analysis, regardless of handedness.

Ethical approval was granted by the Department of Psychology internal ethics committee. Schools chose to use an opt-out consent procedure, rather than opt in. Parents were sent information outlining the study aims and were requested to respond if they wished for their son/daughter to be excluded from the study. Adolescents who were not excluded by their parents, prior to taking part were given information about the study, followed by obtaining individual consent.

4.2.3.2 Materials

Participants completed the tasks/measures using a computer or an iPad. The study was designed with the Qualtrics survey software platform (Qualtrics, Provo, UT). Participants completed questionnaire measures to assess SA (Social Anxiety Scale for Children Revised; La Greca & Stone, 1993) and depression (Child Depression Inventory; Kovacs, 1983), and completed two emotion tasks to assess (1) patterns of hemispheric brain lateralisation for facial emotion processing (NimStim CFT) and (2) FER (see Chapter 3 for stimuli development). The Qualtrics programme was set

[2] Index of multiple deprivation in the UK (IMD), calculated as a decile from 1-10 where 1 = top 10% deprivation 10 = bottom 90-100% of deprivation. Department for Communities and Local Governments (2015)

up to allow pupils to skip questions and trials; in the case that a student skipped a question or trial, the Qualtrics programme highlighted that a response was missing and gave the student the opportunity to continue to respond or to skip. This was set up in this way to avoid students missing items accidently. For the consent form in Qualtrics, responses were set to force response, meaning that students had to answer these questions and agree to take part. If participants selected no for taking part, they were automatically directed to the end of the survey. Adolescents were advised that they could exit the survey at any time.

Child Depression Inventory (CDI; Kovacs, 1983)

This scale consisted of 27 items assessing negative mood, interpersonal problems, ineffectiveness, anhedonia and negative self-esteem, and has been developed for the use with 7- to 17-year-olds (Kovacs, 1985; Wang, Jiang, Cheung, Sun, & Chan, 2015; see Appendix 1, section 7.1.2). There is much research to support the psychometric properties of the CDI as a valid and reliable measure of depressive symptoms (Carlson & Cantwell, 1979; Craighead, Smucker, Craighead, & Illardi, 1998; Kovacs, 1992). The CDI can differentiate between depressed and non-depressed groups, demonstrating its discriminant validity (Carlson & Cantwell, 1979). The CDI shows good levels of internal consistency (Kovacs, 1992), good levels of test-rest reliability (Craighead et al., 1998; Kovacs, 1992). It is also sensitive to change over time (Kovacs, 1992) and has been found to be reliable over repeated administration (Finch, Saylor, Edwards, & McIntosh, 1987).

For each item, participants are required to pick one out one of three sentences that was true of them in the previous two weeks (e.g., I am sad once in a while, I am sad many times, I am sad all time). Thirteen of the 27 items were negatively scored. Responses were coded as 0-2 for each of the 27 items and summed to provide a total score (range 0-54), whereby higher scores indicated high levels of depressive symptoms. Cronbach's alpha indicated an excellent level of internal consistency (α =.90).

Social Anxiety Scale for Children Revised (La Greca & Stone, 1993)

The Social Anxiety Scale for Children Revised (SASC-R) has been used with children from aged 7 – 14 years (La Greca & Stone, 1993) and has been found to be a reliable and valid measure of SA (Ginsburg, La Greca, & Stone, 1998; La Greca & Stone, 1993; La Greca & Lopez, 1998). The measure has been shown to discriminate between clinical samples (Ginsburg et al., 1998; La Greca & Stone, 1993; La Greca & Lopez, 1998), and shows good test-re-test reliability over times (La Greca & Schiloff, 1998)[3]

The scale consisted of 22 items, four of which were included as filler items (see Appendix 1, Table 7.13). The scale was used to assess three aspects of SA in adolescents, with the three sub-scales: (1) Social avoidance and distress specific to new situations (SAD- New) included six items (e.g., I feel shy around kids I don't know), (2) Generalised social avoidance and distress (SAD- General) included four items (e.g., I feel shy even with kids I know well), and (3) Fear of negative evaluation (FNE) included seven items (e.g., I am afraid others will not like me). Participants were asked to indicate how much they feel that each statement is true for them on a five-point Likert scale, deciding between: not at all, hardly ever,

[3] Similar to the SAS-C-R a Social Anxiety Scale for Adolescence (SAS-A; La Greca & Lopez, 1998) was developed for use with 15-16-year-olds. Importantly, the items in the SASC-R and the SAS-A are near identical. The SAS-A has several word changes to make it more developmentally appropriate. For example, 'other kids' is changed to 'others' or 'peers'. Given that the two questionnaires have minimal differences, the decision was made to use the SAS-C-R given the younger age range of some of the students in the participant sample.

sometimes, most of the time and all of the time. Higher scores reflected higher SA symptoms. The scores were summed for each subscale separately so that three scores were obtained; FNE scores ranged from 7-35, SAD-New scores ranged from 6-30, and SAD-General ranged from 4-20. Cronbach's alpha indicated good to excellent levels of internal consistency on all subscales (SAD-New scale, α =.87; SAD-General, α =.81 and FNE, α =.94).

The Chimeric Face Test (CFT)

The CFT was developed for the use in thesis using the NimStim face stimulus set (Tottenham et al., 2009; see Chapter 3 for stimuli development and validation). As outlined in Chapter 3, two males and two females were used to create four chimeric images in total per model and a total of 16 per emotion (see Section 3.2.1 for model selection).

As in Study 1, the task consisted of six blocks, one for each of the six basic emotions (i.e., happiness, sadness, anger, surprise, disgust, fear), with 16 trials per block. The chimeras were presented centrally, mirror images one on top of the other, on a white background. In half of the trials, the image with the emotion presented on the left side was on top and the image with the emotion presented on the right side was on the bottom. In the other half of the trials, this was reversed. The order of presentation of the six emotion blocks was randomised within the Qualtrics platform, as was the order of individual trial presentations within each block. Pupils were asked to judge whether the top or bottom chimeric image looked happier, angrier, sadder, more surprised, more disgusted, or more scared (depending on the emotion block); they responded by selecting the 'top' or 'bottom' labelled button (see Figure 4.1). The chimeric images remained on the screen until participants made a response; importantly, participants were told to decide as quickly as possible.

Coding. To calculate a laterality quotient (LQ) for each participant for each emotion, the formula from Bourne (2005; see Equation 3.1) was used, calculating the proportion of times participants responded that the face was more emotive when the emotion was represented in the left visual field than in the right visual field. This resulted in a calculated score for each emotion block that ranged from -1 to +1, whereby -1 indicates a strong pattern of left hemisphere facial emotion processing bias, 0 indicates no pattern of facial emotion hemispheric bias, and +1 indicates a strong pattern of RH facial emotion processing bias.

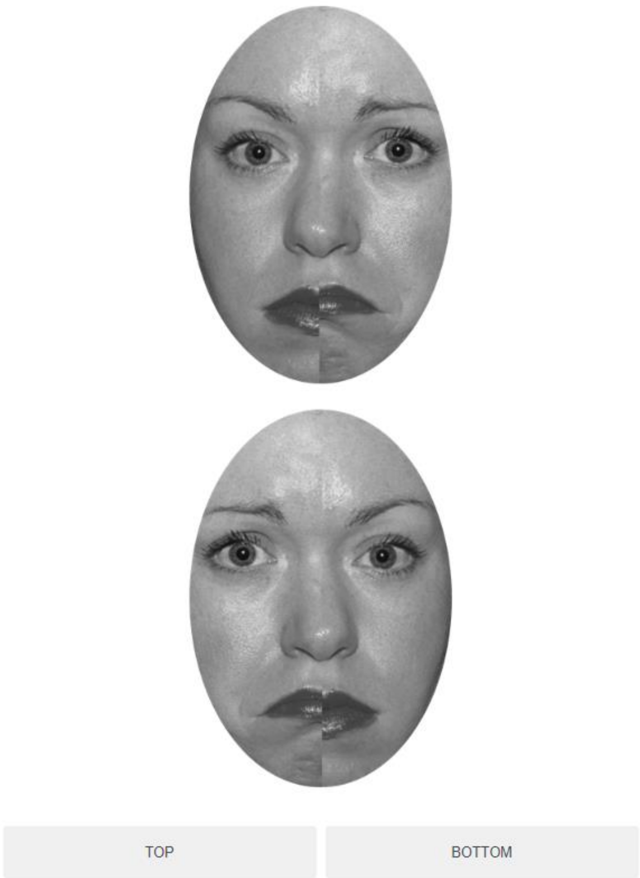

*Figure 4.1.*Example of CFT trial in Qualtrics.

Facial Emotion Recognition (FER) Task

Participants were required to view and decide which emotion label applied to images with facial expressions of emotions. The stimuli were created using the NimStim face stimulus set (Tottenham et al., 2009; see Chapter 3 for stimuli development) for each of the six basic emotions at 30%, 50%, and 70% intensities. The stimuli consisted of four images (two male and two female) for each of the six basic emotions, at the three intensities (4 x 6 x 3), as well as the neutral stimuli presented for all models used (13 images). Participants were shown all 85 stimuli; each image was centrally presented one at time on a white background. The order that the images were presented was randomised through Qualtrics for each participant. Whilst each image was being displayed, participants were asked to judge the emotion of the face, from a list of seven options. Participants were asked to decide if the face displayed was happy, sad, fear, surprised, anger, disgust or no emotion by selecting the labelled button (see Figure 4.2).

Coding. For each participant a raw accuracy score was calculated by summing the amount of emotion faces labelled as the intended expression, this produced a score from 0- 85, with higher scores indicating better FER.

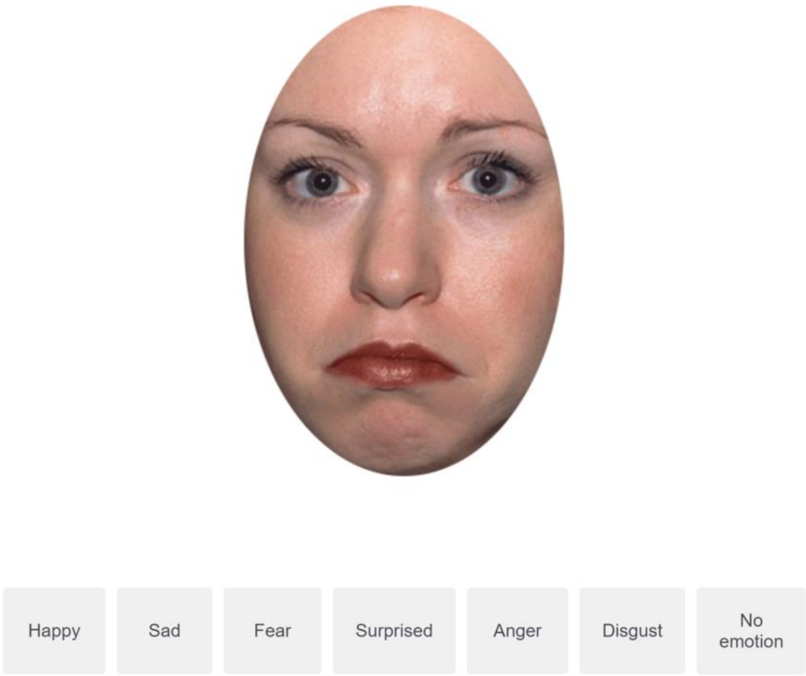

Figure 4.2. Example of FER trial in Qualtrics.

4.2.3.3 Procedure

Participants were seen in groups of no more than 20 students and were sat at an individual computer or at a desk if using an iPad; they were spaced out to avoid seeing what others were doing. Participants were first verbally informed about the project. Participants also viewed an information sheet at the start of the survey. If participants did not consent to taking part, the survey skipped to the end screen. After participants consented to taking part, they were assigned a unique identifier (ID) number to ensure anonymity of results[4]. They then filled in some demographic information (sex, age, DOB, ethnicity, handedness). Following on from this,

[4] Participants unique identified (ID) was stored separate from the data. The purpose of the unique ID was to later identify participants over time for longitudinal analysis (Study 3).

participants completed the two emotion tasks and the set of questionnaires. The task and questionnaire order was randomised using Qualtrics survey software. It took participants approximately 40 minutes to complete. Participants were then debriefed at the end of the session and were given the opportunity to ask questions. All responses were recorded using Qualtrics and later exported for coding and analysis in SPSS 21 statistical package.

4.2.4 Results

4.2.4.1 Design and Analysis

Due to the unbalanced sample of males and females, firstly a series of independent t-tests were run to assess if any sex differences existed for each of the variables measured (Bonferroni correction = .05/7, $\alpha = .007$). Independent t-tests found sex differences on the FER task, with females outperforming males. Further, females were found to be significantly higher on all measures of SA and on depression (see Table 4.1). There was no significant sex difference for the LQ score. In addition to checking for sex differences in hemispheric lateralisation for facial emotion processing, in line with other work, I explored if participants showed a hemispheric bias; one-sample t-tests (with 0 as the reference group, indicating no bias) supported that both males (t (76) = 6.21, $p < .001$) and females (t (463) = 12.52, $p < .001$) showed RH dominancy in their facial emotion processing (laterality scores were on average significantly higher than 0).

Given the sex differences in FER, SA and depression, separate simultaneous multiple regression analyses were run for males and females. For both regressions, FER accuracy was the outcome variable and the predictor variables were age, laterality quotient (LQ), the three sub-scale scores of SA (SAD-General, SAD-New, FNE) and depression. Descriptive statistics and t-tests are presented in Table 4.1, zero-order correlations are presented in Table 4.2.

Table 4.1. Means (SDs) for males and females on all measures. Independent samples t-test show significant differences.

Measure (range)	Male	Female	*t*	Total
FER (0-85)	58.22 (6.98)	60.46 (6.36)	0.83**	60.14 (6.49)
Age (11-17)	14.39 (1.89)	14.19 (1.74)	0.95	14.21 (1.76)
LQ (-1 – +1)	0.24 (0.33)	0.24 (0.41)	0.02	0.24 (0.40)
Depression (0-54)	9.51 (6.66)	13.42 (8.27)	3.94***	12.86 (8.17)
SAD New (6-30)	15.43 (5.13)	17.55 (4.97)	3.46***	17.25 (5.04)
SAD General (4-20)	8.34 (3.38)	9.83 (3.42)	3.56***	9.62 (3.45)
FNE (7-35)	14.31 (5.77)	19.08 (5.67)	6.74***	18.40 (5.92)

Note: ** $p \leq .007$. *** $p \leq .001$.

Table 4.2. Zero order correlations by sex. Males (n = 77) Females (n = 464).

	Age	LQ	Depression	SAD-New	SAD-Gen	FNE	FER
Age		.06	-.03	.06	.05	-.10	-.06
LQ	-.01		.02	.04	.04	-.01	.06
Depression	.25***	-.05		.22*	.31**	.44***	-.03
SAD-New	.12**	-.09*	.47***		.77***	.66***	.10
SAD-Gen	.09*	-.12**	.48***	.70***		.76***	.16
FNE	.09*	-.05	.68***	.59***	.70***		.10
FER	.08*	.05	-.18***	-.12**	-.15***	-.10*	

Note: Female correlations are shaded, males unshaded; *$p < .050$; ** $p < .010$; ***$p < .001$.

4.2.4.2 Predicting Facial Emotion Recognition (FER)

Regression tables for males and females can be found in Table 4.3. For males, the regression model was not significant, $F(6, 76) = 0.53$, $p = .784$; this indicates that including all of the predictors in the model did not improve the ability to predict the male participants' FER accuracy from chance. In contrast, for females, the model including the predictors was significantly better than chance, $F(6, 463) = 4.94$, $p < .001$, explaining 6.1% of the variance in FER accuracy. In the model, age was a significant positive predictor of FER and FNE was approaching significance as a positive predictor ($p = .057$). In contrast, depression and generalised avoidance and distress (SAD-Gen) were found to be negative predictors of FER. Social avoidance and distress specific to new situations (SAD-New) and laterality for emotion processing were not significant predictors of FER, after accounting for the variability explained by the other predictors.

Table 4.3. Regression tables predicting facial emotion recognition score, by sex.

	Males (n = 77)			Females (n = 464)		
	B	β	t	*B*	β	t
(Constant)	60.05	-	8.73	55.40	-	20.86
Age	-0.28	-0.08	-0.64	0.20	0.14	2.93^{**}
LQ	1.25	0.06	0.51	0.46	0.03	0.65
Depression	-0.09	-0.09	-0.65	-0.17	-0.22	-3.63^{***}
SAD-New	-0.08	-0.06	-0.29	-0.01	-0.01	-0.12
SAD-Gen	0.51	0.25	1.14	-0.27	-0.15	-2.00^{*}
FNE	-0.02	-0.02	-0.09	0.15	0.14	1.90^{+}

Note: $^{+}p < .06$; $^{*}p < .050$; $^{**}p < .010$; $^{***}p < .001$. *B* = unstandardized coefficients, β = standardized coefficients.

4.2.5 Discussion

The aim of this study was to examine to what extent age, degree of laterality for emotion processing, sub-scales of SA and depression could predict FER in adolescent males and females. It was found that the model with all predictors explained a significant amount of variance in FER for females only. As expected, older female adolescents showed stronger FER. When examining social-emotional predictors, as predicted, females who were higher in their generalised avoidance showed poorer FER performance. Similarly, higher level of depression in females predicted poorer FER. Importantly, there was a trend for females higher in FNE to show stronger FER (although not significant). Whilst generalised social avoidance negatively predicted FER, one sub-facet of SA, social avoidance and distress specific to new situations was not a significant predictor of FER, nor was degree of laterality for emotion processing. Unexpectedly, for males including the predictors did not improve the model beyond chance; no factors in the model were significant independent predictors.

In line with previous research, females were found to outperform males in their FER, supporting evidence that documents a female advantage in FER (Hoffman et al., 2010; Montagne, et al., 2005). Further, sex differences were also evident when examining measures of SA and depression, with females reporting significantly higher levels than males. These findings are consistent with evidence that sex differences in both SA and depression are more pronounced in adolescence (APA, 2015). In contrast, there was no significant sex difference in the degrees of laterality for emotion processing. These findings are inconsistent with adult literature, documenting that males may be more strongly lateralised for their processing of emotions than females (Bourne & Todd, 2004; Bourne, 2005, 2008). One explanation for the lack of differences between male and female laterality scores could be due to the increased levels of SA and depression in the female adolescents. Increased levels of SA and depression in females, may contribute to stronger patterns of lateralisation in the female sample. Additionally, hormonal fluctuations in female adolescents may influence how emotions are lateralised in the brain. For example, researchers have found evidence of fluctuations in cerebral lateralisation throughout the menstrual cycle (Hausmnann, 2005; Weis, Hausmannm Stoffers, & Strurm, 2008). Importantly, in line with previous research, males and females in this study showed RH dominance in their processing of emotions (Watling et al., 2012; Workman et al., 2006; Bourne, 2010).

For females, age significantly predicted FER, with older adolescents performing better. This is in line with previous literature (Lawrence, Campbell, & Skuse, 2015;

Scherf et al., 2012; Thomas et al., 2007), adding further support for the continued development of emotion recognition skills throughout late childhood and adolescence. Unexpectedly, there was not support of continued development in FER with age for males. These contradictory findings may be explained by the use of less intense emotional stimuli in this study. As highlighted in Section 1.4.1, females have been shown to have an advantage in FER, and this may be specifically evident in the recognition of mid and low intensity expressions (Hoffman et al., 2005). These findings could suggest that females' age-related improvements in FER could be the result of continued development of the recognition of subtle emotions. This idea needs further exploration in future research.

In contrast to findings with children (Watling & Bourne, 2013; Watling & Damaskinou, 2018), it was found that laterality for emotion processing was not a significant predictor of FER performance when social-emotional factors were included in the model with adolescents. Differences in these findings may be explained by the age differences of the samples used. As highlighted in Section 2.2.3, no research to date has examined laterality for emotion processing and its relationship with FER in adolescents. Patterns of laterality for emotion processing have been proposed to develop in parallel to increasing emotion recognition skills, both expecting to reach adult levels by 10-12 years (e.g., Watling et al., 2012). In this study the adolescents were already RH dominant in their processing of emotions, yet it was shown that age was a significant predictor for FER for adolescent females. The fact that laterality was not an independent predictor of FER may be the result of two things: in adolescence lateralisation for emotion processing is not important, or social-emotional factors are more important in predicting variability in FER. In

Study 3, I will examine to what extent changes in laterality for FER may predict later FER, after accounting for social-emotional factors.

Generalised social avoidance and distress (SAD-General) was a negative predictor of FER, with females who had higher social avoidance scores having poorer FER. It is known that social interactions are important for the acquisition of social skills (Simonian et al., 2001). In fact, research has associated level of generalised avoidance with the number of best friends, the intimacy of relationships, and perceived peer support (La Greca & Lopez, 1998). Importantly, positive peer interactions are important in building social skills (Parker & Gottman, 1989, 2006; Merrell, 1999). The findings presented here are consistent with evidence that preadolescent children who are higher in generalised avoidance show poorer decoding of emotions in voices (McClure & Nowicki, 2001). As highlighted previously, if children and adolescents avoid social interactions then it would be expected that they would have poorer FER due to lack of exposure; this is supported by our research but requires further research to better understand these relationships.

Whilst generalised avoidance was a significant negative predictor of FER in females, social avoidance specific to new situations was not. This finding is perhaps unsurprising given that individuals higher on SAD-General have been found to have more substantial impairments in social functioning than individuals higher on SAD-New (Golda, Ginsburg, Greca, & Silverman, 1998). In fact, it has been shown that adolescents belonging to submissive-rejected and neglected sociometric groups tended to have higher SAD-General, whereas there was no difference between sociometric groups for individuals high in SAD-New (Inderbitzen, Walters, & Bukowski, 1997). It may be that individuals who are high in SAD-New may show relatively minor impairments in FER. Unlike SAD-General, with SAD-New avoidance and inhibition allows for opportunities of socialisation within a familiar context, so individuals higher on SAD-New gain social feedback and experience that results in less profound social deficits (La Greca & Stone, 1993).

Interestingly, it was found that individuals who scored higher on FNE tended to show stronger FER, albeit this finding was only approaching significance. This may be explained by a negative interpretation bias in socially anxious individuals (Winton et al., 1995), or that individuals with high FNE show hypervigilance to threat (Leber, Heidenreich, Stangier, & Hofmann, 2009) and to emotional stimuli more generally (Rossignol et al., 2013). Given that the majority of our stimuli were negative (e.g., fear, anger, sad, disgust) this may explain this finding. Indeed, future research may wish to examine more closely how FNE may be related to the recognition of specific emotional stimuli.

As well as feelings of SA, it was demonstrated that female adolescents who reported higher depressive symptoms performed more poorly on FER. This is in line with the majority of work in the adult literature (for a review see Bourke, Douglas & Porter, 2010) and supports Mikhailova et al.'s (1996) finding with adults that depression is associated with an overall poorer emotion accuracy of schematic faces. This is also consistent with the limited work in this area conducted with children (e.g., Lenti et al., 2000); thus, supporting conclusions that depressed children and adolescents may have difficulties with FER.

It is thought that being more depressed may impact FER as a result of differences in information processing (see Asthana, Mandal, Khurana, & Nizamie, 1998); for example, there is evidence that individuals who are high on depression may show a lack of positivity bias (McCabe & Gotlib, 1995), which may impact recognition of positive emotional stimuli. They may also have mood-congruent biases (Bourke et al., 2010), which may lead to misattribution of sadness to emotional stimuli more generally. Such biases would be expected to link with poorer accuracy on FER, as depressed individuals may have an inability to discriminate between different emotional stimuli. Alternatively, given that depressed adults experience greater levels of distress when exposed to faces (Persad & Polivy, 1993), it may be that this leads to avoidance. Similar to the argument above for SAD-General, this may explain deficits in FER. Importantly, the association with depression and FER is independent of the association with SAD-General and FER; therefore, the avoidance in each may have differing impact on the individual, which requires further work.

As highlighted above, whilst social-emotional factors were able to predict FER in females, this was not the case for males. This could suggest that social-emotional factors are more important in predicting FER in females than in males. In fact, there is evidence that for females, but not males, SA is more strongly related to social functioning (La Greca & Lopez, 1998; Yonkers et al., 2001), and that for females, depression is more closely related to difficulties in FER (LeMoult et al., 2009). Importantly, in this study, males scored significantly lower on all measures of SA and depression in comparison to the females; it may be that without reaching higher levels of SA and depression that these factors are not influencing FER in the males. In order to examine how individual differences impact FER further, in Study 3, I will examine if changes in social-emotional factors and the lateralisation for emotion processing may predict later FER skills in females.

4.2.5.1 Conclusion

In Study 2, it was demonstrated that for females, but not males, age and social-emotional factors were able to predict FER. Specifically, it was demonstrated that females who scored higher on general avoidance were poorer in their FER and that females who were higher in FNE were stronger in their FER (albeit this was only approaching significance). It was also shown that females who were found to score higher in depression performed more poorly on the FER task. Together, the findings from this study highlight that social-emotional factors may be important in explaining FER in adolescent females. In contrast, FER was not predicted by social-emotional factors in males, which may be a consequence of significantly lower SA and depression scores in this sample. In Study 3, I will examine if changes in social-emotional factors and lateralisation for emotion processing are able to predict later FER in females; specifically, whether FER can be predicted from changes in these factors over six and 12 months.

4.3 Study 3

4.3.1 Introduction

In Study 2, it was shown that with age the females increased in their ability to recognise the facial expressions of emotion, and that their FER skills were related to social-emotional factors. This study will examine whether changes in the social-emotional factors and in lateralisation for emotion processing may predict later FER across three time points, six months apart.

To date, some researchers have found individual differences in the stability of both symptoms of SA (Beesdo-Baum et al., 2012) and depression (Holsen, Kraft, & Vitterso, 2000;Rushton, Forcier, & Schectman, 2002;) throughout adolescence, implying that levels of both SA and depression may change across the adolescent period. This raises the question as to whether FER skills in adolescents may be predicted from individual differences in changes in social-emotional factors over time. In clinical samples, adolescent reduction in depressive symptoms has been associated with improved parent reported social skills (Spence, O'shea, & Donovan, 2016), providing support for the notion that changes in depressive symptoms may be associated with improvements in social skills (more specifically FER). In SA, social withdrawal over time may limit opportunities to develop social skills (Biggs, Vernberg, & Wu, 2012); therefore, changes in social anxiety over time may play a role in developing social skills (more specifically FER). Taken together, it is expected that changes in facets of SA and depression may explain variance in later FER skills.

Patterns of lateralisation for emotion processing, may also show changes across the adolescence period, which may explain variance in later FER skills. As highlighted earlier, researchers have found evidence that degree of laterality for facial emotion processing may be impacted by hormones. For example, researchers have found evidence that there are fluctuations in cerebral lateralisation across the menstrual cycle (Hausmnann, 2005; Weis, Hausmannm Stoffers & Strurm, 2008). It may therefore be expected that the patterns of lateralisation for emotion processing will fluctuate across the adolescent period. Further, as discussed earlier (see Section 2.2.2.3 and 2.2.2.4), researchers have found links between social-emotional factors and degree of lateralisation for emotion processing suggesting that across adolescence patterns of lateralisation for emotion processing may change as a result of social-emotional factors. Given previous links between degree of lateralisation for emotion processing and FER skills, it may be expected that changes in patterns of lateralisation for emotion processing may relate to later FER. Given that these factors (i.e., hormones and social-emotional factors) may impact the degree of lateralisation for emotion processing across the adolescent period, in this study I explore if changes in lateralisation for emotion processing may predict later FER skills.

Notably, Watling and Damaskinou (2018) showed that changes in degree of laterality for emotion processing across one year predicts later emotion skills in children when task demands are more difficult. They found that changes in patterns of lateralisation towards the RH predicted performance on the emotion matching task, but it did not predict performance on the easier emotion discrimination task where all children were performing close to ceiling (emotions were presented at 100% intensity). Watling and Damaskinou suggest that relationships may be found between patterns of lateralisation for emotion processing and emotion recognition ability when the task is more difficult (either not yet developed the skills, or the task is more demanding). In this study, it may therefore be expected that changes in the degree of hemispheric lateralisation for emotion processing towards the RH may predict later FER on this task as I have varied the intensity to reduce ceiling effects. In the following study, this research will examine to what extent changes in lateralisation for emotion processing may predict later FER, after accounting for initial lateralisation and changes in social-emotional factors.

In summary, no research to date has examined how changes in social-emotional factors and the degree of lateralisation for emotion processing may explain variance in later FER in adolescents. As highlighted above, social-emotional symptoms may fluctuate across the adolescent period, which is expected to play a role in later FER skills. Patterns of lateralisation for emotion processing are also believed to fluctuate across the adolescent period, due to hormonal factors and as a result of social-emotional symptoms. Taken together, this study aims to address whether changes in these factors over time can predict later FER. Importantly, given that in Study 2 the social-emotional factors were only important in predicting FER in females, not males, and that females were significantly higher in all measures of SA and depression, this study includes a female only sample. The current study follows female adolescents from Study 2 that agreed to take part in the longitudinal study (aged 11-17) across a one-year period, using identical measures after approximately six months (time two) and then again six months later (12 months; time 3). Three separate analyses will be run to predict FER at time one (as this study only included a sub-set of females recruited for longitudinal examination, the analysis was repeated to examine if the same effects were held with the reduced sample), time two and time three, respectively, to assess:

(1) To what extent can FER in adolescent females be predicted from age, facets of SA, depression and degree of lateralisation for emotion processing? (identical analysis as Study 2)

(2) To what extent can FER in an adolescent females be predicted six and 12 months after initial evaluation from changes in levels of SA, depression and degree of lateralisation over time (after accounting for initial scores)

4.3.2 Methods

4.3.2.1 Participants

All schools who took part in Study 2 were asked if they would be happy to continue taking part in our longitudinal study. Therefore, participants at the first time point were a subset of those presented in Study 2. In total, 404 or the 464 female adolescents from Study 2 agreed to take part in the longitudinal research study. Due to incomplete data, the final sample at time 1 consisted of 389 adolescents aged 11 –

17 years (M_{age}=13.96 years, *SD*=1.63), who were 78.5% White, 11.5% Asian, 1.5% Black, 5.5% Mixed, 0.5% other. Ethnicity data was not provided by 2.5% of the sample (*n*=9). As in Study 2, handedness data was collected; however, given that the outcome variable is FER all participants were included in this study regardless of handedness (see Appendix 1, Table 7.3 for handedness of sample for each time-point).

Of those initially seen, 199 adolescents participated at time 2, on average 184.89 days after time 1 (SD=2.38, range 184-192), and 194 adolescents participated at time 3, on average 369.38 days after initial testing at time 1 (SD=7.22, range 320-379 days). Due to some variations in the duration between testing points, time (in days) from initial testing will be included as a control variable in subsequent analyses. There was a higher attrition rate than expected; this was primarily due to older adolescents in the sample changing schools during this period (transition to pre-tertiary education). Participants who took part in all three-time points were compared on all initial time one measures to those who did not take part in the final testing. Independent samples t-tests (with Bonferonni correction applied α =.007) demonstrated those who were included in the final sample differed on initial age only (see Table 4.4.). As discussed above, this supports that this is likely to due to the high attrition of the older adolescents in the sample.

Table 4.4. Means (SD) on participants included in all three time points of data collection compared to those who were not (drop-out).

	Included	Not included	T
FER	60.56 (6.47)	59.95 (6.31)	0.95
Age	13.63 (1.68)	14.23 (1.51)	4.01***
LQ	0.23 (0.41)	0.25 (0.41)	0.47
Depression	12.28 (7.83)	13.86 (8.55)	1.91
SAD New	16.92 (4.60)	17.84 (5.29)	1.83
SAD General	9.65 (3.23)	10.08 (3.55)	1.25
FNE	0.23 (0.41)	0.25 (0.41)	1.58

Note: $^{***}p < .001$; Bonferroni correction $\alpha \leq .007$.

4.3.2.2 Materials and Procedure

The methods and procedure used were identical to that reported in Study 2 (see 4.2.3). Participants were seen at three time points across a one-year period, approximately six months apart. In all sessions, participants completed in a randomised order all questionnaire measures (assessing depression and SA, see Section 4.2.3.2) and the two emotion-based tasks, to assess lateralisation for emotion processing (the NimStim CFT; see Chapter 3 for stimuli development), as well as a FER task (see Section 4.2.3.2). SA sub-scale scores and depression showed good – excellent levels of internal consistency at all time points (see Table 4.5.).

Table 4.5 Reliability statistics: Cronbach's alpha for measure of SA and depression at each time point.

	Time 1 (N=389)	Time 2 (N=199)	Time 3 (N=194)
SAD- General	.82	.82	.80
SAD-New	.86	.87	.89
FNE	.94	.95	.95
Depression	.90	.93	.92

4.3.3 Results

4.3.3.1 Changes over time

A repeated-measures multivariate analysis of variance (MANOVA) was run to examine whether there were significant changes in each of the variables over time. The independent variable was time with three levels (initial, 6 months, and 12 months). The dependent variables were FER, lateralisation for emotion processing, the three sub-scale scores of SA, and depression. Means and standard errors for each of these variables at each visit time point are shown in Table 4.6.

Table 4.6. Means (standard errors) for the final time point sample (N = 194), assessing change in variables over time.

	Time 1	Time 2	Time 3
	Mean (*SE*)	Mean (*SE*)	Mean (*SE*)
FER	60.57 (0.47)	63.05 (0.49)	62.65 (0.69)
LQ	0.23 (0.03)	0.29 (0.03)	0.21 (0.03)
Depression	12.25 (0.57)	12.33 (0.61)	13.13 (0.66)
SAD-New	16.92 (0.33)	16.88 (0.36)	16.92 (0.37)
SAD-Gen	9.64 (0.23)	9.65 (0.25)	9.88 (0.24)
SAD-FNE	18.58 (0.42)	17.89 (0.40)	18.48 (0.41)

There was a significant multivariate effect of time, $F(12, 181) = 3.92$, $p < .001$, $\eta^2 = .21$. Univariate ANOVA's showed no significant main effect of time for depression scores and for the three facets of SA subscale scores (*ps* >.05). However, there was a significant main effect of time for degree of laterality, $F(2, 384) = 3.81$, $p = .023$, $\eta^2 = .02$, and for FER, $F(1.71, 327.80) = 9.99$, $p < .001$, $\eta^2 = .21$. Pairwise comparisons with Bonferroni corrections showed that for degree of laterality, there was no significant difference in degree of laterality between time 1 and time 2 ($p = .089$) or between time 1 and time 3 ($p = 1.000$), but there was a significant decrease in laterality scores between time 2 and time 3 ($p = .046$; see Section 4.3.3.1). Pairwise comparisons with Bonferroni corrections showed that FER significantly increased between time 1 and time 2 ($p < .001$) and between time 1 and time 3 ($p = .007$) but did not significant differ between time 2 and time 3 ($p = 1.00$; see Section 4.3.3.1).

4.3.3.2 Predicting Facial Emotion Recognition (FER)

A simultaneous multiple regression predicting FER at time 1 (initial) and two hierarchical multiple regressions predicting FER at time 2 (6 months) and 3 (12 months), respectively. Descriptive statistics, including the means (SDs) are presented in Table 4.7 for the participants included in the analyses at each time point.

As in Study 2, the first regression aimed to examine whether FER can be predicted from the core predictors of interest, including age, laterality for emotion processing (LQ), the three facets of SA (FNE, SAD-New, and SAD-General) and depression, with the female adolescents who agreed to take part in the longitudinal study. Due to some variation in the differences in the amount of times between sessions, times from initial testing was included as a control, as was initial FER score when examining predictors of FER at time 2 and 3 (included in block 1). To assess whether FER could be predicted 6 months later, after taking into account initial scores on the core predictors (block 2), change scores from time one to time two for the core predictors (calculated as T_2- T_1) were included in block 3. The final regression analysis was run to examine whether FER could be predicted 12 months later, after accounting for initial scores on the core predictors (block 2), change scores from time one to time three for the core predictors (calculated as T_3-T_1) were included in block 3.

Table 4.7. Means and Standard Deviation (SD) of all measures at each time point.

	Time 1(*N*=389) Mean (*SD*)	Time 2(*N*=199) Mean (*SD*)	Time 3(*N*=194) Mean (*SD*)
Age	13.96 (1.63)	13.62 (1.03)	14.66 (1.67)
FER	60.25 (6.39)	62.03 (8.63)	62.54 (9.72)
LQ	0.24 (0.41)	0.28 (0.44)	0.21 (0.45)
Depression	13.07 (8.22)	12.73 (9.41)	13.16 (9.15)
SAD-New	17.38 (4.97)	16.72 (4.97)	16.95 (5.10)
SAD-Gen	9.86 (3.40)	9.56 (3.51)	9.88 (3.30)
SAD-FNE	19.02 (5.73)	18.24 (5.84)	18.50 (5.72)

Predicting Time 1 (T1) Facial Emotion Recognition

Zero order correlations for the predictors and outcome variable at time 1 are presented in Table 4.8. The model was found to predict FER significantly better than chance, $F(6,382) = 5.69$, $p < .001$, explaining 8.2% of the variance in FER time 1 scores. Consistent with Study 2, age and FNE were positive predictors of FER, and SAD-General and depression were significant negative predictors of FER (see Section 4.2.4.2). SAD-New and lateralisation for emotion processing were not significant predictors after considering the variability explained by the other predictors.

Table 4.8. Zero order correlations between time 1 variables (N = 389).

	2.	3.	4.	5.	6.	7.
1. Age	.07	-.03	$.27^{**}$	.08	$.09^{+}$	.05
2. FER	-	.08	$-.21^{**}$	$-.15^{*}$	$-.19^{**}$	$-.12^{*}$
3. LQ		-	-.05	$-.10^{+}$	$-.13^{*}$	-.06
4. Depression			-	$.37^{**}$	$.38^{**}$	$.54^{**}$
5. SAD-New				-	$.71^{**}$	$.60^{**}$
6. SAD-General					-	$.70^{**}$
7. FNE						-

Note: $^{+}$ $p \leq .10$; * $p \leq .05$; ** $p \leq .001$

Table 4.9. Regression analyses. Predicting T_1, T_2 and T_3 FER.

	Predicting FER_{T1} (N = 389)			Predicting FER_{T2} (N = 199)			Predicting FER_{T3} (N = 194)		
	B	β	t	*B*	β	t	*B*	β	t
Control variables									
(Constant)				-62.75	-	-1.54	66.61	-	1.89
Days from T_1				0.47	0.13	2.09^{*}	-0.10	-0.07	-1.08
FER_{T1}				0.65	0.49	8.04^{**}	0.53	0.35	5.21^{**}
Time 1 variables									
(Constant)	55.51	-	18.37	-45.19	-	-1.03	41.37	-	0.78
Days from T_1				0.42	0.12	1.78^{+}	-0.06	-0.04	-0.48
FER_{T1}				0.61	0.47	7.26^{**}	0.51	0.34	4.97^{**}
Age	0.52	0.13	2.62^{*}	-0.56	-0.07	-1.05	0.21	0.04	0.38
LQ_{T1}	0.83	0.05	1.08	1.10	0.05	0.82	4.71	0.20	2.96^{*}
$Depression_{T1}$	-0.18	-0.24	-3.63^{**}	-0.16	-0.16	-1.88^{+}	-0.24	-0.19	-2.01^{*}
SAD-New_{T1}	-0.02	-0.02	-0.26	0.06	0.03	0.35	0.26	0.12	1.30
SAD-Gen_{T1}	-0.36	-0.19	-2.43^{*}	0.16	0.06	0.63	0.34	0.11	1.03
FNE_{T1}	0.20	0.18	2.21^{*}	-0.01	-0.01	-0.07	0.09	0.05	0.48
Change scores									

(Constant)		-51.59	-	-1.28	37.82	-	0.70
Days from T_1		0.45	0.13	2.09*	-0.06	-0.04	-0.43
FER_{T1}		0.60	0.46	7.86**	0.52	0.35	5.01**
Age		-0.49	-0.06	-1.00	0.27	0.05	0.47
LQ_{T1}		1.53	0.07	1.17	5.42	0.23	3.20*
$Depression_{T1}$		-0.17	-0.17	-2.16*	-0.23	-0.19	-1.90^{+}
SAD-New_{T1}		0.23	0.13	1.25	0.23	0.11	1.00
SAD-Gen_{T1}		-0.53	-0.20	-1.72^{+}	0.31	0.10	0.71
FNE_{T1}		0.19	0.13	1.22^{+}	0.09	0.08	0.58
LQ_{change}		3.48	0.15	2.46*	3.38	0.13	1.84^{+}
$Depression_{change}$		-0.36	-0.23	-3.71**	-0.13	-0.09	-1.11
SAD-New_{change}		-0.11	-0.05	-0.66	-0.06	-0.02	-0.27
SAD-Gen_{change}		-0.92	-0.30	-3.56**	0.03	0.01	0.08
FNE_{change}		0.30	0.16	1.89^{+}	0.12	0.06	0.55

Note: $^{+}$ $p \leq .10$ * $p \leq .05$ ** $p \leq .001$, Change scores calculated as T_2-T_1 for predicting T_2 FER and T_3-T_1 for predicting T_3 FER. *B* = unstandardized coefficients, β = standardized coefficients.

Predicting Time 2 (T_2) Facial Emotion Recognition

Zero-order correlations for the predictors and outcome variable at time 1 and 2 are presented in Table 4.10. The first block was significant, $F(2,196) = 36.92$, $p < .001$, explaining 27.4% of the variance in FER scores at time 2. Adding age, and time 1 predictors (laterality quotient, SA facets and depression) did not significantly improved the model, $F(6,190)= 1.33$, $p = .247$. Importantly, adding change scores from time 1 to time 2, in block 3 significantly improved the model, $F(5, 185) = 9.35$, $p < .001$. The final model was significant, $F(13, 185) = 11.34$, $p < .001$, explaining 44.3% of the variance in FER scores.

In the final model, as expected, time 1 FER significantly and positively predicted later FER. Initial depression scores at time 1, negatively predicted FER at time 2. As expected, changes in social-emotional factors were predictors of FER at time 2, with increases in generalised avoidance and distress and increases in depressive symptoms between time 1 and 2 predicted poorer FER at time 2. Changes in FNE were approaching as a significant positive predictor of later FER. Further, changes in laterality for emotion processing towards the RH (increases) between time 1 and 2 significantly predicted better FER at time 2 (see Table 4.10).

Predicting Time 3 (T_3) Facial Emotion Recognition

Zero-order correlations for the predictors and outcome variable at time 1 and 3 are presented in Table 4.11. The first block was significant, $F(2,191) = 15.37$, $p < .001$, explaining 13.9% of the variance in FER. In block 2, adding age, time 1 predictors (laterality quotient, SA facets and depression) significantly improved the model, $F(6,185) = 2.69$, $p = .016$, explaining an additional 6.9% of the variance in FER at time 3. Interestingly, including change scores from time 1 to time 3 did not significantly improve the model, $F(5,180) = 1.05$, $p = .393$; although changes in laterality from time 1 to time 3 was approaching significance as a positive predictor of FER at time 3 ($p = .068$).

The final accepted model was model 2; this model was significantly better than chance at predicting FER scores at time 3, $F(13,180)= 4.14$, $p < .001$, accounting for 23.0% of the variance. In the final model time 1 FER and laterality for emotion processing were significant positive predictors of FER at time three. Baseline (time 1) depression was a significant negative predictor of FER at time 3.

Table 4.10. Table of Correlations for Time 2 analysis (*N* = 199).

		2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1.	FER$_1$	.51**	-.03	.08	-.24**	-.11^{+}	-.22**	-.11^{+}	-.04	.01	.05	.07	<.01
2.	FER$_2$		-.13*	.09^{+}	-.24**	-.04	-.11^{+}	-10^{+}	.10	-.22*	-.14*	-.24**	-.09
3.	Age$_2$			-.02	.29**	.13*	.17*	.20*	.02	-.01	-.07	-.03	-.18*
4.	LQ$_1$				-.03	-.11^{+}	-.10^{+}	-.07^{+}	-.33**	-.04	<.01	-.06	<.01
5.	Depression$_1$					.46**	.52**	.66**	-.07	-.17**	-.12*	-.02	-.20**
6.	SAD-New$_1$						.68**	.62**	-.02	-.03	-.35**	<-.01	-.16^{+}
7.	SAD-Gen$_1$							.70**	.01	-.09	-.09	-.33**	-.13*
8.	FNE$_1$								<.01	-.02	-.14*	-.13*	-.39**
9.	LQ $^{T1\text{-}T2}$									.08	.03	-.09	-.06
10.	Depression$^{T1\text{-}T2}$										.29**	.27**	.29**
11.	SAD-New $^{T1\text{-}T2}$											.34**	.49**
12.	SAD-Gen $^{T1\text{-}T2}$												.46**
13.	FNE$^{T1\text{-}T2}$												

Note: $^{+}$ $p \leq .10$; * $p \leq .05$; ** $p \leq .001$

Table 4.11. Table of Correlations for Time 3 (T_3) analysis. (N = 194).

	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
FER$_1$	.37**	.12^{+}	.02	-.20*	-.06	-.16*	-.08	-.10^{+}	-.03	.04	.13*	.05
FER$_3$	-	.10^{+}	.17*	-.07	.12*	.07	.06	.05^{+}	-.11^{+}	-.04	<.01	-.01
Age$_3$		-	-.06	.26**	.19*	.19*	.20*	-.05	-.16*	-.07	-.16*	-.25**
LQ$_1$			-	.05	-.05	-.08	-.05	-.33**	-.12*	.01	.03	.03
Depression$_1$				-	.48**	57**	.68**	-.08	-.21*	-.13*	-.23**	-.33**
SAD-New$_1$					-	.68**	.61**	.04	-.08	-.26**	-.12^{+}	-.23**
SAD-Gen$_1$						-	.73**	.08	-.12*	-.12*	-.46**	-.30**
FNE$_1$							-	.06	-.09	-.08	-.20*	-.41**
LQ $^{T1-T3}$								-	-.03	-.04	-.12*	-.05
Depression $^{T1-T3}$									-	.29**	.35**	.45**
SAD-New^{T1-T3}										-	.45**	.47**
SAD-Gen^{T1-T3}											-	.47**
FNE^{T1-T3}												-

Note: $^{+}$ $p \leq .10$; * $p \leq .05$; ** $p \leq .001$

4.3.4 Discussion

The aims of this study were to examine if FER in adolescence can be independently predicted by facets of SA, depression and degree of lateralisation for emotion processing. Additionally, this study aimed to assess, whether FER could be predicted from changes in these factors over time (six and 12 months after baseline measures taken), after accounting for scores on these measures at baseline (time one). Overall, the findings highlight that FER in adolescents can be predicted by social-emotional factors, and that FER over time can be predicted from both changes in social-emotional factors and changes in the degree of lateralisation for emotion processing. Interestingly, the importance of social-emotional factors and the degree of lateralisation for emotion processing differ across the one-year period examined. In predicting FER at time one, social-emotional factors were significant predictors, when also accounting for lateralisation for emotion processing, whereas over time there is an interplay between the importance in changes in social-emotional factors and changes in degree of emotion processing. Interestingly, when predicting FER at 12 months, changes in social-emotional factors appeared less important, while initial laterality score and changes in lateralisation for emotion processing over the year were important.

4.3.4.1 Predicting Time 1 FER.

As expected, using a sub-set of females from Study 2 produced the same pattern of results. Again, age was a significant positive predictor of FER – older adolescents had better FER. Social-emotional factors were also significant predictors, as with Study 2, adolescents higher on measures of generalised avoidance distress performed more poorly on FER, whereas individuals higher on FNE performed better on FER (now significant). Social avoidance and distress specific to new situations did not significantly predict FER. Adolescents higher on depression were poorer in their FER and lateralisation for emotion processing was not a significant predictor of FER. For a more detailed discussion of these findings, see Section 4.2.5. Given that the main aims of this study are to examine individual differences in FER over time, here I focus predominantly on the longitudinal findings.

4.3.4.2 Predicting Time 2 FER: 6 months after initial measures.

It was found that FER six months after baseline was predicted from initial level of depression, as well as changes in depression over time – higher levels of depression initially (time 1) predicted poorer FER six months later and increases in depression over the six-month period predicted decreases in FER scores, after accounting for initial (time 1) and when accounting for changes in SA and lateralisation for emotion processing. These findings highlight that level of depression may have a long-lasting impact on FER skills. In fact, some evidence has found that patients who are currently in remission for depression still show some difficulties in FER (LeMoult, Joormann, Sherdell, Wright, & Gotlin, 2009). Whilst the overall group means for depression did not appear to change significantly over the six-month period, it was demonstrated that adolescents who showed increases in their level of depression over six months were poorer in their FER at time 2, suggesting that changes in level of depression over time may be associated with FER skills.

Interestingly FER six months after baseline was not predicted by initial levels of SA, but changes in SA over time were significant predictors. Specifically, increases in general avoidance and distress predicted poorer FER at time 2. These findings support the notion social avoidance may be detrimental for social skills (Biggs, Vernberg, & Wu, 2012). As highlighted in Section 1.3.1, social exposure is important for the acquisition of non-verbal decoding skills and individuals who show increased levels of social withdrawal and avoidance, may be limited in opportunities to learn these skills from their social environments (Biggs, Vernberg, & Wu, 2012). Approaching significance was also a trend whereby increases in FNE were positively associated with FER at time two, providing some indication that changes in level of FNE may be associated with later FER skills in female adolescents.

Importantly, when accounting for initial and changes in social-emotional factors, changes in FER across approximately a 6-month period were predicted from changes in the degree of lateralisation for emotion processing. Becoming more RH dominant in degree of lateralisation for emotion processing predicted better FER performance six months later. Interestingly, initial laterality scores (time 1) did not predict FER at time 2. These findings are in line with research in children (i.e., Watling & Damaskinou, 2018) when the task was more difficult (performance not at ceiling) that show that changes towards the RH for the processing of emotions is associated with increased FER skills over time, but that initial laterality for emotion processing was not a significant predictor of later FER. From the MANOVA, it can be seen that FER is significantly improving between time 1 and time 2; it could be that further increases towards the RH in the processing of emotions support better FER over time.

Degree of lateralisation for emotion processing may be related to later FER, given that it is known that hormones and social interactions may influence how emotions are processed in the brain (Watling et al., 2012). When predicting FER at time 1, social-emotional factors, but not lateralisation, were important in explaining variance in FER. It could be that when FER skills are compromised that the RH may attempt to compensate. In fact, researchers have found evidence of increased RH activation in patients with depression (Fu et al., 2008) and have suggested that the RH may attempt to compensate for functional inefficiencies of the RH (see Rotenberg, 2004; for review; Watling & Damaskinou, 2018). It is therefore likely, that alongside individual changes in social-emotional factors during this period, there may also be changes in the processing of emotions.

4.3.4.3 Predicting Time 3 FER: 12 months after initial measures.

When examining predictors of FER approximately one year after initial testing, the results of our analyses show that baseline measures (time 1) of depression and laterality for emotion processing predicted later FER; individuals higher in depression at baseline were poorer in their FER one year later, and those who were more RH dominant for their emotion processing at time one were stronger in their FER one year later. When change scores were including in the model, the model did not significantly improve; yet, changes in laterality for emotion processing (increases in patterns of RH processing) was approaching as a positive predictor of later FER performance.

Similar to findings predicting FER at six months, initial levels of depression, but not SA was a significant negative predictor of FER after one year, providing further support that that level of depression may be associated with long-lasting links with FER skills in adolescents (LeMoult, Joormann, Sherdell, Wright, & Gotlin, 2009). Importantly, when change scores were included in the model, initial level of depression was no longer a significant predictor of FER. It is possible that changes in laterality for emotion processing over this time period accounted for shared variance between lateralisation and social-emotional factors at this time.

It was found that adolescents who were more RH dominant for emotion processing at time 1 showed stronger FER performance 12 months later (time 3). This is in contrast with the previous findings; laterality for emotion processing was not a significant predictor of FER at baseline after accounting for other variables within the model. Similarly, laterality for emotion processing at baseline did not predict FER six months later, after accounting for other variables within the model. Instead it was changes in laterality for emotion processing (towards the RH) that predicted FER at six months. Importantly, it could be that FER skills for adolescents who were initially more strongly lateralised to the RH for emotion processing may be protected from being affected if they become more socially anxious or more depressed across the year (typically linked to decline in FER performance). In fact, correlations showed that adolescents who were more RH dominant in their emotion processing to begin with showed less change in laterality for emotion processing over time.

It is important to note that whilst in this study there were changes in social-emotional factors and lateralisation for emotion processing over time; these were calculated over a one-year period; therefore, it is possible that the differences in the findings may be the result of FER stabilising. In fact, when examining changes in variables over time, it was found that whilst FER significantly improved between the first and last time point, there was no significant change in FER skills between time point 2 and 3. This may therefore suggest that changes in social-emotional factors may be important predictors of FER when emotion skills are developing and that lateralisation for emotion processing may be more important once these skills are developed.

Changes in laterality for emotion processing across the year was approaching as a significant positive predictor of FER at 12 months after baseline, providing further support for a positive relationship between increased RH processing and improvements in FER. Given that over time fluctuations in symptoms of SA and depression may influence how emotions are processed in the brain, it could be argued that emotion processing may be experience dependent, such that changes in the environment (i.e., changes in SA and depression) may lead to changes in lateralisation for emotion processing over time (Watling, Workman, & Bourne, 2012; Greenough, Black, & Wallace, 1987). In fact, the data appear to support this – showing that changes in generalised avoidance and distress were negatively correlated to changes in laterality for emotion processing across the year. Previous research has found evidence that during remission patients with depression show improvements in their FER or emotional stimuli presented primarily presented in their left-visual field (indicative of RH processing). These findings highlight the importance of the RH in emotion processing and suggests that social experience may play important role in lateralisation for emotion processing and its relationship with FER skills.

4.4 General Discussion

The aim of this Chapter was to examine to role of social-emotional factors and lateralisation for emotion processing in predicting changes in FER in adolescents. Specifically, in Study 2 the aim was to examine to what extent facets of SA, depression and lateralisation for emotion processing could predict FER for male and female adolescents. The results of this study highlighted the importance of social-emotional factors in predicting FER in females but not males. In particular, as predicted, the facets of SA were related to FER in different directions – whilst generalised avoidance was a negative predictor of FER, FNE was a positive predictor. As researchers have argued that SAD is multifaceted disorder (Moscovitch, 2009), this may explain why we see two distinct trends here. Typically, researchers have used aggregate scores on questionnaires as a measure of SA (e.g., Silvia et al., 2006). Given the findings presented here, with opposing relationships between FNE and SAD-Gen with FER, the null effects that have been found in previous work may be explained through facets in SA cancelling one another out. These findings emphasize the need for further research into how specific facets of SA may be related to FER.

As predicted, level of depression was found to be a negative predictor of FER (specifically in females). Importantly, as highlighted in Section 4.1, little research to date has examined how depressive symptoms in adolescence may relate to FER, with the majority of research focussing on adult populations. Here it is demonstrated that level of depression may also be an important factor in explaining variance in adolescents FER skills. It is important to note that these relationships were not seen in males. As highlighted above, one potential explanation for this may be due to the fact that males scored significantly lower on all measures of SA and depression; it may be that without reaching higher levels, these factors may not be impacting FER skills.

To follow up how social-emotional factors and emotion processing in the brain may influence FER in females, I conducted a longitudinal study (Study 3). Importantly, the decision was made to keep in laterality in the model, as it is believed that lateralisation for emotion processing may fluctuate to compensate for changes in social-emotional factors (Watling & Damaskinou, 2018). Study 3 therefore aimed to examine whether later FER at both six and 12 months after baseline could be predicted by changes in social-emotional factors and lateralisation for emotion processing over time, after accounting for initial scores on these measures. The longitudinal findings show that changes in social-emotional factors and the lateralisation for emotion processing can significantly predict later FER skills. Importantly, whilst increases in level of depression and generalised avoidance of distress predicted poorer FER at six months, and changes in patterns of lateralisation towards the RH predicted better FER at six months, these findings were not present when predicting FER at 12 months. On this occasion, initial laterality for emotion processing was an important predictor of FER one year later. As well as this, becoming more RH dominant for emotion processing was approaching as a significant positive predictor of FER. Taken together these findings highlight that over the course of adolescence that there is an interplay between social-emotional factors and the lateralisation for emotion processing on the ability to recognise facial affect.

In light of the findings reported above, there are several critiques of the study that should be considered. Firstly, it must be acknowledged that the male sample in Study 2 was considerably smaller than that of the females, and that this may in part explain why the model was not significant (insufficient power to detect an effect). Albeit, the findings were in line with some work that does suggest that social-emotional factors may be more closely linked to females' social skills than males (Ginsburg, La Greca, & Silverman, 1998). Future research would benefit from a more in-depth examination of these factors and how they may relate to FER in male sample. Unfortunately, this study suffered from a high attrition rate, primarily due to adolescents changing school within the testing period, although the initial and last sample only differed on age (older students lost), the large drop-out may have reduced the power across time points.

In this study, FER was assessed using a mixture of low, mid and high intensity emotional expressions in order to calculate an overall accuracy score for each participant at each time point. Future research may benefit from examining more closely whether these relationships may be more closely related to specific emotions or at specific intensities. In fact, as discussed in Section 2.1.1.2 and 2.1.2.2, individuals with high levels of SA and depression may show differences in the recognition of specific emotions (e.g., Bedio et al., 2009; Tseng et al., 2017), and there is evidence of increased sensitivity (e.g., Arrais et al., 2010; Bento de Souza et al., 2014) or decreased sensitivity (Csukly et al., 2009; Montagne et al., 2006) to different emotional expressions. Additionally, previous research has suggested that both socially anxious individuals and individuals high in depression may show negative biases in their recognition of emotions (e.g., Amin, Foa, & Coles, 1998; Punkanen, Eerola, & Erkkila, 2011). In Chapter 5, I will examine how differences in the level of SA, depression and laterality for facial emotion processing may relate to differences in FER of different emotions and at different intensities.

4.4.1 Conclusions

Taken together, the results from Study 2 and 3 suggest that: (1) social-emotional factors are important in explaining variance in female adolescent FER – importantly, level of depression was negatively associated with FER and different facets of SA were associated with FER in different ways (2) over time, changes in both social-emotional factors and lateralisation for emotion processing may predict later FER skills; and, (3) over time, there is an interplay between laterality for emotion processing and social-emotional factors in explaining variance in FER ability in adolescents.

5 Face scanning and Emotion Recognition

5.1 General Introduction

The ability to successfully recognise facial affect has been established as a fundamental component of social cognition (Frommann, Streit, & Wölwer, 2003). As highlighted in previous chapters, poor facial emotion recognition (FER) has been recognised as central characteristic in many neuropsychiatric disorders (e.g., Kornreich & Philippot, 2006). In recent years, a growing body of literature has begun to examine how social anxiety (SA) and depression may influence the ability to recognise facial emotions. Alongside this, researchers have begun to employ the use of eye-tracking technology to examine how individuals with SA and depression may differ in their scanning of emotional content. Eye-tracking allows a continuous direct measure of gaze location, which is tightly coupled with allocation of attention (Wright & Ward, 2008), and there is evidence that accuracy of FER may be linked to visual attention (Hall, Hutton, & Morgan, 2010; Nacewicz et al., 2006; Sullivan et al., 2007). Indeed, significant associations have been found between dwell time on the eye region and accuracy and speed of FER (Hall et al., 2010), and difficulties in FER have been linked to few spontaneous fixations to the eyes (Adolphs et al., 2005). This chapter focuses on examining differences in how those higher in SA and depressive symptoms, and those who are more right-hemisphere (RH) dominant for their facial emotion processing may attend to faces when completing a FER task. Given the research above, it may be that any differences found in FER may be linked to differences in the scanning of informative regions that may be necessary for the identification of facial emotions.

As highlighted in Chapter 1 (see Section 1.4), during FER individuals preferentially attend to salient 'features' of the face, showing an inverted triangle scan-path (Walker-Smith, Gale, & Findlay, 1977; Yarbus, 1967), primarily scanning the eyes, nose and mouth. Individuals typically scan regions that may be more informative for the successful recognition of emotions (Eisenbarth & Alpers, 2011; Yarbus, 1967). While the nose has been found to be important in the expressing of disgust (Bassili, 1979; Calder et al., 2010) and anger (Wells, Gillespie, & Rotshtein, 2016), researchers typically emphasise the importance of the eye region and mouth in FER (Eisenbarth & Alpers, 2011; Kestenbaum, 1992). As discussed in Section 1.4, the eyes have been found to be the dominant feature in the recognition of sadness, fear, anger and surprise (Eisenbarth & Alpers, 2011; Kestenbaum, 1992; Schurgin et al., 2014) and the importance of the mouth region has been put forward as imperative in recognition of happiness and disgust (Eisenbarth & Alpers, 2011; Kestenbaum, 1992). Much research has highlighted the importance of the eyes as a critical source of emotion information (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001); in fact, the eyes have been found to receive the majority of fixations during face scanning (Lundqvist, Esteves, & Öhman, 1999; Walker-Smith et al., 1977; Wegrzyn, Vogt, Kireclioglu, Schneider, & Kissler, 2017). Examining where individuals are scanning when completing a FER task, may shed light on some of the behavioural outcomes in FER of these individuals.

The aims of this chapter are therefore to examine differences in how those higher and lower in social anxiety, higher and lower in depressive symptoms, and who are more RH dominant (compared to bilateral) for their emotion processing attend to faces when completing a FER task. In particular, I will focus on whether these groups show differences in scanning of facial features (eyes, nose, mouth), as well as the amount of time spent viewing the eye regions on their own. Importantly, I will also evaluate, through comparing findings, whether differences in FER between groups on each measure may be explained by differences in attention to facial features and the eyes during FER.

5.1.1 Social-emotion factors

5.1.1.1 Social Anxiety

In Section 2.1.1.2, it was shown that individuals with social anxiety may be characterised by difficulties in FER (Simonian, Beidel, Turner, Berkes, & Long, 2001). In Study 2 and 3, it was shown that different facets of social anxiety may be differentially related to FER. Specifically, those higher in FNE tended to have stronger FER skills and those higher on generalised social avoidance tended to have poorer FER skills. Importantly, in Chapter 4 FER was examined collapsed across emotions, yet it is known that individuals with social anxiety may have difficulties in the recognition of specific emotions (Tseng et al., 2017). For example, Simonian et al. (2001) showed that individuals with social anxiety may be poorer at recognising happy, sad and disgust emotional expressions, and Tseng et al. (2017) found that individuals with social anxiety were poorer in their recognition of fear. It is therefore possible that social anxiety is associated with difficulties in the recognition of specific emotions. In this chapter, I will examine whether individuals differing in their level of social anxiety (specifically in these sub-facets) show differences in their recognition of specific emotions.

There is a growing body of literature that heightened levels of social anxiety are related to differences in scanning of emotional faces in both clinical and non-clinical samples (Horley, Williams, Gonsalvez, & Gordon, 2003; Lazarov, Abend, & Bar-Haim, 2016; Weeks, Howell, & Goldin, 2013). In fact, attentional biases in social anxiety are believed to reflect cognitive biases in social anxiety and may contribute to both the development of and the maintenance of the disorder (Clark et al., 1995; Wieser, Pauli, Weyers, Alpers, & Mühlberger, 2009). As highlighted in Section 2.1.1.3, increasing evidence employing eye-tracking has shown that individuals with social anxiety show differences in their scanning of emotional faces (e.g., Horley et al., 2003; Horley, Williams, Gonsalvez, & Gordon, 2004; Mansell, Clark, Ehlers, & Chen, 1999). However, the majority of work examining attention in social anxiety has focused on how individuals with social anxiety attend to emotional faces when multiple faces are presented simultaneously (usually pairs of stimuli). Researchers have found that individuals with social anxiety show biases in attention towards emotional stimuli and to threatening stimuli (compared to neutral; Garner, Mogg, & Bradley, 2006; Shechner et al., 2013; Stevens, Rist, & Gerlach, 2011), as well as show difficulties in disengaging from threatening stimuli (Chen, Clarke, MacLeod, & Guastella, 2012). On the other hand, some researchers have shown that when presented with pairs of images (emotional and neutral), socially anxious individuals show avoidance of emotional stimuli (Singh, Capozzoli, Dodd, & Hope, 2015), as well as avoidance of threat stimuli (Wieser et al., 2009). As highlighted above, when trying to understand differences in FER, it may be more appropriate to examine how individuals with social anxiety scan faces when presented one at a time during a FER task.

There is much evidence that individuals higher on social anxiety report (Schneier, Rodebaugh, Blanco, Lewin, & Liebowitz, 2011) and show (Daly, 1978; Farabee, Holcom, Ramsey, & Cole, 1993) less eye contact in social situations. Using eye-tracking, researchers have found evidence of both feature (Horley et al., 2003, 2004) and eye avoidance (Horley et al., 2003, 2004; Weeks et al., 2013) in individuals with heightened levels of social anxiety and social phobia. For example, Horley and colleagues (2003) used eye-tracking to examine how individuals with social phobia and controls passively viewed different emotional expressions. It was found that individuals with social phobia, showed avoidance of facial features, in particular the eye regions but instead showed increased scanning of non-features in comparison to controls. Given that specific facial features are important for the successful identification of facial affect (Eisenbarth & Alpers, 2011; Kestenbaum, 1992) and that in particular the eyes are a critical source of emotional information (Baron-Cohen et al., 2001), avoidance of facial features and the eyes when viewing emotional stimuli may be a maintenance factor in poor social skills and more specifically, poor FER.

This Chapter will examine whether individuals who differ in their level of social anxiety may show differences in the scanning generally of facial features and scanning specifically of the eyes during a FER task. Although, researchers have consistently found evidence of eye-avoidance in social anxiety, researchers have not examined this in the same study as looking at FER. It may therefore be that any differences found in FER in socially anxious individuals, may be evident in differences within scanning patterns, such as the amount of time spent fixating to facial features and the amount of time spent fixating to the eye region during FER.

5.1.1.2 Depression

In Section 2.1.2.2, it was shown that difficulties in the recognition of facial affect are well-documented in depression (Bourke, Douglas, & Porter, 2010) and are believed to play a role in the development and maintenance of the disorder (Beck, 1987). Importantly, whilst some researchers have found global deficits in FER in depression (e.g., Asthana, Mandal, Khurana, & Haque-Nizamie, 1998; Battaglia et al., 2012;

Csukly et al., 2011; Dalili, Penton-Voak, Harmer, & Munafò, 2015; Persad & Polivy, 1993), others have found that individuals with depression may have difficulties in the recognition of specific emotions (see Bourke et al., 2010, for review), such as for the recognition of happiness (Bourke et al., 2010; Harmer et al., 2009; Joormann & Gotlib, 2006; Rubinow & Post, 1992) and sadness (Bedio et al., 2009; Bourke et al., 2010; Rubinow & Post, 1992). Thus, in this chapter, I will explore how those high and low in depressive symptoms may differ in their FER for the six emotions.

As highlighted in Section 2.1.2.3, individuals with depression may also be characterised by attentional biases, which are believed to underlie some of the interpersonal difficulties in this group (Suslow, Junghanns & Arolt, 2001). Much of the work examining attention in depression has also focused on attention to competing emotional stimuli (e.g., Eizenman et al., 2003; Koster et al., 2011). Research shows that individuals with depression typically spend more time looking at dysphoric stimuli (Sears et al., 2011; Siegle et al., 2000), show difficulty in disengaging from depressive-like stimuli (Sanchez, Vavquez, LeMoult &Joormann, 2013) and spend less time looking at positive stimuli in comparison to individuals without depression (Isaac et al., 2014; see Armstrong & Olatunji, 2012, for review).

To date, only a handful of studies have examined how individuals with depression may view faces when presented one at a time. This may be particularly important to examine, given that the ability to successfully detect an individual's emotion relies on attention to the face and therefore difficulties in interpersonal functioning, and FER more specifically, may be related to differences in scanning of faces during a social exchange. Loughland et al. (2002) found that depressed individuals, when asked to passively view happy, sad and neutral faces, showed more avoidance of facial features indicated by reduced fixation to facial features compared to healthy controls. This may suggest that these individuals are not extracting important information that is necessary for the successful detection of emotional information.

To my knowledge, only one study to date has examined FER in individuals differing in their level of depression, whilst their eye movements were recorded. Wu, Pu, Allen and Pauli (2012) had students who were high and low in depressive symptoms memorise the six basic emotion words. Following this they were shown different emotional expressions whilst their eye movements were recorded. Students were instructed to verbally label the emotional expressions during a self-paced task. No significant differences were found in the accuracy of emotion recognition between the depression groups; however, those in the high depression group demonstrated overall quicker response times in their FER than those in the low depression group. The authors concluded that students with heightened levels of depression show enhanced ability to detect facial affect and hypersensitivity during FER. Importantly, it was shown that the high depression group spent less time looking at facial features during FER than the low depression group.

The findings of Wu et al. (2012) suggest that individuals with higher levels of depression may spend less time scanning facial features during FER, although unexpectedly these findings did not seem to relate to FER accuracy. These seemingly contrasting findings may be the result of the high intensity emotional expressions used in this study resulting in high accuracy rates overall, which may partially explain why there were no behavioural differences found in FER abilities between the depression groups. As highlighted in Section 2.1.2.2, individuals with depression may show differences in their sensitivity in FER (Bento de Souza et al., 2014; Gollan et al., 2008, 2010). One potential explanation could be that the authors did not control for overall looking time. In their study individuals high in depression were quicker in their FER judgements; this might explain why overall individuals with higher levels of depressive symptoms spent less time scanning facial features during FER that individuals with lower levels of depressive symptoms. Examining the proportion of time spent viewing facial features as a portion of the overall time spent examining an image may provide a clearer index of whether individuals differing in their level of depression show differences in their scanning of features and the eyes during FER. In this following set of studies, I will examine whether individuals differing in their level of depression show differences in the amount of time spent focusing on facial features and the eyes during FER, as a percentage of their overall viewing time, whilst also exploring if these patterns may differ depending on the emotion displayed.

5.1.1.3 Laterality for Emotion Processing

As mentioned in Section 2.2.3, lateralisation for emotion processing has been found to relate to FER (Barth & Boles, 1999; Watling & Bourne, 2013). Findings within Study 3 supported this, with changes in lateralisation patterns over time towards to the right-hemisphere (RH) being associated with increases in FER accuracy at six months (see Section 4.3.4.2). Overall, it has been shown that greater strength of lateralisation for emotion processing to the RH is associated with better emotion recognition. Importantly, researchers have found that lateralisation for emotion processing may be more strongly related to task performance when the task was more challenging (Watling & Damaskinou, 2018). FER skills are continuing to develop in adolescence (see Section 1.2.2) and the task in the next set of studies present emotions at reduced intensities to reduce ceiling effects (making the task more challenging). It is expected that individuals who are stronger in their lateralisation for emotion processing to the RH (in comparison to left hemisphere or

BL) may have stronger FER performance when the emotions are presented at lower intensities, but that differences may not emerge at high intensity emotions.

To my knowledge, no research to date has directly examined how individuals with varying levels of hemispheric lateralisation for facial emotion processing may show differences in their scanning of facial emotions during FER, but instead have focused on the scanning of chimeric faces (e.g., Butler et al., 2005; Coronel & Federmeirer, 2014).

Eye-tracking studies of chimeric face tests have found evidence that fixation patterns are linked to behavioural responses in these tasks (Butler et al., 2005). Butler and colleagues (2005) found that when left visual field decisions were made during a gender chimeric face test (chimeras had half face male and half face female; participants decided gender of face), decisions were associated with longer fixations to the left side of the face, interestingly no associations were found between fixations and decisions biased towards the right side of the face (left-hemisphere processing). Despite this, all participants showed an overall left scanning bias initially, but those who were defined as more RH dominant showed increased fixations to the left side of the face when making decisions during these tasks. These findings highlight that individuals who are more RH dominant may scan chimeric faces differently. When examining the scanning of full emotional faces (not chimeric faces). In contrast to the left visual field biases found in the CFT, Eisenbarth and Alpers (2011) documented a trend towards a right bias in the number and duration of fixations to the right visual field (right side of image). They proposed that a leftward bias might relate to initial processing of faces. In fact, it was shown that the left-eye was more often the location of the first fixation. The authors suggest that laterality for emotion processing may therefore be closely related to initial processing of emotional stimuli;

however, the authors did not directly assess how individuals differing in their degree of laterality for emotion processing may differ in their scanning of faces, specifically to features that may important in the recognition of emotions. This work will address this gap.

It is proposed that being more RH dominant for emotion processing may be linked to differences in the scanning of faces, as individuals who are more strongly lateralised to the RH have been found to perform better on FER. This research will examine whether individuals who are more strongly RH dominant in their processing of emotions differ in their FER performance and in the amount of time spent examining features and the eyes during FER in comparison to those who less strongly lateralised to the RH.

5.1.2 Unbiased hit rates

An important consideration is that the majority of research has used raw accuracy or error scores when calculating emotion recognition skills. It has been suggested that raw accuracy or percentage correct may be a problematic measure of decoding accuracy (see Wagner, 1993), as it fails to account for response bias (i.e., if an individual over uses or under uses a particular emotional category). In the following set of studies, an unbiased hit rate will be calculated to takes into account the amount of times a particular decision response is used, regardless of stimulus. The use of an unbiased hit rate may be of paramount importance when examining individuals with both heightened levels of both social anxiety and depression, given that there is some evidence that these groups may be characterised by negative response biases (Amin, 1998; Crane, 2007). Much of the research to date examines differences in FER in individuals with depression and social anxiety but has often failed to account for response bias (e.g., Joormann & Gotlib, 2006; Rubinow & Post, 1992; Simonian et al., 2011; Wu et al., 2012), which may explain some of the inconsistencies in findings reported.

5.1.3 Summary

In summary, researchers have emphasised the importance of attending to facial features, especially the eyes in the successful identification of facial affect (Baron-Cohen et al., 2001; Emery, 2000; Spezio et al., 2007). Importantly, researchers have found that individuals with social anxiety may show differences in their scanning of faces, including avoidance of facial features (Horley et al., 2003, 2004; Weeks et al., 2013) and avoidance of the eyes (Horley et al., 2003, 2004; Weeks et al., 2013). Similarly, those who are reported to be higher in depression (or depressive symptoms) have been found to show avoidance of features (Wu, Pu, Allen, & Pauli, 2012) during FER, but this was not related to FER ability — albeit the stimuli used were of high-intensity emotions. To date, it has yet to be examined whether individuals differing in their degree of lateralisation for emotion processing may show differences in their scanning of faces during FER. In this Chapter, I will examine if individuals differing in their levels of social anxiety, depression and degree of lateralisation for emotion processing show differences in both their FER of specific emotions and in their attention to facial features within the image when making decisions, first to general features and second to the eyes only.

5.2 Study 4

5.2.1 Introduction

In Studies 2 and 3 I have explored FER for all six emotions combined, disregarding the type of emotion and the emotion intensity level of the stimuli. As highlighted above, evidence points to that FER patterns may differ by emotion depending on levels of SA and depression (e.g., Arrais et al., 2010; Gollan et al., 2008, 2010; Joorman et al., 2009; Montagne et al., 2006). Further, it is important to understand if emotion intensity affects FER (e.g., patterns of lateralisation for emotion processing may be more closely related to performance when the task is more difficult; see Watling & Damskinou, 2018). This study will therefore examine the role of emotion and intensity in FER.

In addition to assessing FER, within this study, I will examine adolescents' (late adolescence) attention to facial features and the eyes when making FER judgements. As mentioned above, differences in scanning of emotional faces have been found in both social anxiety and depression, but little research to date has examined this within an FER task, making it difficult to draw conclusions about the role of attention in FER. Further, to my knowledge, the role of emotional intensity and attention has not been examined together during FER. It may be that when task demands are more difficult individuals may rely on features even more for successful FER. Importantly, individuals high on social anxiety and depressive symptoms may show increased or decreased sensitivities in their recognition of emotions, they may show differences in their scanning of features and the eyes during FER tasks. This will be examined within this study.

In addition to the emotion task manipulations (emotion and intensity), in this set of studies I explore sex differences. As highlighted in Chapter 4, previous research has found evidence that females show stronger performance than males in the ability to recognise facial affect (McClure, 2000; Montagne et al., 2005;). This may reflect an increased ability for females to accurately recognise less intense emotions (Hoffman, 2010) or specific emotions (i.e., disgust; Connolly et al., 2018). Sex differences have also been documented in the scanning of emotional faces, with females having longer fixations to the eye regions when decoding emotional faces. Importantly, Hall, Hutton and Morgan (2010) found a female advantage in looking at the eye region was linked to both speed and accuracy of FER.

Sex differences are also important to evaluate as these exist within our measures (see Section 1.4.1). Males and females typically differ in their level of depression (APA, 2013; Bennett, Ambrosini, Kudes, Metz & Rabinovich, 2005), social anxiety (APA, 2013; Wittchen et al., 1999) and in their degree of lateralisation for emotion processing (Bourne, 2005). Given these findings, sex will be included as between subject's variable in the following set of studies to enable the examination of any sex differences in FER, the scanning of faces and any potential effects that might interact with sex.

5.2.1.1 Aims and Hypotheses

This study aims to explore if FER differs by emotion type and intensity level, and how these patterns may be integrated with findings on how adolescents attend to emotional faces depending on levels of social anxiety, level of depressive symptoms, and degree of lateralisation for emotion processing. Importantly, when examining each factor, the other factors will be controlled for in order to examine the independent effects of each variable (e.g., when examining depression group, social anxiety subfacets and laterality score will be controlled for). It is expected that:

1. There will be group differences in FER and patterns of attention to facial images by social anxiety group for each facet of social anxiety. For social avoidance, research shows negative relationships to FER (Chapter 4); therefore, it is hypothesised that adolescents high compared to low in generalised avoidance will show poorer FER. For FNE, research shows those high in FNE may have hypervigilance to emotional stimuli, and show stronger FER (see Study 3); therefore, it is expected that individuals high compared to low in FNE may show stronger FER, which may be specific for specific emotions. With regards to attention, little research to date has examined links between social anxiety and attention to faces when presented individually. However, evidence shows that individuals with social phobia show less time viewing facial features and the eyes when viewing emotional faces (e.g., Horley et al., 2003, 2004). It is therefore expected that individuals high compared to low in facets of social anxiety will show differences in the amount of time spent examining facial features and the eyes during FER. Given evidence that individuals with heightened levels of social anxiety may be stronger (Arrisas et al., 2010) or weaker (Montagne et al., 2006) in their FER, the effect of intensity on FER and attention to facial images during the FER task is examined.

2. In line with previous research, it is predicted that individuals higher in depressive symptoms, compared to lower in depressive symptoms, will have poorer FER, and that this may be the case for specific emotions (e.g., happiness, sadness). Further, in line with previous research (Wu et al., 2012), it is expected that individuals in the high compared to low depression group will show less

time fixating to the features and eyes during FER. Given evidence that individuals with heightened levels of depression may show increased (Gollan et al., 2008, 2010) or decreased (Csukly et al., 2009) sensitivity in their FER, the effect of intensity on FER is examined.

3. Further, it is predicted that individuals who are more strongly lateralised in their emotion processing towards the RH compared to those who are more BL will show better FER, which may be pronounced with low intensity expressions. As highlighted, no research to date has explicitly examined if degree of laterality may relate to the scanning of faces during FER. Consistent with research that more RH dominance in the strength of lateralisation is linked to stronger FER and that patterns of scanning faces has been found to be related to FER, it is expected that individuals differing in their degree of lateralisation for emotion processing will show differences in their time spent examining facial features and the eyes during FER.

5.2.2 Method

5.2.2.1 Participants

There were 48 participants (M_{age} = 19.46 years, *SD* = 1.41, range 16.77 -24.29 years), 27 females (56.3%) and 21 males (43.8%), who were recruited from the local community and as part of a Psychology Department undergraduate research credits scheme. The participants were 70.8% White, 20.8% Asian, 4.2% Black, 2.1% Mixed and 2.1% other.

Participants were asked whether they had been diagnosed with a psychological condition in the past year, this was the case for 22.9% of the sample (*n* = 11). Of those that had received a diagnosis in past year, four were currently taking medication for a psychological condition. One participant who answered no to being diagnosed with a psychological condition in the *past year* was currently medicated for a psychological condition. Given that psychiatric medication has been found to alter emotion processing (Harmer et al., 2009; Wells, Clerkin, Ellis & Beevers, 2015), these five participants were removed from analyses. A further four participants were removed due to not responding to more than 90% of trials for the FER task and/or CFT, leaving 39 participants for the FER analyses (M_{age} = 19.36 years, *SD* = 1.40, range 16.77 -24.29 years), 20 females (51.3%) and 19 males (48.7%) see Appendix 5, Table 7.6 for participant sex by ethnicity). For the later eye-tracking analyses a further two individuals (2 females) were excluded from the analyses, due to poor calibration or less than 70% of gaze samples recorded, leaving 37 participants for the eye-tracking analyses. Participants included in the eye-tracking analysis all had normal or corrected to normal vision. Prior to taking part, all participants provided informed consent and were given the opportunity to ask questions. Ethical approval was received through the RHUL Research Ethics Committee.

5.2.2.2 Apparatus

Eye-movements were recorded for both emotion tasks using a Tobii X-300 screen-based eye-tracker with a sampling rate of 120Hz. Tobii Studio software (3.4.6) was used for presentation of stimuli and visualisation of fixation data. [5]Areas of interest were defined prior to analysis in Tobii Studios software, these included the left eye (2° by 1°), right eye (2° by 1°), mouth (3° by 2°), nose (1° by 3° by 2°) and the whole face (6° by 9°), see Figure 5.1. Before both emotion tasks, participants took

[5] The frame refresh rate was 300Hz and the screen resolution was 1920 by 1080 pixels

part in a 5-point calibration. Where an initial acceptable calibration was not found, the calibration process was repeated until a successful calibration was made. As highlighted above, participants who could not achieve an acceptable calibration or those for whom less than 70% of gaze samples recorded, were excluded from the study (n = 2).

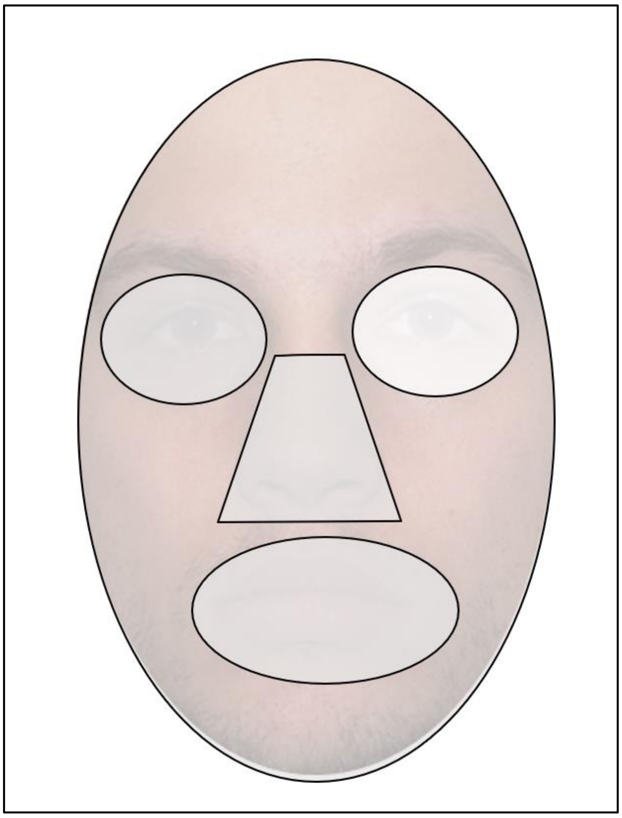

Figure 5.1. Example pictorial representation of predefined areas of interest (AOIs) for images.

5.2.2.3 Materials

Participants completed all tasks using on a Windows computer. There were four tasks in total; two questionnaire measures, programmed using Qualtrics survey software (Qualtrics, Provo, UT), to assess (1) social anxiety (Social Anxiety Scale for Adolescents; SAS-A; La Greca & Lopez, 1998) and (2) depression (Centre for Epidemiological study depression scale; Radloff, 1977). Participants also completed two emotion-based tasks to assess lateralisation for emotion processing and FER performance. Tobii Studio software (3.4.6) was used for the presentation of stimuli for both emotion tasks, allowing for eye-tracking (number of fixations and total fixation duration) to be recorded for the emotion tasks. Within this thesis only eye-tracking data from the FER will be analysed, given the aims of this study.

Centre for Epidemiological Study Depression Scale (CES-D; Radloff, 1977)

Participants were required to complete the Centre for Epidemiological study depression scale (Radloff, 1977). This scale has been developed to measure depression symptom severity in the general population. Participants were asked to read 20 statements and indicate how often they had felt that way in the past week on a Likert scale a scale from rarely or none of the time (less than 1 day), some or little of the time (1-2 days), occasionally or moderate amount of the time (3-4 days) and most or all of the time (5-7 days). Depression scores ranged from 0-60, whereby higher scores indicated higher levels of depression symptoms. According to Moon et al. (2017) scores from 0-9 indicate non-depressed individuals, 10-15 indicate mild depression, 16-24 represents moderate depression and 25+ indicate severe depression. Cronbach's alpha indicated good level of internal consistency ($\alpha = .89$). This scale has previously been found to have internal reliability and validity with both adolescent (Radloff, 1991; Roberts, Andrews, Lewinsohn & Hops, 1990) and adult participants (Radloff, 1991, 1997).

Social Anxiety Scale for Adolescence

Participants completed the Social Anxiety Scale for Adolescence (SAS-A; La Greca & Lopez, 1998). Similar to the SAS-C-R (La Greca & Stone, 1993) used in Studies 2 and 3, the SAS-A was developed to use more appropriate language for older adolescents. In the same way as the SAS-C-R, the scale consists 22-item scale (4 filler items) and was developed to assess three aspects of social anxiety: *(1)* Social avoidance and distress specific to new situations (SAD-New, 6 items; e.g., I feel shy around people I don't know), *(2)* Generalised avoidance and distress (SAD- General, 4 items; e.g., I feel shy even with people I know well), and *(3)* Fear of negative evaluation (FNE, 8 items; e.g., I am afraid others will not like me). In the same way as the previously used SAS-C-R (La Greca & Stone, 1993), participants are asked to indicate how much they feel the statement is true for them on a five-point Likert scale from 'not at all', 'hardly ever,' 'sometimes,' 'most of the time' to 'all of the time'. Higher scores reflected higher SA symptoms, the scores were summed for each subscale separately. FNE scores ranged from 8-40, SAD-New scores ranged from 6-30, and SAD-General ranged from 4-20. In all instances, higher scores indicated higher level of social anxiety for each scale. Cronbach's alpha indicated questionable to excellent levels of internal consistency on all subscales (SAD-New scale, α =.89; SAD-General, α =.68; and FNE, α =.91).

Chimeric Face Test (CFT)

This task was identical to that presented in Studies 2 and 3 (six emotion blocks with 16 trials in each block). Each trial began with a fixation cross presented centrally for 1500ms. This was followed by the presentation of two chimeras presented one above the other centrally on a white background (~1°appart). Faces subtended about 7° horizontally and 10° vertically at a viewing distance of approximately 60cm. Once participants made their response (pressing the upward or downward arrow corresponding to the face, top or bottom, that they judged as more emotive), this signalled the start of a new trial (see Figure 5.2 [A] for example trial).

Coding. In the same way as in studies 1-3, a laterality score for each emotion block were calculated (see Equation 3.1) that ranged from -1 (indicating left-hemisphere processing bias) to +1 (indicating RH processing bias). To calculate an overall laterality quotient, the six emotion laterality quotients were averaged.

Facial Emotion Recognition (FER) Task

This task was identical to that presented in Studies 2 and 3, with one amendment. Consistent with the other studies, participants were presented with faces showing the six basic emotions (and neutral) morphed at low (30%), mid (50%) and high (70%) intensity. Eighty-six stimuli were shown in total. Participants were instructed that they will be asked to look at faces and judge the emotion that they think the face is showing. Due to using eye-tracking methods, unlike in the previous studies, participants were presented with only the facial image on the screen and made their emotion decision on a new screen. Each trial began with a central fixation cross for 1500ms, followed by the central presentation of a facial stimuli. Participants could examine the face for as long as they wanted and were required to press the space bar when they were ready to make their response. This triggered the response screen that asked participants to identify 'which emotion is the face showing', with seven options presented centrally in a grid. Participants responded using the number key that corresponded to the emotion..This procedure was used to avoid participants looking downwards at the keyboard during viewing of the emotional stimuli, as a way to ensure eye position samples were collected. Once the participants made a number response, the next trial begun (see Figure 5.2 [B] for example trial procedure). The order of the stimulus presentation was randomised for each participant within Tobii Studio, there were two versions of the response grid options (e.g., Version 1: Disgust = 1, Happiness = 2, Sadness = 3, Surprised = 4, Fear = 5, Anger = 6, No emotion = 0; Version 2: Anger = 1, Surprised = 2, Fear = 3, Sadness = 4, Disgust = 5, Happiness = 6, No emotion = 0), which were counterbalanced between participants.

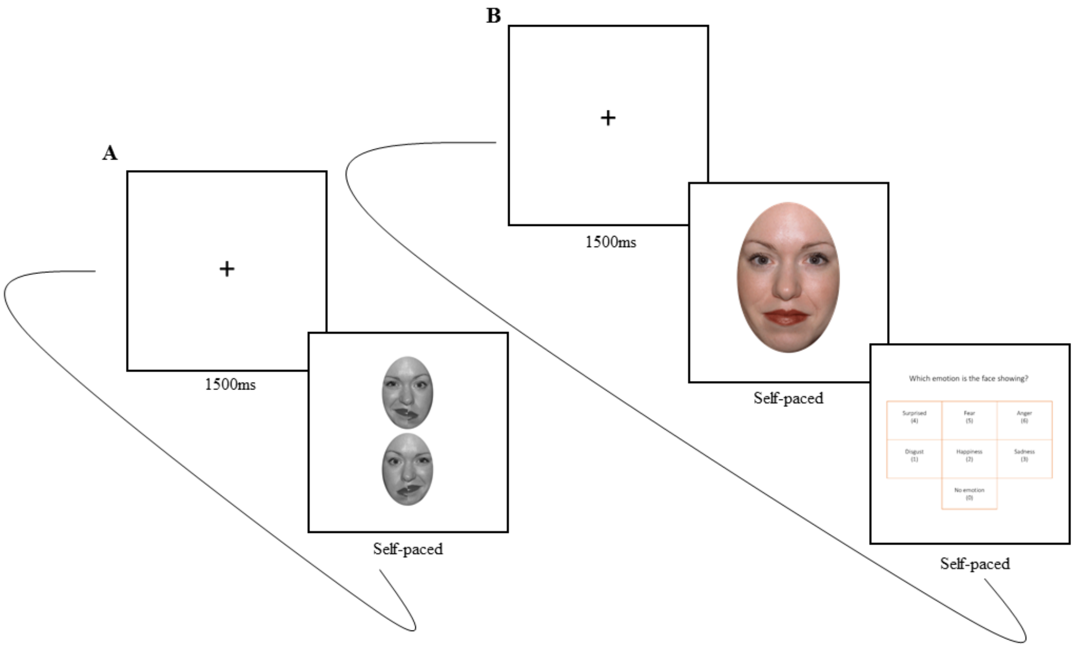

Figure 5.2. Trial examples for both emotion tasks. **A**. Chimeric Face Test. Participants viewed a fixation cross, followed by the onset of the chimeric stimuli, participants made an upwards or downwards response on the keyboard, which triggered the next trial. **B.** Facial Emotion Recognition task. Participants viewed a fixation cross, followed by the onset of an emotional face. When participants were ready to make their decision, they pressed the space bar to triggered the response screen. When a response was logged, the next trial began.

Coding.

Unbiased hit rates (*Hu scores*) were calculated for each emotion at each intensity level. Neutral faces were not included in this calculation, given they have no intensity. To calculate Hu scores, Wagner's (1993) equation was used (see Equation 5.1).

Equation 5.1. Unbiased hit rate calculation

$$Hu = \frac{A^2}{(B \times C)}$$

Note: **A** refers to the number of correct responses of that emotion, **B** indicates the amount of times the stimuli was present, and **C** represents the amount of times the emotion was selected overall. Hu scores ranged from 0-1, but were subsequently arcsine transformed prior to analysis, as recommended by Wagner (Wagner, 1993), resulting in possible scores from 0-1.57. In any instances where participants did not use a particular response (i.e., did not say any of the faces were happy) the Hu score was entered as 0; this is because a zero error occurs if the denominator is 0 and would indicate that the participant never selected the correct response for the particular emotion at that intensity.

Attention during FER.

To assess attention during FER, two computations were needed to calculate the percentage of time participants spent viewing facial features and the eyes during FER.

First, given that the task was self-paced, the relative total fixation duration (TFD) that participants spent looking at facial features was calculated as the sum of the time spent looking at the eyes (left eye and right eye summed), nose and mouth divided by the total amount of time that the stimulus was present (in milliseconds) and then multiplied by 100 to get the percentage of time, see Equa Equation ***5.2***). Second, the relative TFD that participants spent looking at the eyes was calculated as the sum of the time spent looking at the left and right eye, divided by the total amount of time

Equation 5.2. Calculating relative percentage total fixation duration on facial features.

that the stimulus was present (in milliseconds) and then multiplied by 100 to get the percentage of time, see Equation 5.3.

$$\frac{TFD\ eyes + TFD\ nose + TFD\ mouth}{Stimulus\ presentation\ time}\ \mathrm{X}\ 100$$

Equation 5.3. Calculating relative percentage total fixation duration to the eyes.

$$\frac{(Total\ fixation\ duration\ left\ eye + Total\ fixation\ duration\ right\ eye)}{Stimulus\ Presentation\ Time} \times 100$$

5.2.2.4 Procedure

Participants were seen by one researcher and tested individually in an eye-tracking lab. The whole session lasted around 1 hour in total. Participants gave fully informed consent prior to taking part. The order of the tasks was counterbalanced between participants (half participants started with the two-emotion based tasks, half started with the questionnaire measures). Participants were given short breaks between tasks. Eye movements were only recorded during the emotion-based tasks. Participants were fully debriefed at the end of the session and were given the opportunity to ask any questions.

5.2.2.5 Design and Analysis

A median split was used to divide the participants into two groups for each of the social-emotional and laterality measures; means and standard deviations are presented in Table 5.1. A median split was used to create two groups differing in their level of depression and sub-scales of social anxiety, specifically to create a 'low' and 'high' group for each of these measures. Independent t-tests showed that the groups created significantly differed from one another (see Table 5.1). Of note, according to the cut-off scores provided by Moon et al., (2017), our low depression group represented a non-depressed group and the high depression group in this study reflected moderately depressed group. Previous researchers have established cut-offs for total social anxiety score when combining the three-subscale scores into a total score, but given that groups were split on subscale scores, to my knowledge there is currently no break-down for criteria of high and low subscale scores, nonetheless the groups created on all social anxiety facets significantly differed from one another. Descriptive statistics on the relationships between the variables can be found in Appendix 5, Table 7.5.

Table 5.1. Means (SD) and *N* for participants split into high and low groups for sub-scale scores of social anxiety (SA), and depression and those allocated to the BL and RH laterality groups.

	Low		***High***		
	M (SD)	*N*	*M (SD)*	*N*	t
Depression	7.90 (2.93)	21	22.11 (8.08)	18	7.07***
FNE	16.32 (2.87)[a]	19	27.10 (5.23)[b]	20	8.04***
SAD-General	6.22 (1.06)[c]	18	11.00 (1.82)[d]	21	4.78***
SAD- New	14.11 (3.09)[e]	19	21.90 (2.95)[f]	20	8.10***
	BL		***RH***		
	M (SD)	*N*	*M (SD)*	*N*	*t*
CFT	-0.11 (0.30)	20	0.58 (0.20)	19	8.55***

[a] SA total, *M* = 38.26 *SD* = 6.92 [b] SA total, *M* = 58.70 *SD* =9.45 [c] SA total, *M* = 37.72 *SD* = 6.88 [d] SA total, *M* = 58.19 *SD* = 9.39 [e] SA total, *M* = 38.05 *SD* = 6.70 [f] SA total, *M* = 58.90 *SD* = 9.14

Note: *** $p < .001$, all groups significantly differed from one another. FNE, SAD-General and SAD-New also differed in their overall total level of social anxiety.

As indicated above, a median split was also used to divide participants into two groups based on their laterality quotient. Whilst researchers have found that adults tend to be RH dominant in their processing of emotions, the aim was to create two groups, one which had stronger RH dominance and one which had weaker RH dominance, the two groups significantly differed from one another (see Table 5.1). Further, one sample t-tests were run to determine whether the laterality groups created significantly differed for 0 (indicating no hemispheric dominancy). The group with higher laterality scores significantly differed from 0, $t(18) = 13.11$, $p < .001$, showing that the group was RH dominant in their processing of emotions.

Importantly, the group with lower laterality scores showed no difference from 0, $t(19) = 1.362$, $p = .121$, suggesting that this group may represent a more BL group.

5.2.3 Results

5.1.1.1 Facial Emotion Recognition (FER)

Firstly, a mixed 6 x 3 x 2 Analysis of Variance (ANOVA) was run to examine if there were any differences in FER depending on the emotion (happy, sad, angry, fear, surprise, and disgust) and intensity (30%, 50%, and 70%) being assessed and sex (male and female). Emotion and intensity were entered as within subjects' variables and sex as a between-subjects factor. The dependent variable was the FER unbiased hit rates (referred to as accuracy).

Following exploring the overall differences in FER due to our manipulations and for sex, I conducted a set on mixed Analysis of Covariance (ANCOVAs), examining group differences in FER for each of the independent variables of interest in the analysis (five analyses – (1) Depression group (2) SAD-General group (3) SAD-New group (4) FNE group (5) Laterality group). In all instances, emotion and intensity were within subjects' measures and sex was a between subjects' measure. The dependent variable was FER unbiased hit rates (accuracy). During each analysis the variables that were not the independent variable in the particular analysis were controlled for (i.e., when exploring the difference in FER by depression group, all three facets of social anxiety [subscale scores] and laterality quotient were controlled for). Given that the main findings for differences in FER accuracy by emotion, intensity and sex were the same throughout, only main effects of social-emotion and laterality groups and interactions with group will be reported below. Where sphericity is violated, a Greenhouse- Geisser correction is reported. Any interactions will be broken down using simple effects analyses, and where appropriate, pairwise comparisons will be used, with Bonferroni corrections applied.

FER by Emotion, Intensity and Sex

Full descriptives for emotion by intensity, with total scores, are presented in Table 5.2. There was a main effect of emotion, $F(2.93, 108.36) = 27.63$, $p < .001$, $\eta^2 = .43$. Pairwise comparisons found that happiness was recognised significantly better than all other emotions (sad, disgust, anger, surprise, fear; all *ps* < .05). Surprise was recognised significantly better than anger and fear (*ps* < .001), and disgust and sadness were both recognised significantly better than anger (*ps* < .05). There was a main effect of intensity, $F(2, 74) = 125.52$, $p < .001$, $\eta^2 = .77$. As expected, pairwise comparisons showed that emotional expressions at 70% were recognised significantly better than emotions at 30% and 50% (*ps* < .001), and emotions at 50% were recognised significantly better than at 30% ($p < .001$). There was no significant sex difference in overall emotion recognition $F(1, 37) = 1.26$, $p = .268$, $\eta^2 < .10$, (males $M = 0.79$ SE = 0.05; females $M = 0.86$, SE = 0.05).

There was a significant interaction between emotion and intensity, $F(7.14, 264.24) = 4.84$, $p < .001$, $\eta^2 = .12$. For anger and fear, faces at 70% intensity were recognised significantly better than faces presented at 50% intensity (*ps* < .05), for all other emotions there was no significant difference in the recognition of emotions presented at 50% and 70% emotional intensity (*ps* > .05; see Table 5.2.).

Table 5.2. Unbiased hit rate mean (SD) of faces presented at different intensities for each emotion (possible *Hu* score 0 – 1.57).

	Happy	**Sad**	**Surprised**	**Anger**	**Fear**	**Disgust**	***Total***
30%	0.73 (0.07)	0.32 (0.04)	0.73 (0.06)	0.20 (0.04)	0.40 (0.05)	0.60 (0.06)	0.50 (0.03)
50%	1.37 (0.06)	0.93 (0.08)	1.00 (0.07)	0.61 (0.06)	0.81 (0.07)	0.83 (0.07)	0.92 (0.04)
70%	1.42 (0.06)	1.06 (0.07)	1.10 (0.07)	0.89 (0.08)	0.98 (0.08)	0.91 (0.08)	1.06 (0.05)
Total	1.17 (0.05)	0.77 (0.05)	0.94 (0.05)	0.57 (0.05)	0.72 (0.05)	0.78 (0.05)	

5.1.1.2 FER by Depression group

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and depression group as between subject's measures. Mean centred scores on all social anxiety variables and laterality quotient were entered as covariates. There was no significant difference in FER for those in the high (M = 0.81, SE = 0.06) and low (M = 0.84, SE = 0.05) depression groups, $F(1, 31) = 0.16$, $p = .690$, $\eta^2 < .01$. There was a significant interaction between emotion and depression group, $F(2.83, 87.63) = 2.87$, $p = .044$, $\eta^2 = .09$. It was found that participants in the high depression group were significantly poorer at recognising happiness than individuals in the low depression group ($p = .020$); there were no significant differences for the other emotions (*ps* >.50; see Figure 5.3).There was no significant interaction between intensity and depression group, $F(2, 62) = 0.08$, $p = .926$, $\eta^2 < .01$, as well as no three-way interaction between intensity, depression group and emotion on FER, $F(10, 310) = 1.27$, $p = .247$, $\eta^2 = .04$. There was no significant interaction between depression group and intensity, or any interactions with depression group and sex, $F < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.7.

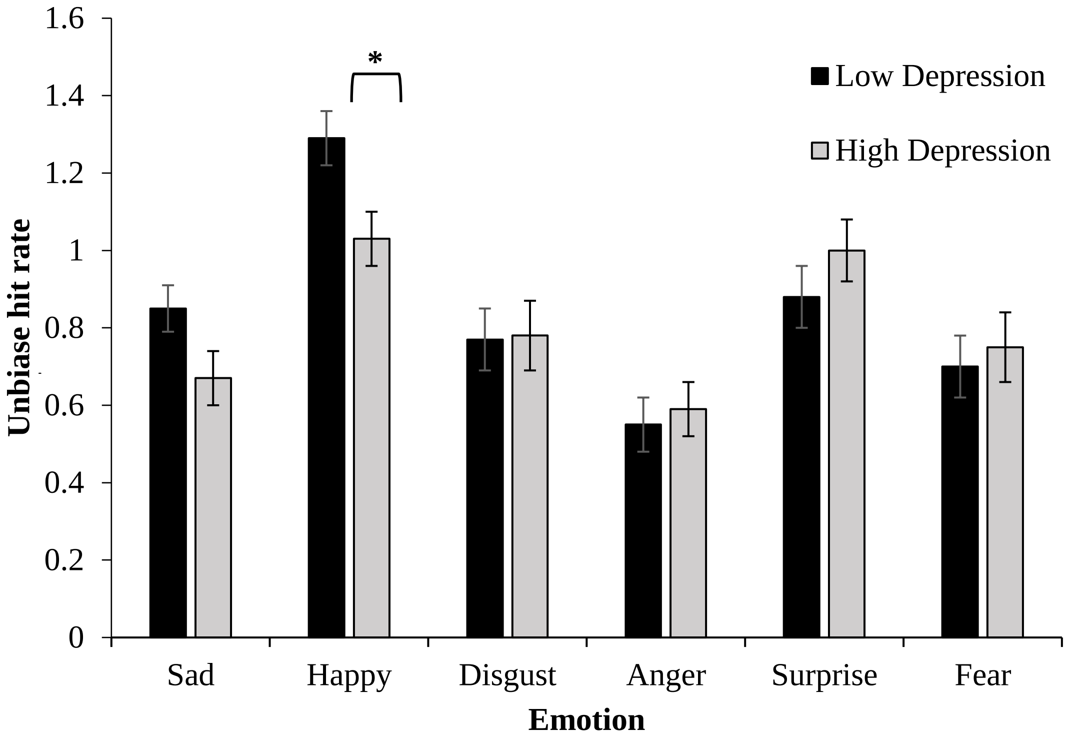

Figure 5.3. Unbiased hit rates for each emotion for low and high depression groups. *Note:* * $p < .050$.

5.1.1.3 FER by Social Anxiety Groups

FER by FNE group

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and FNE group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in emotion recognition for those in the high (M= 0.80, SE = 0.06) and low (M = 0.85, SE = 0.06) FNE group, $F(1, 31) = 0.24$, $p = .630$, $\eta^2 < .01$. Further, there were no significant interactions with FNE: emotion and FNE group, $F(2.80, 86.78) = 0.64$, $p = .580$, $\eta^2 = .02$; intensity and FNE group, $F(2, 62) = 0.94$, $p = .910$, $\eta^2 < .01$; emotion, intensity, and FNE group, $F(6.72, 208.45) = 0.77$, $p = .610$, $\eta^2 = .02$. There were no significant interactions including sex, $F < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.8.

FER by SAD-General group

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and SAD-General group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in emotion recognition for those in the high (M = 0.75, SE = 0.06) and low (M = 0.92, SE = 0.07) SAD-General groups, $F(1, 31) = 2.48$, $p = .125$, $\eta^2 < .01$. There were no significant interactions with SAD-General group: emotion and SAD-General group, $F(2.88, 89.17) = 0.41$, $p = .735$, $\eta^2 = .01$; intensity and SAD-General group, $F(2, 62) = 0.71$, $p = .494$, $\eta^2 = .02$; emotion, intensity and SAD-General group, $F(6.54, 202.82) = 1.18$, $p = .895$, $\eta^2 = .01$. There were no significant interactions including sex, $F < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.9.

FER by SAD-New group

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and SAD-New group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in emotion recognition for those in the high (M = 0.89, SE = 0.06) and low (M = 0.75, SE = 0.06) SAD-New groups, $F(1, 31) = 1.93$, $p = .174$, $\eta^2 < .01$. Further, there were no significant interactions with SAD-New group: emotion and SAD-New group, $F(2.88, 89.15) = 0.47$, $p = .699$, $\eta^2 = .02$; intensity and SAD-New group, $F(2, 62) = 0.38$, $p = .685$, $\eta^2 = .01$; emotion, intensity and SAD-New group, $F(6.72, 208.21) = 0.82$, $p = .565$, $\eta^2 = .03$. There were no significant interactions including sex, $F < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.10.

5.1.1.4 FER by Laterality for Emotion Processing group

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and laterality group as between subject's measures. Mean centred scores on social anxiety variables and depression were entered as covariates. There was no significant difference in emotion recognition between the RH (M = 0.81, SE = 0.05) and BL (M = 0.84, SE = 0.05) laterality groups, $F(1, 31) = 0.12$, $p = .730$, $\eta^2 < .01$. There was a significant interaction between emotion and laterality group, $F(2.83, 87.58) = 3.42$, $p = .023$, $\eta^2 = .10$. Simple effects analyses showed a trend for individuals in the bilateral (BL) laterality group showing stronger sad recognition compared to the RH group, and a trend for the BL group to show poorer surprise recognition than the RH group. Importantly, after adjusting for multiple comparisons, these findings were not significant ($p = .056$ and $p = .086$, respectively; see Figure 5.4). There was no significant interaction between intensity and laterality group on unbiased hit rates, $F(2, 62) = 1.81$, $p = .172$, $\eta^2 = .063$, and no three-way interaction between intensity, laterality group and emotion, *F*(10, 310) = 1.07, *p* =.388, $\eta^2 = .01$. There were no significant interactions including sex *Fs*< .1, *ps* > .050. Full table of descriptives is available Appendix 5, see Table 7.11.

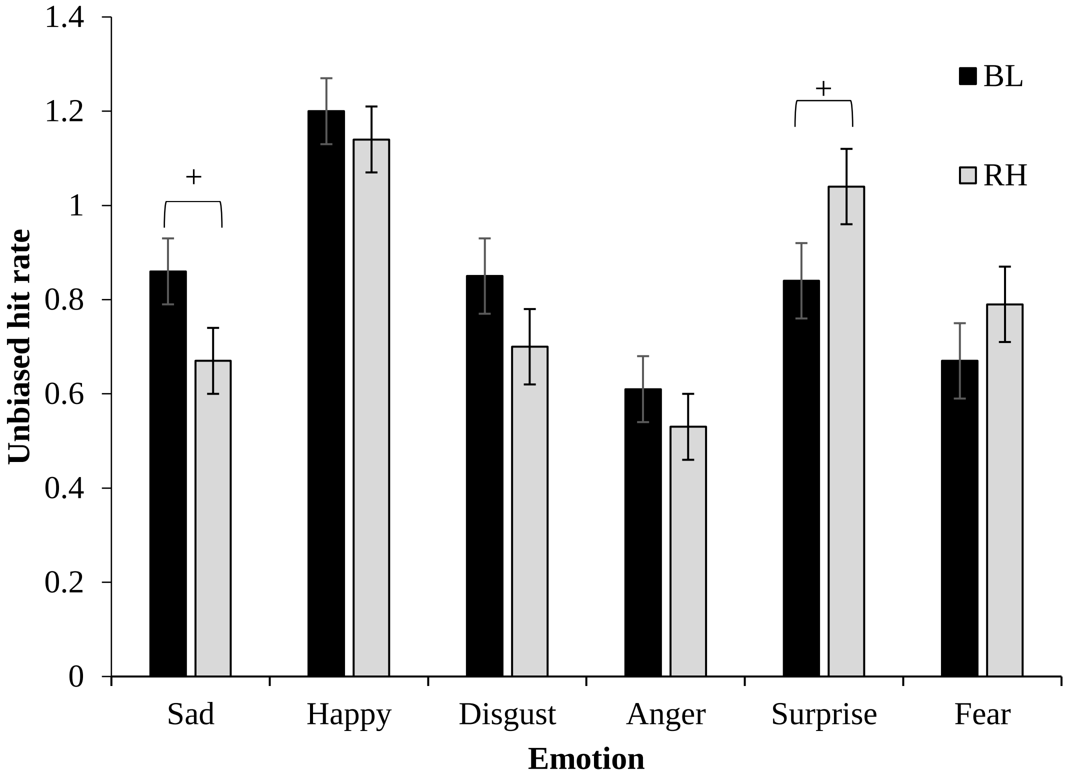

Figure 5.4. Unbiased hit rates for each emotion for the right-hemisphere (RH) and bilateral (BL) laterality groups. *Note* $^+$ *p* < .100.

5.1.1.5 Fixation Durations and FER

In this section, I now consider whether scanning differences may underlie FER abilities. For example, although no behavioural differences were found in FER with different social anxiety groups, here I examine whether this is also reflected in eye movements or whether there may be differences in scanning that may compensate for cognitive strategy in FER task. Importantly, whilst previous research has examined attention to features in general, the eyes have often been highlighted as an important feature for accurate FER, and differences have been found in scanning of the eyes in both social anxiety and depression (see Section 2.1.1.3). I will therefore also examine scanning of the eyes on their own.

Firstly, two mixed Analysis of Variance (ANOVA) were run to examine any differences in the relative total fixation duration to facial features and the eyes by emotion, intensity and sex. Emotion and intensity were entered as within subjects' variables and sex as a between-subjects factor. The dependent variables were (1) the percentage relative total fixation duration (TFD) of stimulus presentation time that participants looked at facial features during FER and (2) the percentage relative total fixation duration of stimulus presentation time that participants looked at the eyes during FER.

Separate mixed Analysis of Covariance (ANCOVAs) were run, examining each of the variables of interest as independent variables in the analysis (5 analyses – (1) Depression group (2) SAD-General group (3) SAD-New group (4) FNE group (5) Laterality group). In all instances emotion and intensity were within subjects' measures and sex was a between subjects' measure. The dependent variables were (1) the percentage total fixation duration that participants looked features and (2) the percentage total fixation duration that participants looked at the eyes. Given that the main findings with TFD to features, emotion, intensity and sex were the same throughout, only main effects of group and interactions with group will be reported below. During each analysis the variable that was not the independent variable in this analysis was controlled for. In all instances, where sphericity was violated, a Greenhouse-Geisser correction is reported. Interactions will be broken down using simple effects analyses, and where appropriate, pairwise comparisons will be used with Bonferroni corrections applied.

TFD on features by Emotion, Intensity and Sex

Full descriptivs for emotion by intensity, with total scores, are presented in Table 5.3. A mixed ANOVA was used with emotion and intensity as within subjects variables and sex as a between subjects variable. There was no significant main effect of emotion on the percentage of time spent fixating to features, $F(5, 175) = 0.99$, $p = .423$, $\eta^2 = .03$. There was no significant sex difference in the percentage of time spent looking at features, $F(1, 35) = 2.27$, $p = .141$, $\eta^2 = .06$, (males, M = 63.41%, SE = 4.69; females, M = 73.53%, SE = 4.81). There was no significant effect of intensity on TFD to features, $F(1.67, 58.38) = 1.29$, $p = .279$, $\eta^2 = .04$. There were no significant interactions including sex ($ps > .050$).

Table 5.3. Mean Percentage TFD (Standard Error) on facial features for each emotion at 30%, 50% and 70% emotional intensity.

	Happy	**Sad**	**Surprised**	**Anger**	**Fear**	**Disgust**	***Total***
30%	70.35	69.43	69.35	68.19	69.98	68.44	69.29
	(3.74)	(3.74)	(4.16)	(3.60)	(3.68)	(3.77)	(3.51)
50%	67.16	72.58	66.45	65.62	67.12	70.79	68.29
	(4.01)	(3.70)	(3.83)	(3.61)	(3.63)	(3.57)	(3.27)
70%	70.11	67.68	67.20	67.51	66.88	67.56	67.82
	(3.78)	(3.56)	(3.73)	(3.93)	(3.91)	(4.02)	(3.42)
Total	69.21	69.90	67.67	67.11	67.99	68.93	
	(3.58)	(3.49)	(3.54)	(3.42)	(3.44)	(3.50)	

TFD on the eyes by Emotion, Intensity and Sex

Full descriptives for emotion by intensity, with total scores, are presented in Table 5.4. There was a significant main effect of emotion on the percentage of time spent looking at the eyes, $F(3.89, 136.11) = 2.47$, $p = .049$, $\eta^2 = .07$. Pairwise comparisons showed a significant difference in the amount of time looking at the eyes for surprise and angry faces, with significantly less time looking at the eyes for surprise compared to anger ($p = .043$; see Table 5.4); no other comparisons were significant, $p > .05$. There was no significant main effect of intensity, $F(2, 70) = 3.08$, $p = .052$, $\eta^2 = .08$, albeit there was a trend for higher intensity emotional expressions, participants tended to spend less time examining the eye region. There was no main effect of sex, $F(1, 35) = 0.04$, $p = .844$, $\eta^2 < .01$ (males, M = 23.88%, SE = 3.69; females, M = 22.83%, SE = 3.79).

Table 5.4. Mean Percentage fixation duration (Standard Error) on the eye region for each emotion at 30%, 50% and 70% emotional intensity.

	Happy	**Sad**	**Surprised**	**Anger**	**Fear**	**Disgust**	***Total***
30%	23.14 (2.99)	22.81 (2.86)	23.74 (3.28)	26.02 (3.02)	24.33 (2.85)	25.58 (2.95)	24.27 (2.77)
50%	22.97 (3.32)	25.73 (2.93)	21.07 (2.54)	26.77 (2.96)	22.70 (2.95)	22.10 (2.94)	23.55 (2.64)
70%	22.10 (3.52)	23.28 (2.52)	21.23 (2.86)	24.69 (3.01)	23.37 (3.05)	18.98 (2.84)	22.25 (2.66)
Total	22.72 (3.07)	23.94 (2.61)	21.98 (2.63)	25.83 (2.82)	23.47 (2.78)	22.20 (2.70)	

TFD by Depression group

TFD on facial features

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and depression group as between subject's measures. Mean centred scores on all social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in the relative amount of time spent looking at features for individuals high (M = 75.09, SE = 5.99) and low (M = 63.46, SE = 5.09) on depression, $F(1,29) = 1.84$, $p = .185$, $\eta^2 = .06$. Further, there were no significant interactions with depression group; emotion and depression group, $F(5,145) = 0.50$, $p = .776$, $\eta^2 = .02$; intensity and depression group, $F(1.62, 46.92) = 0.24$, $p = .741$, $\eta^2 < .01$; emotion, intensity and depression group, $F(10, 290) = 0.64$, $p = .783$, $\eta^2 = .02$. There were no significant interactions including sex on TFD to facial features, $F < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.12.

TFD on the eyes

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and depression group as between subject's measures. Mean centred scores on all social anxiety variables, and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in percentage fixation duration to the eyes for high (M = 22.17, SE = 4.47) and low (M = 24.19, SE = 4.00) depression group, $F(1, 29) <0.01$, $p = .767$, $\eta^2 <.01$. Further, there were no significant interactions with depression group: emotion and depression group, $F(5,145) = 0.32$, $p = .901$, $\eta^2 =.01$; intensity and depression group, $F(2, 48) = 0.14$, $p =.870$, $\eta^2 < .01$; emotion, intensity and depression group, $F(10, 290) = 0.83$, $p =.602$, $\eta^2 = .03$. There were no significant interactions including sex, $Fs< .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.12.

TFD by FNE group

TFD on facial features

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and FNE group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in the relative amount of time spent looking at features for individuals high (M = 68.56, SE = 5.83) and low (M = 68.93, SE = 6.64) on FNE, $F(1, 29) < 0.01$, $p = .971$, $\eta^2 <.01$. Further, there were no significant interactions with FNE group: emotion and FNE group, $F(5, 145) = 0.11$, $p = .990$, $\eta^2 <.01$; intensity and FNE group, $F(1.67, 48.29) = 0.90$, $p = .397$, $\eta^2 = .03$; emotion, intensity and FNE group, $F(10, 290) = 0.51$, $p = .885$, $\eta^2 = .02$. There were no significant interactions including sex, $Fs < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.14.

TFD on the eyes

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and FNE group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in percentage fixation duration to the eyes for high (M = 18.70, SE = 4.55) and low (M = 28.78, SE = 5.17) FNE individuals, $F(1, 29) = 1.66$, $p = .208$, $\eta^2 = .05$. Further, there were no significant interactions with FNE group: emotion and FNE group, $F(5, 145) = 0.64$, $p = .667$, $\eta^2 = .02$; intensity and FNE group, $F(2, 58) = 2.70$, $p = .076$, $\eta^2 = .09$; emotion, intensity and FNE group, $F(10, 290) = 0.60$, $p = .813$, $\eta^2 = .02$. There were no significant interactions including sex, $Fs < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.15.

TFD by SAD-General group

TFD on facial features

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and SAD-General group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in the relative amount of time spent looking at features for individuals high (M = 72.99, SE = 5.85) and low (M = 63.02, SE = 3.93) on SAD-General, $F(1,29) = 0.89$, $p = .352$, $\eta^2 = .03$. Further, there were no significant interactions with SAD-General group: emotion and SAD-General group, $F(5,145) = 0.90$, $p = .486$, $\eta^2 = .03$; intensity and SAD-General group, $F(1.63, 47.19) = 0.42$, $p = .620$, $\eta^2 = .01$; emotion, intensity and SAD-General group, $F(10, 290) = 0.23$, $p = .993$, $\eta^2 < .01$. There were no significant interactions including sex, $F < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.16.

TFD on the eyes

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and SAD-General group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in percentage fixation duration to the eyes for high (M = 24.39, SE = 4.50) and low (M = 20.80, SE = 5.33) SAD-General individuals, $F(1, 29) = 0.20$, $p = .662$, $\eta^2 < .01$. Further, there were no significant interactions with SAD-General group: emotion and SAD-General group, $F(5, 145) = 1.02$, $p = .406$, $\eta^2 = .03$; intensity and SAD-General group, $F(2, 58) = 0.10$, $p = .902$, $\eta^2 < .01$; emotion, intensity and SAD-General group, $F(10, 290) = 1.69$, $p = .082$, $\eta^2 = .06$. There were no significant interactions including sex, $F < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.17.

TFD by SAD-New group

TFD on facial features

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and SAD-New group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in the relative amount of time spent looking at features for individuals high (M = 69.47, SE = 6.13) and low (M = 67.62, SE = 6.82) on SAD-New, $F(1,29) = 0.03$, $p = .864$, $\eta^2 < .01$. Further, there was no significant interactions with SAD-New group: emotion and SAD-New group, $F(5,145) = 1.82$, $p = .112$, $\eta^2 = .06$; intensity and SAD-New group, $F(1.67, 48.34) = 2.52$, $p = .100$, $\eta^2 = .08$; emotion, intensity and SAD-New group, $F(10, 290) = 0.35$, $p = .968$, $\eta^2 = .01$. There were no significant interactions including sex, $F < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.18.

TFD on the eyes

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and SAD-new group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in percentage fixation duration to the eyes for high (M = 22.23, SE = 4.47) and low (M = 24.50, SE = 5.23) SAD-New individuals, $F(1, 29) = 0.08$, $p = .784$, $\eta^2 < .01$. Further, there were no significant interactions with SAD-New group: emotion and SAD-New group, $F(5, 145) = 0.78$, $p = .565$, $\eta^2 = .03$; intensity and SAD-New group, $F(2, 58) = 1.17$, $p = .319$, $\eta^2 = .04$; emotion, intensity and SAD-New group, $F(10, 290) = 1.08$, $p = .337$, $\eta^2 = .04$. There were no significant interactions including sex, $Fs < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.19.

5.1.1.6 TFD by Laterality for Emotion Processing group

TFD on facial features

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and laterality group as between subject's measures. Mean centred scores on all social anxiety variables, and depression were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in the relative amount of time spent looking at features between the RH (M = 72.28 SE = 5.00) and BL (M = 64.44, SE = 5.14) laterality groups, $F(1, 29) = 1.14$, $p = .294$, $\eta^2 = .04$. Further, there were no significant interactions with laterality group: emotion and laterality group, $F(5,145) = 0.29$, $p = .920$, $\eta^2 = .01$; intensity and laterality group, $F(1.67, 48.43) = 0.37$, $p = .658$, $\eta^2 = .01$; emotion, intensity and laterality group, $F(10, 290) = 0.65$, $p = .775$, $\eta^2 = .02$. There were no significant interactions including sex, $Fs < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.20.

TFD on the eyes

A mixed ANCOVA was run, with emotion and intensity as within subject's measures and sex and laterality group as between subject's measures. Mean centred scores on all social anxiety variables and depression were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in percentage fixation duration to the eyes for between the RH (M = 22.53 SE = 4.05) and BL (M = 24.26, SE = 4.16) laterality groups, $F(1, 29) = 0.08$, $p = .774$, $\eta^2 < .01$. Further, there were no significant interactions with laterality group: emotion and laterality group, $F(5, 145) = 0.28$, $p = .925$, $\eta^2 < .01$; intensity and laterality group, $F(2, 58) = 0.25$, $p = .778$, $\eta^2 < .01$; emotion, intensity and laterality group, $F(10, 290) = 0.83$, $p = .599$, $\eta^2 = .03$. There were no significant interactions between laterality group and sex, $F < .1$, $ps > .050$. Full table of descriptives is available in Appendix 5, see Table 7.21.

5.2.4 Discussion

5.2.4.1 Aims

This study had two key aims. Firstly to examine differences in FER for the six basic emotions at differing levels of intensity, depending on levels of social anxiety, depression and patterns of lateralisation for emotion processing. Secondly, this study aimed to explore whether these groups were characterised by differences in attention to facial features and the eyes, when making decisions on a FER task.

5.2.4.2 The role of intensity in FER and attention

It was demonstrated that intensity affected FER accuracy, with overall FER being poorer for emotions presented at 30% than for emotions presented at 50% and 70% intensity. For anger and fear only, faces at 70% intensity were also recognised significantly better than emotions at 50% intensity. For all other emotions (i.e., happiness, sadness, surprise, disgust), there were no significant differences in FER for emotions presented at 50% and 70% emotional intensity. Importantly, there was no effect of emotional intensity in the amount of percentage of time spent attending to the facial features or to the eyes during FER. Although not significant, there was a trend whereby the higher the emotional intensity the less time spent examining the eye region during FER.

In contrast to previous research, in this study it was found that individuals differing in their levels of social anxiety (i.e., the three sub-facets) and of depression did not show differences in their FER for emotions presented at different intensities.

Previous literature has suggested both increased and decreased sensitivities to different emotional expressions in individuals with social anxiety (Gutierrez, Garcia & Calvo, 2017; Montagne et al., 2006) and depression (Bannerman et al., 2010; Bento de Souza et al., 2014; Gollan et al., 2013, 2010). Further, these findings do not support previous work that suggested that being more strongly lateralised to the RH for emotion processing may be more closely related to FER performance when the task is more difficult (Watling & Damaskinou, 2018). Despite this, no significant differences were found between the two laterality groups in their FER at different emotional intensities. It was also found that there were no differences in the amount of time spent attending to facial features and attending to the eyes depending on levels of intensity, emotion, and for the social anxiety, depression and degree of lateralisation for emotion processing groups.

One consideration of this study is the possible effects of viewing time; this study was a free-viewing task with no time restrictions. In fact, in day to day life, emotions are often presented briefly, future research would benefit from examining whether adolescence differ in their FER under different exposure times. Additionally, attentional biases have been shown to pertain at different temporal phases of processing in depression and social anxiety, which would allow us to further examine attentional processing under different exposure times. In fact, it may be that when adolescents are given free time to respond, eye movements may reflect decisional processes rather than perceptual/attentional processes. This may not be the case under restricted viewing times. This will be considered in Study 5.

5.2.4.3 Social Anxiety, FER and Attention

The results of this study show that individuals high and low on different facets of social anxiety did not differ in their FER. Specifically, individuals high and low in generalised avoidance and distress, avoidance and distress to new situations and FNE showed no differences in their FER for any of the different emotions and at the different levels of intensity. Alongside this, individuals high and low on facets of social anxiety did not show differences in the relative amount of time spent scanning features or the eye region during FER. These findings suggest that individuals high and low in facets of social anxiety do not show differences in their FER or scanning of faces.

The findings suggest that, for this sample, individuals high and low in different facets of social anxiety are not characterised by differences in the recognition of different emotions, including when emotion is presented at different intensities. Further, the lack of differences in scanning of emotional faces was largely inconsistent with previous research that finds that individuals with social anxiety, in comparison to control group participants, show reduced scanning of facial features and of the eyes when viewing emotional stimuli (Horley et al., 2003, 2004). However, in considering that no differences were found in FER, it is unsurprising that no differences in attention to features and the eyes were found, given their importance in successful FER (Eisenbarth & Alpers, 2001). These findings will be explored further in the chapter discussion (following Study 5).

Importantly, the findings of this study are in contrast to previous literature on social anxiety around FER (e.g., McClure & Nowicki, 2001;Simonian et al., 2001; Tseng et al., 2017) and to the findings of Studies 3 and 4, which found that increased SAD-General was associated with an overall poorer FER and that FNE was associated with better FER. Individuals high and low on generalised avoidance and distress showed no differences in their ability to recognise facial affect. The results are also in contrast to findings that individuals higher in avoidance showed poorer recognition of emotions (McClure & Nowicki, 2001). This could be the result of participant's generally scoring low on this scale. Whilst the groups significantly differed from one another on the SAD-General measure, the high group were still relatively low in their reported anxiety (*M* = 11.00 SD= 1.82; with 74.4% of the sample scoring 10 or lower on this scale out of 20). It may be that differences are more apparent when using individuals who scored highly on this measure, given that these individuals would therefore show more behavioural avoidance, which might have a larger impact on their FER. This is further shown by the lack of evidence for avoidance behaviour in the fixation durations.

5.2.5 Depression, FER and Attention

In this study it was found that the two depression groups did not significantly differ in their overall ability to detect emotions but did find that those in the high depression group showed poorer recognition of happiness than those in the low depression group. These findings are in contrast to previous research that suggests that individuals with depression may demonstrate a global deficit in emotion recognition skills (Asthana et al., 1998; Persad & Polivy, 1993), but supports research that suggests that individuals with depression may experience difficulties in the recognition of specific emotions, (Bedio et al., 2009; Bourke et al., 2010; Rubinow & Post, 1992), and in particular in their recognition of happiness (Joorman & Gotlib, 2006).

Interestingly, the two depression groups did no differ in the amount of time spent fixating on facial features in general or on the eyes during FER. These findings suggest that attention to features and the eyes cannot explain why individuals high in depression were poorer in their recognition of happiness. As highlighted in Section 5.1, the mouth has been found to the most important feature in the recognition of happiness (Eisenbarth & Alpers, 2011; Kestenbaum, 1992); in this study total fixation duration to the mouth region was not examined on its own, but instead this study examined differences to facial features more generally. It could be that although individuals in the high depression group when compared to those in the low depression group spent the same time looking at the eyes and the facial features in total, they may have allocated their attention over the mouth and nose features differently, not focusing enough on the mouth. Alternatively, these results may suggest that poorer happiness recognition in the high, compared to low, depression group may not be the result of attention, but instead may reflect differences in information processing ability; specifically, a lack of ability to recognise positive emotions. Researchers have often reported that individuals with heightened levels of depression may use negative internal representations to guide how information is processed in the environment (see Section 2.1.2.1).

Importantly, the fact that individuals differing in their level of depression did not show differences in the amount of time spent examining features and the eyes during FER is in contrast to findings that level of depression may be associated with reduced viewing of the eye region when scanning faces (Loughland et al., 2002) and features during FER (Wu et al., 2012). Of the one eye-tracking study examining viewing of single faces during FER (Wu et al., 2012), it was noted that individuals higher on depression fixated less overall on the features of the face, but this was not found in this study. This may in part be explained by methodological differences. Wu et al. (2012) used high intensity emotions, which may be easier to recognise without extensive feature processing. However, in our study given that the emotion stimuli were of low-mid intensity facial expressions of emotions, it may have been important for both those in the high and in the low groups to allocate attention to specific regions to successfully decode emotions, which may have reduced any potential differences between groups. Further, within Wu et al.'s study, time spent examining features was not averaged over the overall viewing time, consequently faster responses overall would implicitly lead to less time viewing features. In Study 4, I decided to not explore raw scores to provide a more robust measurement of the percent of time viewing features to judge emotion in faces; therefore, I used the percentage of time spent examining features was averaged across the stimuli presentation time, which may explain the differences in findings.

5.2.6 Laterality, FER and Attention

When examining differences between laterality groups on FER accuracy and attention during FER, it was found that there were no overall differences in FER accuracy between those who were more RH compared to BL in their emotion processing. Finding showed that FER accuracy differed depending on emotion and RH group; however, when breaking down the interaction whilst there were trends for those who were RH dominant showing better recognition of surprise, and poorer recognition of sadness than the BL group these trends was not significant. Importantly, there were no significant differences found between RH and BL participants in the time spent scanning general facial features and the eye region. These findings suggest that attention to facial features and the eyes may not be able to account for group differences in FER performance between RH and BL participants. To my knowledge, no research to date has examined whether individuals who are more RH dominant in their processing of emotions differ in their scanning of emotional faces, but instead has examined how laterality for emotion processing may relate to the scanning of chimeric faces (Butler et al., 2005) or has drawn links between lateralisation for emotion processing and face scanning without examining this directly (Eisenbarth & Alpers, 2011). These findings are novel and may suggest that an individual's hemispheric dominance for facial emotion processing may not be related to attention to facial features or to the eyes during an emotion recognition task, but instead may reflects a higher-order holistic processing mechanism, as suggested by Levy and Sperry (1968).

5.2.7 Conclusion

In summary, this study examined whether individuals high and low on facets of social anxiety, depression and those who were RH dominant versus BL in their processing of emotions showed differences in the recognition of the six basic emotions at varying levels of intensity. As well as this, this study examined whether there were differences in the relative amount of time spent examining facial features and the eye region during a FER task for these groups. Overall, it was shown that individuals high and low on different facets of social anxiety showed no differences in their overall FER or attention to features and the eyes during the FER task. Individuals in the high depression group were characterised by poorer recognition of happiness, in the absence of differences in attention to faces during FER. RH compared to BL participants showed some differences in their FER (better recognition of surprise, poorer recognition of sadness), but did not show differences in the time spent examining features or the eyes during FER. Further, there were no significant differences in FER of attention to facial features and to just the eyes for these groups depending on level of intensity. Taken together these findings suggest that, differences in FER are not necessarily evident in differences in attention to features or the eyes during FER, however, given few differences reported in FER, the conclusions about the role of attention to features and the eyes in FER remains unclear.

5.3 Study 5

5.3.1 Introduction

In Study 4, few differences were found in FER for groups differing in their level of depression and social anxiety. One consideration may be that participants in Study 4 were given an unlimited amount of time to make their decision. In fact, previous research has demonstrated in adults that there was no association between level of social anxiety and labelling of facial expressions when participants were given unlimited time (Arrais et al., 2010; Campbell et al., 2009; Heuer et al., 2010; Joormann & Gotlib, 2006). Individuals high in their level of social anxiety may take longer on FER tasks than individuals with low levels of social anxiety (Tseng et al., 2017), and this may lead to equivalent FER outcomes for the two groups. It has been suggested that under free viewing (unrestricted) times, individuals with high social anxiety may have time to inhibit any initial spontaneous responses, which may consequently lead to better performance (Heuer et al., 2010). In contrast, it has been demonstrated that socially anxious individuals show an interpretation bias under restricted viewing times (Heuer et al., 2010). Additionally, individuals high in levels of depression also are poorer at FER under shorter exposure times than when in free-viewing conditions. For example, Surguladze et al. (2004) demonstrated that individuals with depression showed significantly poorer FER under short exposure time (100ms), while no group differences were found when participants were given a longer amount of time (2000ms). These findings may relate to an overall general cognitive slowing characteristic of individuals with depression (Cooley & Nowicki, 1989; Surguladze et al., 2004). Taken together, these findings suggest that differences in FER may be more pronounced under shorter exposure times and that with free-viewing these differences may be reduced. The ability to recognise emotions quickly is reflective of how emotions are reacted to in real life and therefore difficulties under short exposure times may contribute to interpersonal difficulties reported in individuals differing in their level of social anxiety and depression.

As mentioned in 2.2.3, individuals' degree of lateralisation for facial emotion processing has been found to relate to FER, especially when tasks are more difficult (Watling & Damaskinou, 2018). Unexpectedly in Study 4, there were no group differences between the two laterality groups and intensity. In this study with increased task difficulty – under shorter exposure times — I expect that individuals differing in their level of degree of lateralisation for emotion processing may show differences in their recognition of emotions.

The aims of this study are to examine whether individuals differing in their level of social anxiety, depression and degree of lateralisation for facial emotion processing show differences in their FER of the six basic emotions under differ exposure times. A further aim of this study is to examine whether individuals differing in their level of social anxiety, depression and degree of lateralisation for emotion processing show differences in their scanning of facial features and of just the eyes during FER at different exposure times. The free-viewing conditions in Study 4 may explain why in the study no differences were found between high and low groups in their level of depression, social anxiety and lateralisation for emotion processing, for the time spent examining facial features and the eyes. When participants have restricted viewing time, it would be expected that they will attend to the emotional images differently as they decide what emotion is being displayed.

Researchers have suggested that individuals with social anxiety disorder (SAD) may show differences in their allocation of attention to emotional stimuli over time (Mogg & Bradley, 1998; Wieser et al., 2009). However, in the previous studies examining the scanning of emotional faces in individuals with social anxiety, researchers have often asked participants to passively view stimuli over long exposure times (e.g., 10 seconds; Horley et al., 2003, 2004). A potential critique of these studies is that they fail to account for any differences in the allocation of attention over time, which this study will address.

Moreover, as highlighted in Section 2.1.1.3), researchers have found patterns of both vigilance (Stevens et al., 2011) and avoidance (Horley et al., 2003, 2004) to emotional stimuli in individuals with heightened levels of social anxiety. The hypervigilance avoidance hypothesis (Mogg & Bradley, 1998) has been put forward as a way of reconciling these patterns. This hypothesis posits that individuals with social anxiety may initially fixate to threat and show avoidance over longer exposure time. These findings have been partially supported by research that demonstrates that individuals who are high in FNE initially fixate to emotion stimuli (compared to neutral; within 1500ms) and then show avoidance over extended viewing (Wieser et al., 2009).

Importantly, Wieser and colleagues (2009) examined attention to competing emotional stimuli and not attention to a singular face during FER. There is evidence that scanning of singular faces in social anxiety may be dependent on the time course of attention. Staugaard and Rosenberg (2011) showed that socially anxious individuals compared to a control group showed avoidance of the eyes when faces were presented for 10 seconds, but that there was no significant difference between the two groups at 3 seconds. As mentioned above, researchers have previously found evidence that individuals with SAD show eye avoidance and reduced time scanning features; however, these findings were found in passive viewing tasks (participants required to view and not make decisions) over longer durations (i.e., 10 seconds; Horley et al., 2003, 2004) and may therefore mask any differences in scanning of faces under shorter exposure times, which may be important for FER.

In depression, as highlighted in Section 2.1.2.3, there is little research examining how individuals with high compared to low levels of depression scan faces when presented singularly. Researchers examining attentional biases, have found evidence that depression may not be associated with an initial bias in attention, but may be associated with biases during the late stages of processing, under conditions which allow for elaborative processing (see Mogg & Braddley, 2005, for review). In fact, it has been demonstrated that attentional biases for dysmorphic stimuli have not been found under short exposure times (<500ms) but that differences in attention are found under longer exposure times (>1000ms). If this is the case, then it may be that individuals high in depression may show differences in their scanning of faces under longer exposure times that are not present under shorter times. To my knowledge no research to date has examined the scanning of faces during an emotion recognition task over different exposure times. This research therefore examines whether individuals who are higher in feelings of depression compared to those who are lower in feelings of depression show differences in percentage of time spent examining features and the eyes when faces are presented for different amounts of time.

In relation to the lateralisation for emotion processing, previous research has suggested a role for the RH processing may be related to initial processing (Eisenbarth & Alpers, 2001). It is important to examine the role of exposure time in scanning of faces in individuals differing in their degree of lateralisation for emotion processing. It may be that individuals who are more RH dominant compared to individuals who are more BL in their processing of emotions may show differences in the attention to faces – in the time spent examining facial features and the eyes – under brief exposure times.

5.3.1.1 Age differences in attentional biases

In Study 4, participants included late adolescents and emerging adults (M_{age} = 19.46 years, *SD* = 1.41); however, as highlighted in Section 1.2.2, it is believed that FER skills may show continued development throughout the adolescent period (Thomas et al., 2007; Lawrence et al., 2015). In line with this, the impact of exposure time may influence adolescents and emerging adults differently during FER, which may explain some of the findings I have within this thesis. For instance, in Study 2 during the self-paced FER task adolescents higher in depression and generalised avoidance showed poorer facial emotion recognition, and adolescents higher in fear of negative evaluation show better FER. Further, there may be differences that exist in younger adolescents, when social anxiety and depression are emerging, and when hormonal changes across puberty may be affecting patterns of laterality for emotion processing (see Chapter 2). In this study, I will compare FER performance for a group of early to mid-adolescents with a group of late adolescents and emerging adults in their recognition of specific emotions at varying exposure times to examine if the information they attend to in the facial stimuli differs depending on their levels of social anxiety, depression and degrees of lateralisation for facial emotion processing.

5.3.1.2 Aims and hypotheses

The first aim of this study is to examine whether early-mid adolescents and late-adolescents/emerging adults who are high and low depression and facets of social anxiety (FNE, SAD-New, SAD-General) and who are more strongly lateralised compared to more BL in their processing of emotions show differences in their FER of the six basic emotions and at different exposure times (500ms, 3000ms, 10,000ms), and if these groups show differences in the amount of time spent examining facial features and the eyes during FER.

The timing of 500ms was chosen to examine any differences in initial attention; for example, it might be that if individuals high compared to low in level of social anxiety and depression may show initial fixations towards or away from features during FER. Further, lateralisation for emotion processing may be related to initial processing of faces (Eisenbarth & Alpers, 2001); thus, this study will examine the affect short exposure times on attention to the facial features and the eyes for individuals who are more strongly lateralised in their processing of emotions compared to more BL.

1. It is predicted that differences in FER may differ as a function of exposure time. More specifically, it is predicted that individuals with higher levels of depression will show poorer recognition under short exposure times. Further, little research has examined social anxiety and exposure time, but has suggested that individuals with high levels of social anxiety may misinterpret faces under shorter exposure times (Heuer et al., 2007); it is therefore

predicted that individuals higher on social anxiety may show differences in their recognition of facial emotions under restricted viewing times. This may particularly the case for individuals higher on FNE, who may demonstrate negative biases in their recognition during the initial stages of processing. Finally, given evidence of early attentional biases in social anxiety, it is predicted that for individuals high on facets of social anxiety there may be patterns of hypervigilance when shorter exposure times and evidence of avoidance when longer exposure times. For depression it is expected that there may be differences in the scanning of facial features and the eyes depending on exposure time.

2. With regards to lateralisation for emotion processing, it is expected that individuals who are more RH dominant compared to individuals who are BL will show better FER when task demands are more difficult (at shorter exposure times). Further, some researchers have argued that lateralisation for emotion processing may be related to initial processing (Eisenbarth & Alpers, 2011; Levy & Sperry, 1968), it is therefore expected that differences in attention may be more apparent under shorter exposure times between the two laterality groups.
3. Finally, it may be expected that these patterns may differ by age group, with young to mid-adolescents showing different behavioural and attentional responses in comparison to older adolescents/ emerging adults.

5.3.2 Method

5.3.2.1 Participants

The sample consisted of 77 participants, with 35 early-mid adolescent participants aged 11-17 years (M_{age}= 14.06 years, *SD* = 2.06; 18 males) and 42 late- adolescents – emerging adult participants aged 18-26 (M_{age}= 19.26 years, *SD* = 1.58; 11 males). The sample were white Caucasian (*N* = 61), Asian (*N* = 7), Mixed (*N* = 6), Arab (*N* = 2), two participants did not provide their ethnicity. The adolescent participants were recruited via leaflet distribution in local secondary schools and received £10 to cover travel expenses. Adult participants were recruited as part of a Psychology Department undergraduate research credits scheme. Parents of adolescents under the age of 16 were required to provide parental consent for their child to take part in the study. In all instances the participant also gave informed consent prior to taking part in the study and were giving the opportunity to ask questions.

As with Study 4, participants were asked whether they had been diagnosed with a psychological condition in the past year, this was the case for 16.9% of the sample (*N* = 13). Of those who had received a diagnosis in the past year, three were currently taking medication for a psychological condition. These three medicated participants were removed from the analysis (all from the late-adolescent – emerging adult group). A further three participants were removed due (all from the late-adolescent – emerging adult group) to not responding to more than 90% of trials for the FER task and/or CFT, leaving 71 participants for the FER analyses (see Appendix 6, Table 7.23 for participant age group and sex by ethnicity). For the later eye-tracking analyses a further two individuals (2 female adults – one Asian, one “other” ethnicity) were excluded due to poor calibration or less than 70% of gaze samples recorded, leaving 69 participants for the eye-tracking analyses. Participants included in the eye-tracking analysis all had normal or corrected to normal vision. Ethical approval was received through the RHUL Research Ethics Committee.

5.3.2.2 Materials

Participants were tested individually in an eye-tracking lab. As with Study 4, the study consisted of questionnaire measures (completed on Qualtrics survey software; Qualtrics, Provo, UT) and two emotion-based tasks (FER and CFT). The order of tasks was randomised between participants. The emotion tasks were programmed using E-Prime 2.0 with an extension for Tobii Studio (version).

Social Anxiety Scale for Adolescence

All participants completed the Social Anxiety Scale for Adolescence (La Greca & Lopez, 1998), in an identical format to Study 4. Cronbach's alpha indicated acceptable-excellent levels of internal consistency for the FNE scale (α = .93), the SAD-General scale (α = 76) and SAD-New scale (α = .84) within this study.

Centre for Epidemiological Study Depression Scale (CES-R)

All participants completed the Centre for Epidemiological study depression scale (Radloff, 1977), in an identical format to Study 4. Cronbach's alpha indicated an acceptable level of internal consistency (α = .70) within this study.

Chimeric Face Test

All participants completed a chimeric face test. The task and instructions were the same as Study 4; the only difference being the software shown on. The task was programmed and run using E-Prime instead of Tobii studios.

5.3.2.3 Apparatus

The set-up for this study consisted of a two-computer configuration. The primary computer was the Tobii X300 screen-based eye-tracker was used with a sampling rate of 120Hz, which was connected to a secondary Windows PC through a Digital Visual Interface (DVI) cable. This set-up allowed for communication between the Tobii eye tracker server and E-Prime which is necessary to run both programmes simultaneously using E-Prime 2.0 extension for Tobii. The primary computer was responsible for collecting eye gaze samples and the recording of the experiment through an external video within Tobii studio. The second computer was used to run the E-Prime experiment. The experiment started on the primary Tobii computer by carrying a 5-point calibration. If an acceptable calibration was not made, the calibration was repeated. If after several attempts a successful calibration could not be achieved, then participants were excluded from the study (*N* = 2). After a successful calibration was made, the experimenter switched the CPU to run E-Prime on the same screen, whilst eye-movements were simultaneously being recorded in the background.

Facial Emotion Recognition Task

Similar to Study 4 (see Section 5.2.2.3), participants were required to view and label facial expressions of the six basic emotions at different emotional intensities (e.g., 30%, 50%, and 70%; see Chapter 3 for stimuli development). In total 36 stimuli were selected, this included one male and one female model for each of the basic emotion at the three intensity levels (see Section 3.2.1 for model selection). A further 8 neutral faces were displayed corresponding to all models used throughout the task. The number of stimuli were reduced in this study given time constraints given that all stimuli were shown at three different exposure times

(500ms, 3000ms and 10,000ms). In total participants completed 132 trials. Trials for each exposure time were blocked for a total of three blocks, so participants would know how long they may view the face for. Participants were told at the beginning of the task that they will view faces and would need to judge the emotion that the face is showing. They were told that they would see 3 blocks, with some faces appearing very briefly whilst others they would have longer to view the images. Before each exposure block participants were shown a practice trial, using an image that was not included in the trials, to demonstrate the length of time they had to view the subsequent stimuli. At the start of each block participants were told that they would view a face either ‘very quickly, fairly quickly or for 10 seconds’ and would be asked to identify ‘which facial emotion is the face showing’, from happy, sad, scared, disgust, fear and no emotion/neutral. Participants viewed each exposure block separately and were given short breaks between blocks, the order in which participants viewed the blocks were randomised between participants. Before each trial, a fixation cross appeared on the screen, participants were required to fixate on the cross for 100ms which triggered the image to appear (gaze-contingent). After the set duration, participants were presented with a screen with seven options with corresponding numbers (as with Study 4; i.e., Disgust = 1, Happiness = 2, Sadness = 3, Surprised = 4, Fear = 5, Anger = 6, No emotion = 0) and were instructed to press the number that corresponded to the emotion they thought the face was showing (see Figure 5.5). The order of stimulus presentation was randomised, as well as the response screen options (two versions – see 5.2.2). The whole experiment took around one hour to run.

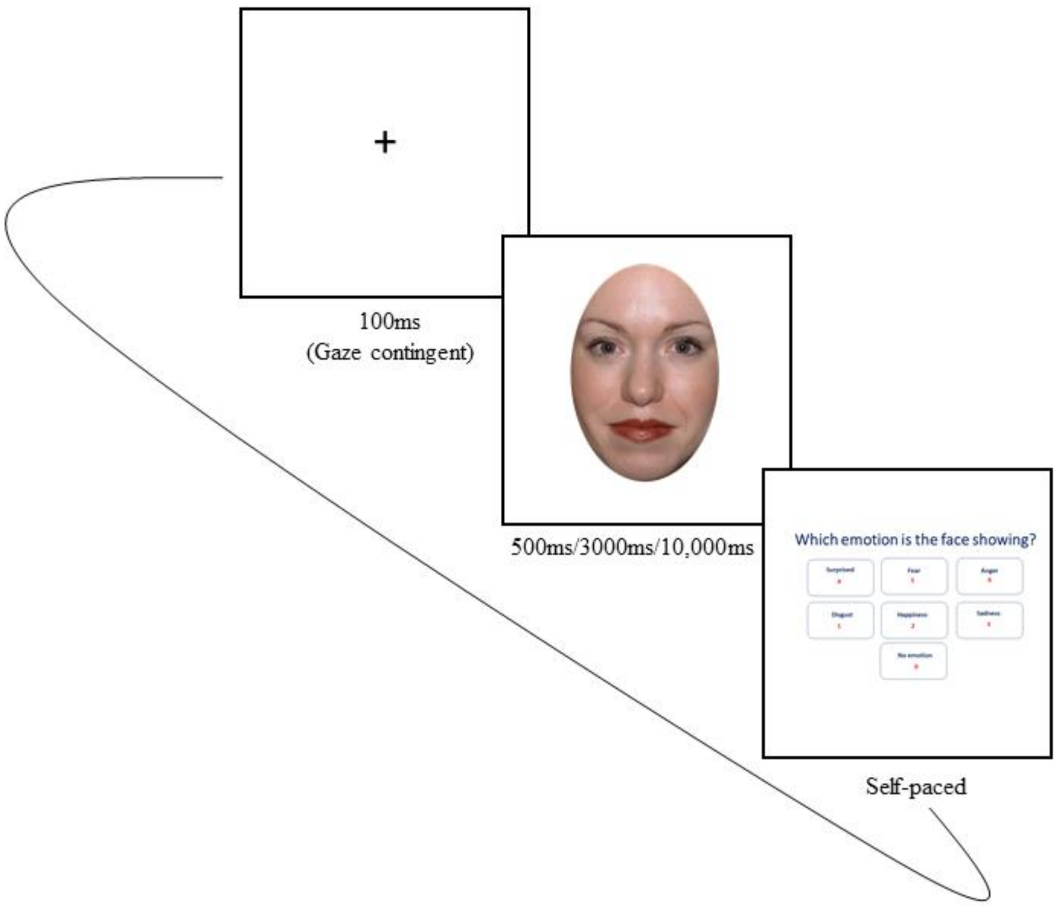

Figure 5.5. Trial example for Facial Emotion Recognition task.
Each trial started with a fixation cross which was gaze contingent, after 100ms, an emotional face appeared for either 500ms, 3000ms or 10,000ms depending on exposure block. Participants were next presented with a response grid and selected the number corresponding to the emotion they believed the face was showing. This signalled the start of the next trial.

Coding. In a similar way to Study 4 (see Section 5.2.2.3), unbiased hit rates (*Hu scores*), were calculated for each emotion at each exposure time (collapsed across intensity), and excluding neutral faces, see Equation 5.1. In this instance **A** refers to the number of correct responses of that emotion at a given exposure time, **B** indicates the amount of times the stimuli was present at that exposure time, and **C** represents the amount of times the emotion was selected overall for that exposure time.

5.3.2.4 Attention during FER

Similar to Study 4, AOIs were defined prior to analysis. These included the left eye (3° by 2°), right eye (3° by 2°), nose (2° by 2°), and mouth (3° by 3°) left eye, right eye, nose, mouth and whole face. To calculate total fixation duration (TFD) to features, the left eye, right eye, nose, and mouth were summed and divided by the trial length (either 500ms, 3000ms, or 10,000ms) to convert raw scores into a percentage of time, and allowing comparisons to be made between different exposure times. To calculate total fixation duration to the eyes, the TFD for the left and right eye were summed and divided by trial length (either 500ms, 3000ms, or 10,000ms) to convert raw scores into a percentage of time.

5.3.2.5 Procedure

The procedure for this study was identical to Study 4 (see Section 5.2.2.4).

5.3.2.6 Design and Analysis

As with Study 4, a median split within each age group was used to split the participants (N = 71; Adolescents *n* = 35, Adults *n* = 36) into two groups according to their scores on the depression scale and their scores on the subscales (facets) of the social anxiety measure (creating high and low groups on these measures), as well as split based on their laterality quotient (creating one group with stronger RH processing and one group with weaker RH processing; see Table 5.6). Independent t-tests showed that the high and low groups significantly differed from one another. For the laterality groups, one sample t-tests were run to determine whether the laterality groups created significantly differed for 0 (zero indicates no hemispheric dominance). The group who with higher laterality scores (indicating stronger RH dominance) significantly differed from 0, t (36) = 14.95, p < .001, showing that the group are RH dominant in their processing of emotions. As with Study 4, the group with lower laterality scores showed no difference from 0, t (35) = 0.49, p = .628, suggesting that this group may represent a more BL group. Further, independent t-tests were showed that there were no significant age group differences for all measures (see Table 5.6). Descriptive statistics on the relationships between the variables are presented in Appendix 6, Table 7.5.

Table 5.5. Means (SD) and range for adults and adolescents on all measures.

	Late adolescents/ emerging adults	Early-mid adolescents	*t*	*p*
Depression	18.33 (*9.89*) (1 – 37)	13.71 (*10.17*) (1 – 39)	1.94	.056
FNE	22.83 (*6.50*) (10 – 37)	19.34 (*8.72*) (9 – 40)	1.91	.061
SAD-New	17.31 (*4.01*) (8 – 25)	15.75 (*4.89*) (7 – 25)	1.48	.145
SAD-General	8.42 (*2.91*) (4 – 16)	7.37 (*3.41*) (4 – 18)	1.39	.169
Laterality	0.36 (*0.32*) (-0.40 – 0.96)	0.24 (*0.42*) (-0.65 – .0.96)	0.93	.355
Age	19.28 (*1.68*) (11— 17)	14.06 (*2.06*) (18—26)	11.72**	<.001

Table 5.6. Means (SD) and N for participants split into high and low groups for sub-score scales of social anxiety, and depression and those allocated to the BL and RH laterality groups.

	Low		**High**		
	M (SD)	N	M (SD)	N	t
Depression	7.36 (3.48)	36	25.00 (6.35)	35	14.45***
FNE	14.37 (2.96)[a]	35	27.67 (4.92)[b]	36	13.82***
SAD-General	5.24 (0.79)[c]	33	10.21 (2.63)[d]	38	11.07***
SAD- New	12.50 (2.83)[e]	32	19.85 (2.41)[f]	39	11.81***
	BL		**RH**		
	M (SD)	N	M (SD)	N	t
CFT	-0.18 (0.22)	35	0.58 (0.23)	36	11.21***

Note: *** $p < .001$, all groups significantly differed from one another. FNE, SAD-General and SAD-New also differed in their overall level of social anxiety. [a] SA total, $M = 34.97$ $SD = 7.72$ [b] SA total, $M = 55.83$ $SD = 8.66$ [c] SA total, $M = 35.39$ $SD = 8.25$ [d] SA total, $M = 54.37$ $SD = 10.18$ [e] SA total, $M = 36.22$ $SD = 10.07$ [f] SA total, $M = 53.21$ $SD = 10.46$ (*ps* <.001).

5.3.3 Results

5.3.3.1 Facial Emotion Recognition (FER)

Firstly, a mixed 6 x 3 x 2 Analysis of Variance (ANOVA) was run to examine if there were any differences in FER depending on the emotion (happy, sad, angry, fear, surprise, and disgust), and exposure time (500ms, 3000ms, and 10,000ms) being assessed and sex (male and female) and age group (early-mid adolescents and late adolescents/emerging adults). Emotion and exposure time were entered as within subjects' variables and sex and age group as a between-subjects factors. The dependent variable was unbiased hit rates (referred to as accuracy).

As with Study 4, following exploring the overall differences in FER due to our manipulations and for sex and age group, I conducted a set of mixed Analysis of Covariance (ANCOVAs) examining group differences in FER for each of the independent variables of interest in the analysis (5 analyses – (1) Depression group (2) SAD-General group (3) SAD-New group (4) FNE group (5) Laterality group). In all instances emotion and exposure time were within subjects' measures and sex and age group were between subjects' measures. The dependent variable was FER unbiased hit rates (accuracy). During each analysis the variables that were not the independent variable within the analysis were controlled for (i.e., when exploring the difference in FER by laterality group, all three facets of social anxiety and depression [actual scores] were controlled for, correlations between the variables are presented in Appendix 6, Table 7.22). Given that the main findings with FER, emotion, exposure time, age group and sex were the same throughout, only main effects of group and interactions with group will be reported below. Where sphericity is violated, a Greenhouse- Geisser correction is reported. Any interactions will be broken down using simple effects analyses, and where appropriate, pairwise comparisons will be used, with Bonferroni corrections applied.

FER by Emotion, Exposure time, Age group and Sex

Full descriptives for emotion by exposure time, with total scores, are presented in Table 5.7. There was a main effect of emotion, $F(3.56, 238.65) = 83.51$, $p < .001$, $\eta^2 = .56$. Simple effects analysis found that happiness was recognised significantly better than all other emotions, *p*s < .05. Surprise was recognised significantly better than all emotions apart from happiness, (*ps* < .001). Disgust was recognised significantly better than anger and fear (*ps* < .001). Anger was recognised significantly poorer than all other emotions (*ps* < .001; see Table 5.7). There was a significant sex difference in emotion recognition, $F(1, 67) = 12.26$, $p = .001$, $\eta^2 = .16$, with females (*M* = 0.86, *SE*= .04) outperforming males (*M* = 0.72, *SE* = .03). And, as expected, there was a significant difference in emotion recognition between the two age groups, $F(1, 67) = 6.87$, $p = .011$, $\eta^2 = .09$, with late-adolescents/ emerging adults (*M* = 0.84, *SE*= .03) outperforming early-mid adolescents (*M* = 0.74, *SE* = .03). There was no significant effect of exposure time on FER, $F(2, 134) = 1.09$, p =.340 η^2 =.016.

There was a significant three-way interaction between emotion, exposure time and age group, $F(7.41, 496.24) = 2.43$, $p = .016$, η2 = .04. Simple effects analysis showed that there were significant differences between age groups for the recognition of happy at 500ms (*p* = .023) and 3000ms (*p* = .036), anger at 3000ms (*p* = .001) and surprise at 3000ms (*p* = .014), whereby in all cases the late adolescent/emerging adult group performed better than the early-mid adolescent group (See Table 5.7).

Table 5.7. Unbiased hit rate, Mean (SD) of faces presented at each exposure times for each emotion for early-mid adolescents and late adolescents/emerging adults separately.

(possible *Hu* score 0 – 1.57).

	Early-mid adolescents			Late adolescents/emerging adults			Overall
	Exposure time			Exposure time			
Emotion	500ms	3000ms	10,000ms	500ms	3000ms	10,000ms	
Happy	1.03 (0.05)+	1.09(0.06)+	1.13 (0.06)	1.22 (0.06)+	1.28 (0.06)+	1.26 (0.06)	1.17 (0.03)
Sad	0.61 (0.07)	0.61 (0.06)	0.61 (0.06)	0.74 (0.08)	0.69 (0.06)	0.76 (0.07)	0.67 (0.04)
Fear	0.62 (0.05)	0.56 (0.06)	0.65 (0.06)	0.61 (0.06)	0.73 (0.07)	0.74 (0.61)	0.65 (0.03)
Anger	0.38 (0.05)	0.38 (0.04)+	0.37 (0.04)	0.47 (0.06)	0.58 (0.04)+	0.50 (0.05)	0.45 (0.02)
Surprise	1.07 (0.07)	0.90 (0.06)+	0.98 (0.07)	0.93 (0.08)	1.13 (0.07)+	1.05 (0.07)	1.01 (0.04)
Disgust	0.69 (0.07)	0.76 (0.06)	0.80 (0.06)	0.87 (0.07)	0.80 (0.07)	0.83 (0.07)	0.79 (0.04)
Total	0.74 (0.04)	0.72 (0.03)	0.76 (0.03)	0.80 (0.40)	0.87 (0.04)	0.86 (0.04)	

Note: + denotes instances where significant differences occur between adolescents and adults for that specific emotion at the given exposure time.

FER by Depression group

A mixed ANCOVA was run, with emotion and exposure time as within subject's measures and sex, age group and depression group as between subject's measures. Mean centred scores on all social anxiety variables and laterality quotient were entered as covariates. There was no significant difference in emotion recognition for those in the high (M = 0.80, SE = 0.03) and low (M = 0.80, SE = 0.03) depression group, $F(1, 59) < 0.01$, $p = .948$, $\eta^2 < .01$. Further there no significant interaction between age group and depression group, $F(1, 59) = 3.06$, $p = .085$, $\eta^2 = .09$; emotion and depression group, $F(3.47, 204.46) = 1.54$, $p =.200$, $\eta^2 = .03$; exposure time and depression group, $F(2, 118) = 2.02$, $p =.140$, $\eta^2 = .03$; and, emotion, exposure time and depression group, $F(7.21, 425.22) = 1.82$, $p =.079$, $\eta^2 = .03$.

There was a significant interaction between sex and depression group on FER, $F(1, 59) = 6.44$, $p = .014$, $\eta^2 = .10$, which further qualified for a three-way interaction with emotion, $F(3.47, 204.46) = 2.56$, $p =.048$, $\eta^2 = .04$. Simple effects analysis found that for males only, there was a significant difference between those high and low in depression on their recognition of fear ($p = .007$), with those in the high depression group performing more poorly than those low on depression and for females there was a significant difference between those high and low on depression on their recognition of sadness ($p = .037$), with the high depression group performing better than those in the low depression group (see Figure 5.6).

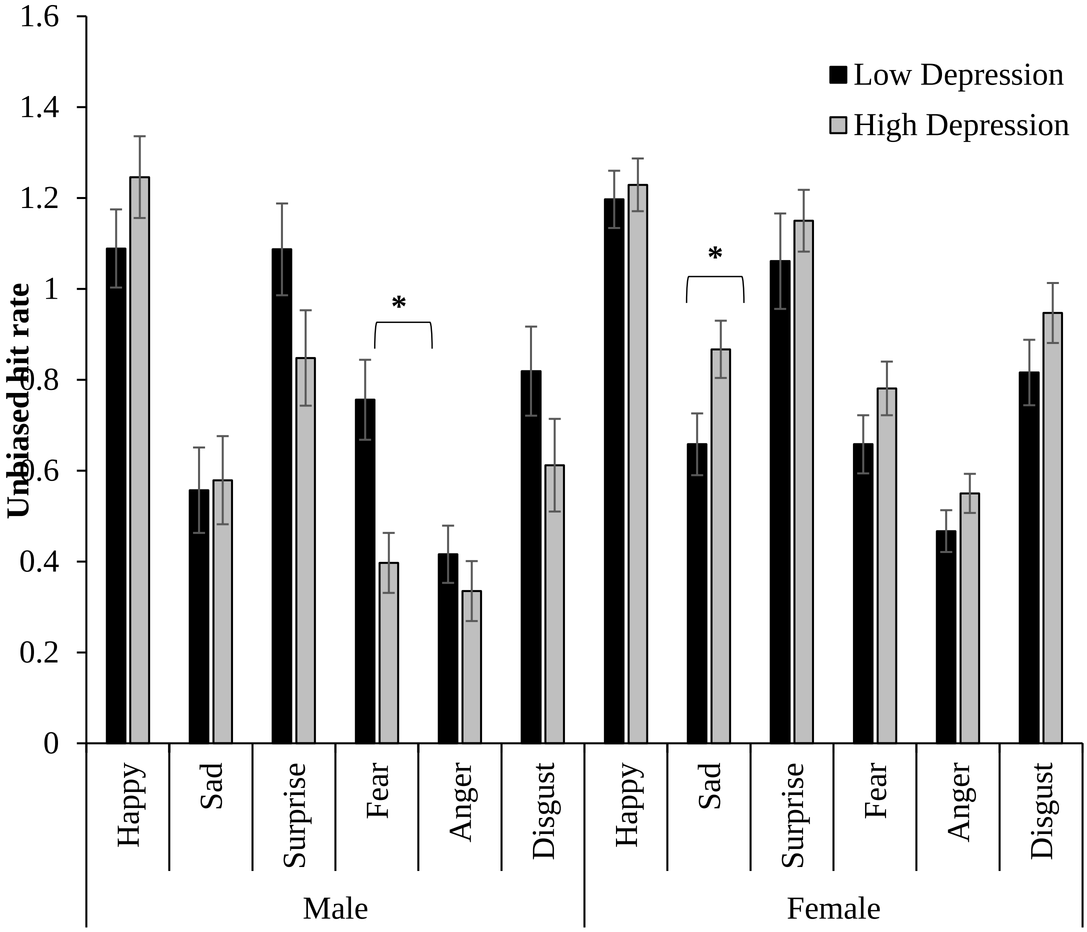

Figure 5.6. Unbiased hit rates each emotion for low and high depression groups for males and females separately.
Note: * p <.050.

There was a significant three-way interaction between exposure time, age group and depression group, $F(2, 118) = 3.16$, $p = .046$, $\eta^2 = .05$, which qualified for a four-way interaction with sex, $F(2, 118) = 3.62$, $p = .030$, $\eta^2 = .06$. To break this down, the file was split by sex to assess if there was a significant three-way interaction between exposure time, age and depression group. This interaction was not significant within the female participant group, $F(1.91, 67.00) = 1.31$, $p = .275$, $\eta^2 = .04$, but was significant within the male participant group, $F(2, 40) = 5.05$, $p = .011$, $\eta^2 = .20$. Simple effect analysis showed that for the early-mid adolescents, there was no significant difference in FER between those in the high and low depression group at varying exposure times ($p > .05$), but for the late adolescent/emerging adult group, the high depression group performed significantly poorer than the low depression group when faces were presented for 3000ms ($p = .006$), but not at any other exposure times ($p > .05$; see Figure 5.7). Full table of descriptives is available Appendix 6, Table 7.24.

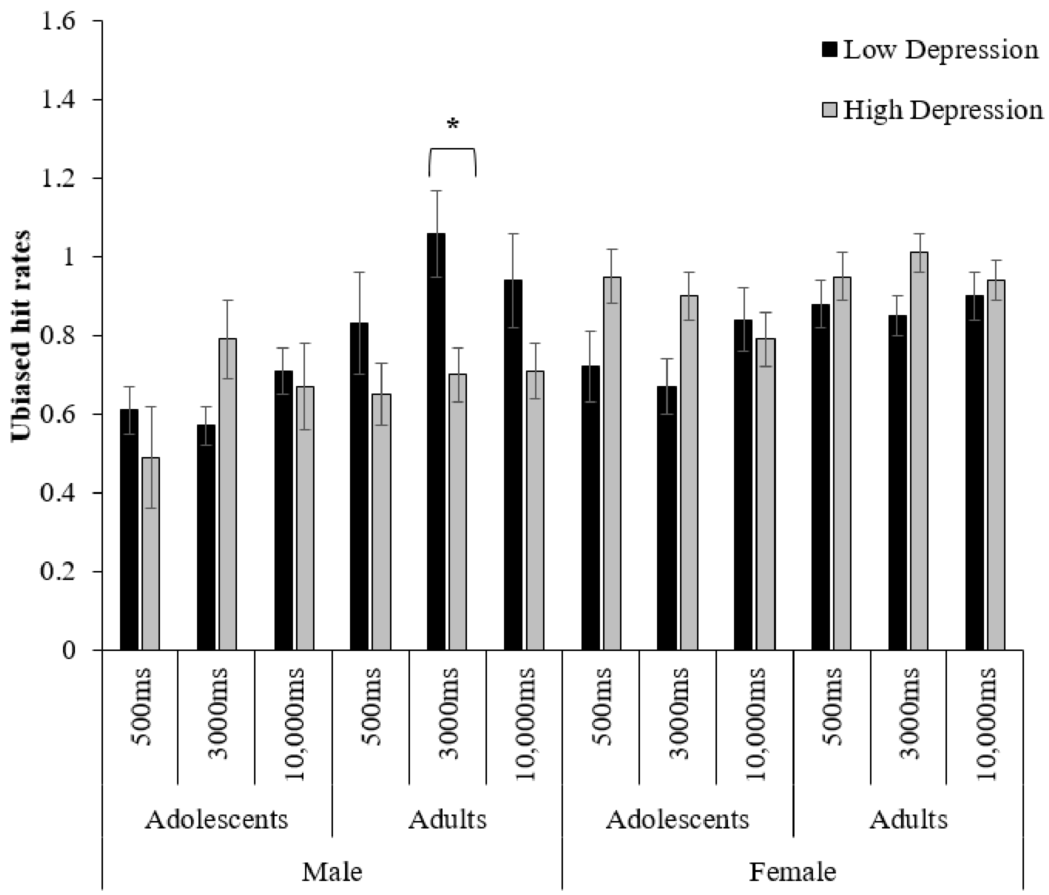

Figure 5.7. Unbiased hit rate mean (SD) for male early-mid adolescents and late adolescents/emerging adults in the low and high depression group, at different exposure times. *Note: * p <.050.*

FER by Social Anxiety Groups

FER by FNE Group

A mixed ANCOVA was run, with emotion and exposure time as within subjects' measures and sex, age group and FNE group as between subjects' measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in emotion recognition for those in the high (M = 0.76, SE = 0.04) and low (M = 0.83, SE = 0.03) FNE group, $F(1, 59) = 2.02$, $p = .161$, $\eta^2 = .03$. Further, there were no significant interactions with FNE group: age group and FNE group, $F(1, 59) = 0.04$, $p = .520$, $\eta^2 < .01$; sex and FNE group, $F(1, 59) = 0.31$, $p = .578$, $\eta^2 < .01$; emotion and FNE group, $F(3.42, 201.81) = 0.55$, $p = .673$, $\eta^2 < .01$; exposure time and FNE group, $F(2, 118) = 0.31$, $p = .719$, $\eta^2 < .01$; emotion, exposure time and FNE group, $F(7.39, 436.27) = 0.65$, $p = .726$, $\eta^2 = .01$. There were no significant interactions including sex, $F < .1$, $ps > .050$. Full table of descriptives is available in Appendix 6, Table 7.25.

FER by SAD-General group

A mixed ANCOVA was run, with emotion and exposure time as within subjects' measures and sex, age group and SAD-General group as between subjects' measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in emotion recognition for those in the high (M = 0.83, SE = 0.03) and low (M = 0.75, SE = 0.04) SAD-General groups, $F(1, 59) = 2.21$, $p = .143$, $\eta^2 = .04$. Further, there were no significant interactions with SAD-General group: age group and SAD-General group, $F(1, 59) = 1.30$, $p = .259$, $\eta^2 = .02$; sex and SAD-General group, $F(1, 59) =$

0.19, p = .666, η^2 < .01; emotion and SAD-General group, F(3.31, 194.98) = 1.23, p =.301, η^2 = .02; exposure time and SAD-General group, F(2, 118) = 1.80, p =.170, η^2 = .03; emotion, exposure time and SAD-General group, F(7.23, 426.35) = 0.80, p =.589, η^2 = .01. There were no significant interactions including sex, F< .1, ps > .050. Full table of descriptives is available in Appendix 6, Table 7.26 .

FER by SAD-New group

A mixed ANCOVA was run, with emotion and exposure time as within subjects' measures and sex, age group and SAD-New group as between subjects measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in emotion recognition for those in the high (M = 0.76, SE = 0.04) and low (M= 0.82, SE = 0.01) SAD-New groups, F(1, 59) = 0.99, p = .325, η^2 = .02. Further, there were no significant interactions with SAD-New group: age group and SAD-New group, F(1, 59) = 0.19, p = .664, η^2 < .01; sex and SAD-New group, F(1, 59) = 0.07, p = .793, η^2 < .01; emotion and SAD-New group, , F(3.40, 200.49) = 0.58, p =.648, η^2 = .01; exposure time and SAD-New group, F(2, 118) = 0.03, p =.971, η^2 < .01; emotion, exposure time and SAD-New group, F(7.56, 446.00) = 0.94, p =.477, η^2 = .02. There were no significant interactions including sex, F< .1, ps > .050. Full table of descriptives is available in Appendix 6, Table 7.27.

FER by Laterality for Emotion Processing group

A mixed ANCOVA was run, with emotion and exposure time as within subjects measures and sex, age group and laterality group as between subjects measures. Mean centred scores on social anxiety variables and depression were entered as covariates. There was no significant difference in emotion recognition for those in the RH (M = 0.79, SE = 0.03) and BL (M = 0.80, SE = 0.03) laterality groups, $F(1, 59) < 0.01$, $p = .954$, $\eta^2 < .01$. Further, there were no significant interactions with age and laterality group, $F(1, 59) = 2.57$, $p = .114$, $\eta^2 = .04$; sex and laterality group; F 1, 59) = 1.28, $p = .263$, $\eta^2 = .02$; emotion and laterality group, $F(3.63, 214.30) = 1.14$, $p = .337$, $\eta^2 = .02$; exposure time and laterality group, $F(2, 118) = 0.10$, $p = .910$, $\eta^2 < .01$ and emotion, exposure time and laterality group, $F(7.25, 427.56) = 0.65$, $p = .724$, $\eta^2 = .01$.

There was a significant three-way interaction between emotion, sex and laterality group on unbiased hit rates, $F(3.63, 214.30) = 6.06$, $p < .001$, $\eta^2 = .10$, see Figure 5.8. For males only that there was a significant difference between the laterality groups on their recognition of fear, with those who were more RH dominant (*M* = 0.78, SE = 0.07) performing better than the more BL group (*M* = 0.40, SE = 0.07). For females only, those who were more BL (*M* = 1.24, SE = 0.08) were better than the RH group (*M* = 1.02, SE = 0.06) in their recognition of surprise. Full table of descriptives is available in Appendix 6, Table 7.28.

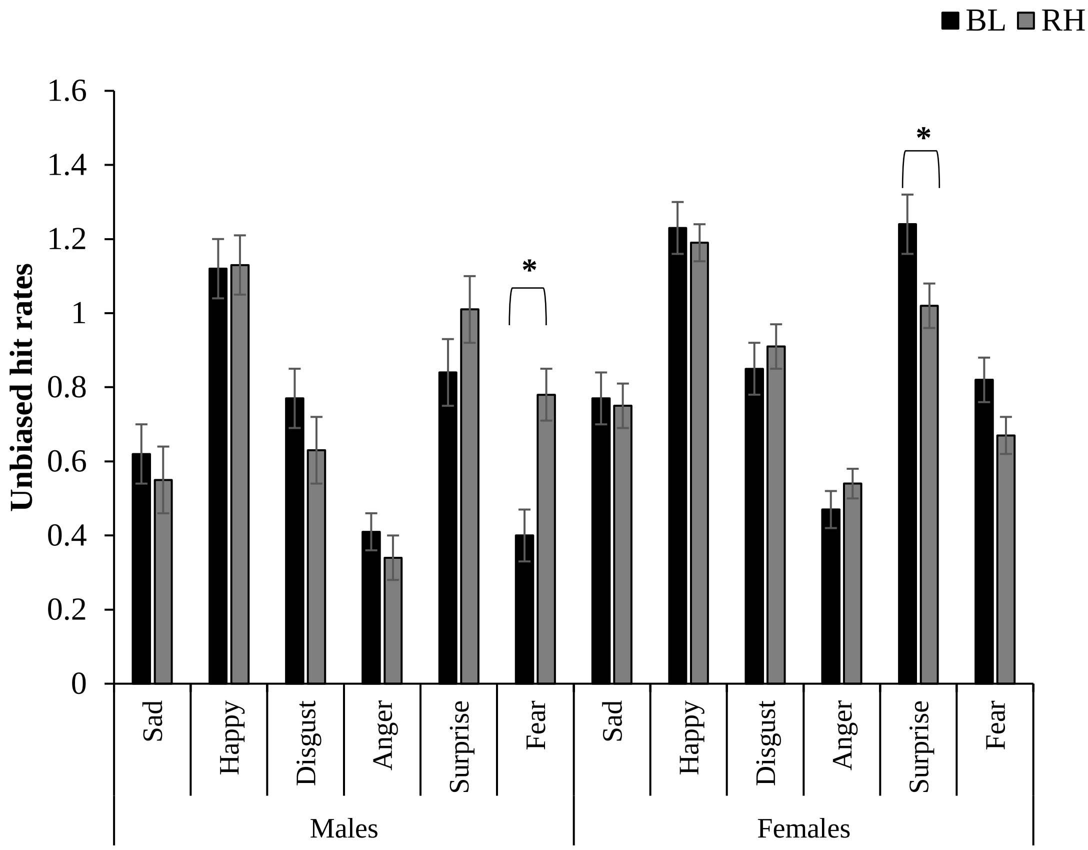

Figure 5.8. Unbiased hit rates (SE) for each emotion by sex and laterality group. *Note: * p <.050.*

5.1.1.7 Fixation Durations and FER

Firstly, two mixed Analysis of Variance (ANOVA) were run to examine any differences in the percentage total fixation duration (TFD) to facial features and the eyes, by emotion, exposure time, sex, and age group. Emotion and exposure time were entered as within subjects' variables and sex and age group were entered as a between subjects factor. The dependent variables were (1) the percentage total fixation duration to features and (2) the percentage total fixation duration to the eyes.

Separate mixed Analysis of Covariance (ANCOVAs) were run, examining each of the variables of interest as independent variables in the analysis (5 analyses – (1) Depression group (2) SAD-General group (3) SAD-New group (4) FNE group (5) Laterality group). In all instances, emotion and exposure time were within subjects' measures and sex and age group were between subjects' measure. The dependent variables were (1) the percentage total fixation duration that participants looked at facial features as a percentage of the stimulus exposure time and (2) the percentage total fixation duration on the eyes. Given that the main findings with TFD to features, emotion, exposure time, sex and age group were the same throughout, only main effects of group and interactions with group will be reported below. During each analysis, the variable that was not the independent variable in this analysis was controlled for. In all instances, where sphericity was violated, a Greenhouse-Geisser correction is reported. Interactions will be broken down using simple effects analyses, and where appropriate, pairwise comparisons will be used with Bonferroni corrections applied.

TFD on features by emotion, exposure time, sex and age group

There was no significant sex difference in percentage of time spent on facial features, $F(1, 60) = 2.39$, $p = .127$, $\eta^2 = .04$, as well as no age group differences, $F(1, 60) = 3.29$, $p = .075$, $\eta^2 = .05$. There was no significant main effect of emotion on the percentage of time spent on features, $F(4.10, 245.92) = 2.30$, $p = .058$, $\eta^2 = .04$. There was a significant main effect of exposure time on the amount of time spent looking at facial features, $F(1.43, 86.05) = 17.38$, $p < .001$, $\eta^2 = .23$. Pairwise comparisons showed that a significant lower percentage of time was spent looking at features when faces were presented for 500ms, compared to 3000 and 10,000ms (*p*s $< .001$), but no significant differences were found in the percentage of time spent examining features between the two higher exposure times (p = 1.000). This was qualified by a two-way interaction with age group, $F(1.43, 86.05) = 6.69$, p =.005, η^2 = .10, see Figure 5.9. Simple effect analyses showed that for early-mid adolescents there was no significant difference between the percentage of time spent examining features, depending on exposure time (all *ps* >.050), but that this pattern above only existed for late-adolescents/emerging adults; adults spent a lower percentage of time examining features under brief exposure (500ms) than at both 3000ms and 10,000ms (*ps* < .001), but showed no difference in the percentage of time examining features between 3000ms and 10,000ms (p = 1.00).

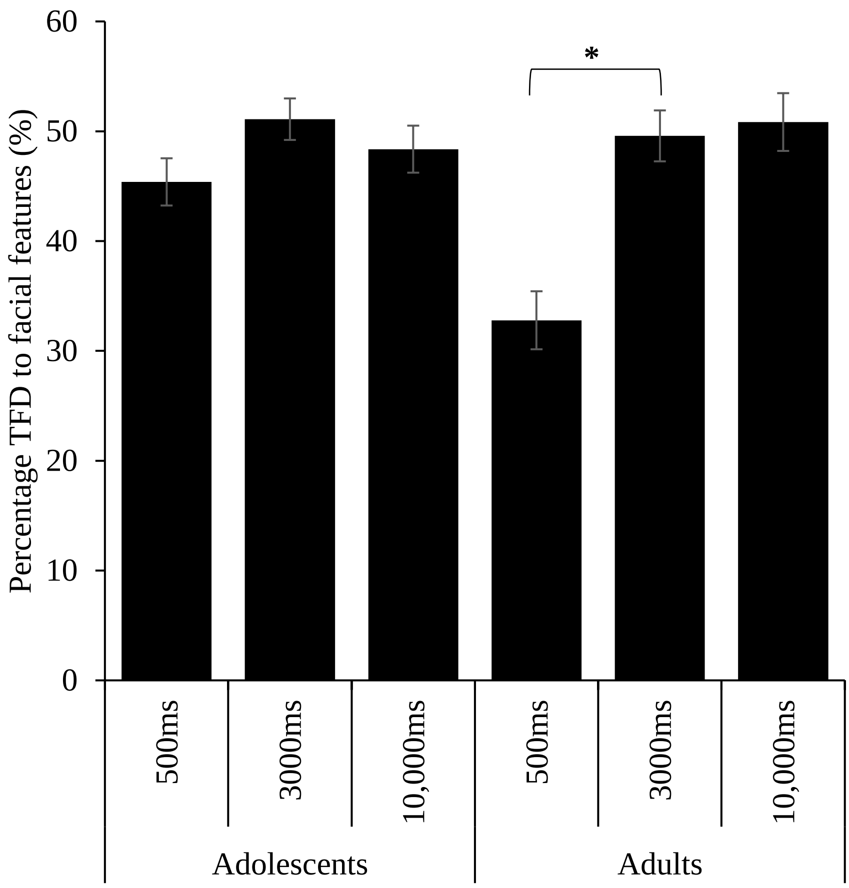

Figure 5.9. Percentage duration fixation to facial features for each exposure time by age group. *Note*: * p <.050.

TFD on the eyes by Emotion, Exposure time, Sex and Age group

A mixed ANOVA was used with emotion and exposure time as within subjects variables and sex and age group as between subjects variables. There was no significant main effect of age group on the percentage of time spent looking at the eyes, $F(1, 60) < 0.01$, $p = .961$, $\eta^2 < .01$, or interactions with age group, $Fs < 1.5$, $ps < .05$. There were no sex differences in amount of time spent looking at the eyes, $F(1, 60) = 0.17$, $p = .682$, $\eta^2 < .01$. There was a significant main effect of emotion on the amount of time spent looking at the eyes, $F(4.13, 247.69) = 13.24$, $p < .001$, $\eta^2 < .18$, see Table 5.8. Simple effects analysis showed a significantly higher percentage of time was spent looking at the eyes for sadness than all other emotions, $ps < .001$, and that participants spent significantly longer looked at the eyes for disgust compared to happy ($p = .001$), no other comparisons were significant ($ps > .050$). Further, there was a significant main effect of exposure time on the percentage of time spent looking at the eyes. Simple effects demonstrated a significantly lower percentage of time was spent looking at the eyes at for 500ms compared to both 3000ms and 10,000ms ($ps < .001$) but there was no significant difference in the percentage of time spent looking at the eyes for the two longer durations ($p = .096$).

Table 5.8. Mean (SE) percentage of fixation duration to the eyes for each emotion at each exposure time

	500ms	**3000ms**	**10,000ms**	***Total***
Happy	10.07 (1.78)	23.36 (2.12)	26.64 (1.88)	20.02 (1.59)
Sad	19.40 (2.46)	29.71 (2.31)	32.44 (2.06)	27.18 (1.82)
Disgust	13.23 (2.24)	26.73 (2.12)	29.87 (1.72)	23.27 (1.64)
Fear	13.04 (2.19)	27.22 (2.17)	27.41 (1.79)	22.56 (1.66)
Anger	10.54 (1.78)	24.53 (2.17)	31.02 (2.03)	22.03 (1.66)
Surprise	11.43 (2.12)	26.51 (2.11)	29.45 (1.89)	22.46 (1.67)
Total	12.95 (1.79)	26.34 (1.98)	29.47 (1.72)	

There was a significant interaction between exposure time and sex on the percentage of time spent looking at the eyes, $F(1.82, 109.16) = 4.34$, $p = .018$, $\eta^2 = .07$, see *Figure 5.10*. Simple effects analysis showed that for males, there was no significant difference in the percentage of time fixating to the eyes between 3000ms and 10,000ms. In contrast, for females, it appeared that they spent a greater percentage of time on the eyes at 10,000ms than 3000ms, although with Bonferroni adjustments, this effect was not significant ($p = .066$). Additionally, as expected, there was a significant interaction between emotion and exposure time on the percentage of time spent looking at the eyes, $F(7.20, 431.67) = 2.34$, $p = .023$, $\eta^2 = .04$, see Table 5.8. Simple effect analysis found that for anger but no other emotions (*ps* > .05), participants looked at the eyes for a significantly higher percentage of time at 10,000ms than 3000ms ($p = .001$).

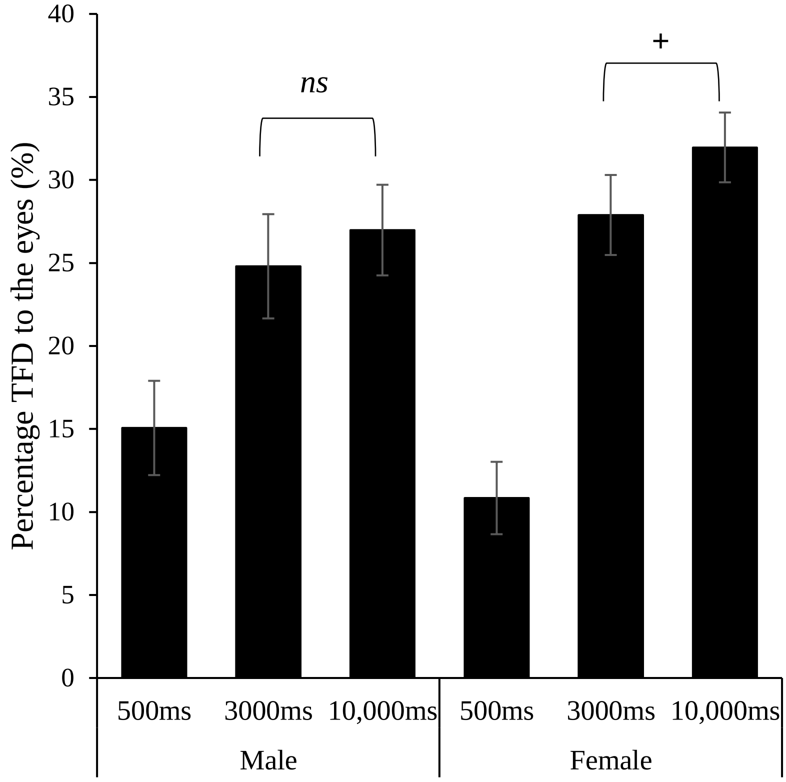

Figure 5.10. Percentage total fixation duration to the eyes by exposure time and sex. *Note:* $^{+}$ p <.100. ns not significant.

TFD by Depression group

TFD on facial features

A mixed ANCOVA was run, with emotion and exposure time as within subjects' measures and sex, age group and depression group as between subjects measures. Mean centred scores on all social anxiety variables, depression and laterality quotient were entered as covariates. There was a significant difference in the amount of time spent examining features for those high and low in depression, $F(1, 52) = 7.03$, p =.011, $\eta^2 = .12$. Those in the high (M = 43.62, SE = 1.75) depression spent significantly less time examining facial features than those who were in the low (M = 50.45 =, SE = 1.68) depression group. There was no significant interaction between emotion and depression group on the percentage fixation duration to facial features, $F(4.02, 208.91) = 0.37$, $p = .829$, $\eta^2 < .01$.

There was a significant three-way interaction between age group, sex and depression group on the amount of time spent viewing facial features, $F(1, 52) = 4.29$, $p = .043$, $\eta^2 = .08$, see Figure 5.11. Simple effects analysis showed that for the late adolescent/emerging adult group, males who were in the high depression group fixated significantly less on features than those in the low depression group ($p = .010$), but for adult females there was no significant difference ($p = .583$). For the early-mid adolescent group, there was no significant differences in males who were high and low in depression in the amount of time they fixated to features; however, females higher in depression viewed features less than those low in depression (albeit when accounting for multiple comparisons, this became non-significant, $p = .061$). There was no significant interaction between exposure time and depression group on the percentage fixation duration to features, $F(1.40, 72.78) = 0.06$, $p = .878$, η 2 < .01, as well as no three-way interaction between exposure time, depression group and emotion, $F(6.33, 329.22) = 0.83$, $p = .551$, η 2 = .02. Full table of descriptives is available in Appendix 6, Table 7.29.

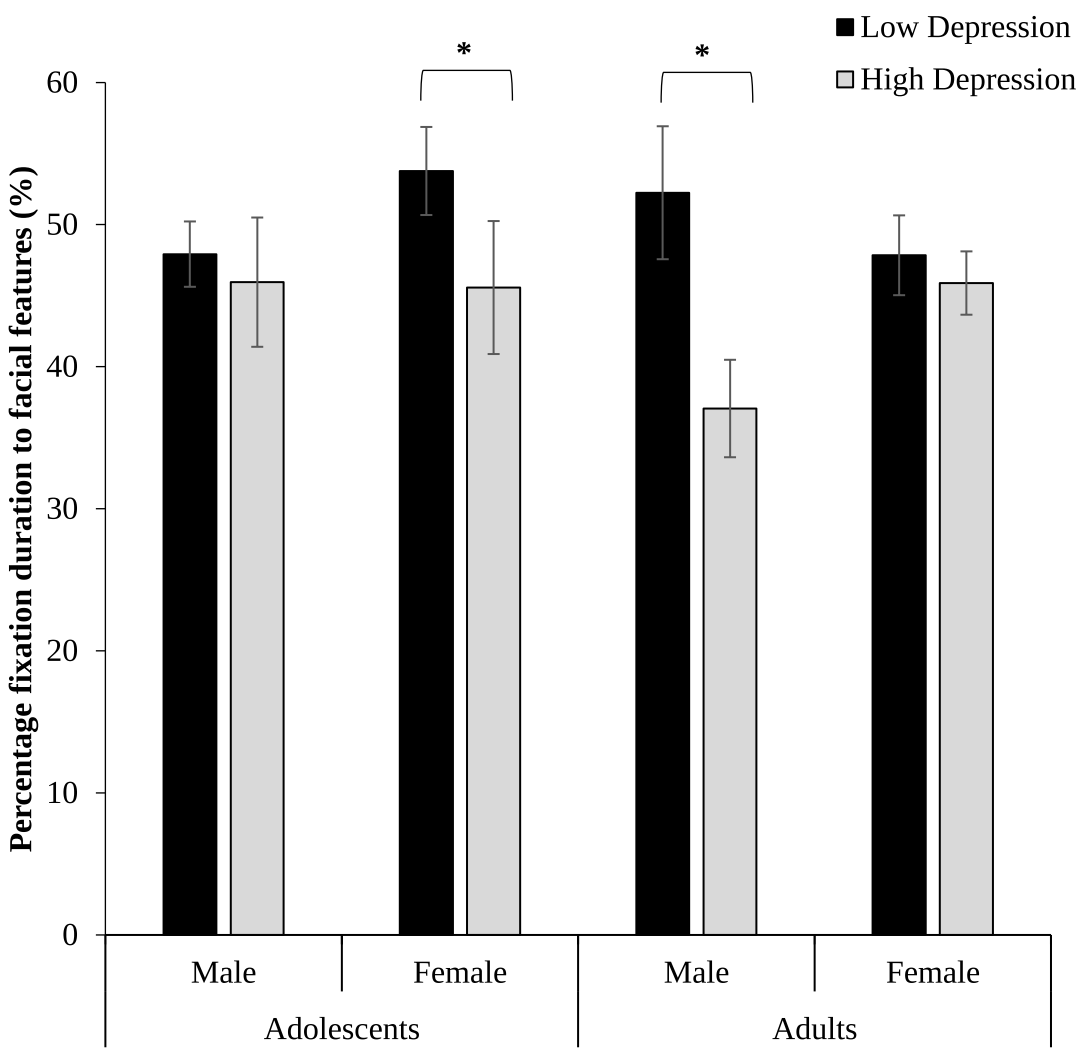

Figure 5.11. Mean (SE) percentage fixation duration to features for males and females in low and high depression groups, shown separately for early-mid adolescents and late-adolescents/adults. *Note: * p <.050.*

TFD on the eyes

A mixed ANCOVA was run, with emotion and exposure time as within subject's measures and sex, age group, and depression group as between subject's measures. Mean centred scores on all social anxiety variables, depression and laterality quotient were entered as covariates. There was no significant difference in percentage fixation duration to the eyes for high (M = 19.77, SE = 2.69) and low (M = 26.09, SE = 2.60) depressed individuals, $F(1, 52) = 2.57$, $p = .115$, $\eta\ 2 = .05$. Further there were no significant interactions with depression group: age group and depression group, (*ps* > .05) ; emotion and depression group, $F(4.15, 215.62) = 1.28$, $p = .274$, $\eta 2 = .02$; exposure time and depression group, $F(2, 104) = 0.03$, $p = .972$, $\eta 2 < .01$; emotion, exposure time and depression group, $F(6.79, 353.13) = 0.72$, $p = .652$, $\eta 2 = .01$. Full table of descriptives is available in Appendix 6, Table 7.30.

TFD by FNE group

TFD on facial features

A mixed ANCOVA was run, with emotion and exposure time as within subject's measures and sex, age group, and FNE group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There were no significant main effects or interactions identified. Specifically, there was no significant difference in percentage fixation duration to features for high (M = 44.56, SE = 1.93) and low (M = 47.91, SE = 1.61) FNE individuals, $F(1, 52) = 1.54$, $p = .220$, $\eta^2 = .03$. Further, there were no significant interactions with FNE group: emotion and FNE group, $F(3.97, 206.22) = 1.66$, $p = .160$, $\eta^2 = .03$; exposure time and FNE group, $F(1.39, 72.02) = 0.30$, $p = .658$, $\eta^2 < .01$; emotion, exposure time and FNE group, $F(6.46, 335.83) = 1.08$, $p = .374$, $\eta^2 = .02$. There were no significant interactions between FNE group and age group (*ps* > .05). Full table of descriptives is available in Appendix 6, Table 7.31.

TFD on the eyes

A mixed ANCOVA was run, with emotion and exposure time as within subject's measures and sex, age group and FNE group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There was no significant difference in percentage fixation duration to the eyes for high (M = 21.36, SE = 2.81) and low (M = 23.95, SE = 2.34)

FNE individuals, $F(1, 52) = 0.43$, $p = .513$, $\eta^2 < .01$. Further, there was no significant interaction between emotion and FNE group, $F(4.00, 207.78) = 0.55$, $p = .699$, $\eta^2 = .01$, or between exposure time and FNE group, $F(2, 104) = 0.69$, $p = .505$, $\eta^2 = .01$. There was no significant three-way interaction between exposure time, FNE group and emotion, $F(6.86, 356.80) = 1.05$, $p = .399$, $\eta^2 = .02$.

There was a significant four-way interaction between emotion, exposure time, age group and FNE group, $F(6.86, 356.80) = 2.13$, $p = .042$, $\eta^2 = .04$, see Table 5.9. To break this down, I split the file by FNE group and re-run the ANCOVA analysis to assess if there was a significant three-way interaction between emotion, exposure time and age group. The interaction was not significant for the low FNE group, $F(4.73, 122.84) = 0.44$, $p = .812$, $\eta^2 = .02$, but was significant for the high FNE group, $F(5.62, 123.66) = 2.21$, $p = .050$, $\eta^2 = .09$. Simple effects analysis showed that for early-mid adolescents in the high FNE group that there was a significant difference in the amount of time spent viewing the eyes for happiness depending on exposure time, with less time spent looking at the eyes for 500ms than for 10,000ms ($p = .016$), but this was not the case for high FNE late adolescents/ emerging adults ($p = .361$). Further, early-mid adolescents high in FNE spent significantly less time looking at the eyes for surprise at 500ms compared to at 3000ms ($p = .020$) and 10,000ms ($p = .028$), while for late adolescents/emerging adults there was no significant difference (*ps* > .05).

Table 5.9. Mean (SE) % TFD to the eyes by age group, emotion, exposure time and FNE group[6].

			Happy	**Sad**	**Surprised**	**Anger**	**Fear**	**Disgust**	**Total**
Low FNE	Adolescents	500ms	6.49 (3.49)	16.83 (4.61)	8.38 (3.96)	5.67 (3.30)	11.48 (4.05)	9.53 (4.26)	9.73 (3.38)
		3000ms	23.49 (4.03)	29.36 (4.39)	25.28 (4.04)	19.62 (4.12)	24.81 (4.06)	25.10 (4.06)	24.61 (3.76)
		10,000ms	23.12 (3.53)	32.44 (3.87)	26.83 (3.48)	30.05 (3.74)	28.05 (3.20)	28.48 (3.19)	28.16 (3.17)
		Total	17.70 (3.05)	26.21 (3.43)	20.16 (3.12)	18.45 (3.12)	21.45 (3.03)	21.03 (3.08)	20.83 (2.94)
	Adults	500ms	10.88 (4.12)	23.11 (5.45)	18.12 (4.68)	14.14 (3.90)	17.79 (4.78)	16.26 (5.03)	16.72 (4.00)
		3000ms	26.07 (4.76)	30.77 (5.18)	29.42 (4.77)	27.39 (4.86)	30.16 (4.79)	29.76 (4.79)	28.93 (4.44)
		10,000ms	32.93 (4.16)	38.13 (4.57)	36.70 (4.11)	38.90 (4.41)	33.77 (3.77)	32.84 (3.76)	35.55 (3.74)
		Total	23.29 (3.60)	30.67 (4.05)	28.08 (3.68)	26.81 (3.68)	27.24 (3.58)	26.29 (3.63)	27.06 (3.47)
	Overall	500ms	8.67 (2.78)	19.97 (3.68)	13.25 (3.16)	9.90 (2.63)	14.63 (3.23)	12.89 (3.40)	13.22 (2.70)
		3000ms	24.78 (3.21)	30.07 (3.50)	27.35 (3.22)	23.50 (3.28)	27.48 (3.23)	27.43 (3.24)	26.77 (3.00)
		10,000ms	28.03 (2.81)	35.28 (3.08)	31.76 (2.78)	34.48 (2.98)	30.91 (2.55)	30.66 (2.54)	31.85 (2.52)
		Total	20.50 (2.43)	28.44 (2.74)	24.12 (2.49)	22.63 (2.48)	24.34 (2.42)	23.66 (2.45)	23.95 (2.34)
High FNE	Adolescents	500ms	8.09 (4.51)	27.19 (5.97)	14.44 (5.13)	12.94 (4.27)	14.39 (5.24)	18.32 (5.52)	15.90 (4.38)
		3000ms	23.55 (5.22)	36.04 (5.68)	29.18 (5.23)	31.75 (5.32)	31.91 (5.25)	29.68 (5.25)	30.35 (4.87)
		10,000ms	25.99 (4.56)	25.50 (5.00)	28.92 (4.50)	27.69 (4.83)	24.10 (4.14)	28.79 (4.12)	26.83 (4.10)
		Total	19.21 (3.95)	29.58 (4.44)	24.18 (4.04)	24.13 (4.03)	23.47 (3.93)	25.60 (3.98)	24.36 (3.80)
	Adults	500ms	12.21 (4.63)	9.91 (6.12)	5.26 (5.26)	7.48 (4.38)	5.07 (5.38)	7.40 (5.66)	7.89 (4.49)
		3000ms	17.82 (5.35)	22.68 (5.82)	21.14 (5.37)	20.87 (5.46)	23.54 (5.39)	20.71 (5.39)	21.13 (5.00)
		10,000ms	23.45 (4.68)	31.29 (5.13)	23.07 (4.62)	26.85 (4.96)	22.53 (4.24)	29.07 (4.23)	26.04 (4.20)
		Total	17.83 (4.05)	21.29 (4.56)	16.49 (4.14)	18.40 (4.14)	17.05 (4.03)	19.06 (4.08)	18.35 (3.90)
	Overall	500ms	10.15 (3.34)	18.55 (4.42)	9.85 (3.79)	10.21 (3.16)	9.73 (3.88)	12.86 (4.08)	11.89 (3.24)
		3000ms	20.69 (3.86)	29.36 (4.20)	25.16 (3.87)	26.31 (3.94)	27.72 (3.88)	25.19 (3.89)	25.74 (3.60)
		10,000ms	24.72 (3.38)	28.39 (3.70)	26.00 (3.33)	27.27 (3.58)	23.32 (3.06)	28.93 (3.05)	26.44 (3.03)
		Total	18.52 (2.92)	25.43 (3.29)	20.33 (2.99)	21.26 (2.98)	20.26 (2.91)	22.33 (2.95)	21.36 (2.81)

[6] Controlling for depression, SAD-General, SAD-New and laterality quotient [actual scores].

TFD by SAD-General group

TFD on facial features

A mixed ANCOVA was run, with emotion and exposure time as within subject's measures and sex, age group, and SAD-General group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There was no significant difference in percentage fixation duration to features for high (M = 46.43, SE = 1.71) and low (M = 47.02, SE = 2.01) SAD-General individuals, $F(1, 52) = 0.04$, $p = .843$, $\eta^2 <.01$. Further, there were no significant interactions with SAD-General group: emotion and SAD-General group, $F(3.96, 206.03) = 0.78$, $p = .536$, $\eta^2 = .02$; exposure time and SAD-General group, $F(1.39, 72.40) = 0.51$, $p = .539$, $\eta^2 = .01$, emotion, exposure time and SAD-General group, $F(6.42, 333.68) = 0.64$, $p =.708$, $\eta^2 = .01$. There were no significant interactions between SAD-General group and age group (*ps* > .05). Full table of descriptives is available in Appendix 6, Table 7.32.

TFD on the eyes

A mixed ANCOVA was run, with emotion and exposure time as within subject's measures and sex, age group, and SAD-General group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There was no significant difference in percentage fixation duration to the eyes for high (M = 24.05, SE = 2.46) and low (M = 22.13, SE = 2.89) SAD-General individuals, $F(1, 59) = 0.20$, $p = .657$, $\eta^2 < .01$. There was no significant interaction between emotion and SAD-General group on the percentage fixation duration to the eyes for high and low SAD-General individuals, $F(3.83, 198.98) = 0.73$, $p = .566$, $\eta^2 = .01$. There was no significant interaction between exposure time and SAD-general group on the percentage fixation duration to the eyes, $F(1.80, 93.50) = 1.68$, $p = .194$, $\eta^2 = .03$.

There was a significant three-way interaction between exposure time, SAD-general group and emotion, $F(6.87, 357.26) = 2.28$, $p = .029$, $\eta^2 = .04$, see Table 5.10. Simple effects analysis was used to break down this interaction by splitting by emotion and examining the two-way interaction between exposure time and SAD-General group. It was found that for sad but no other emotion that there was a trend for individuals who were in the high SAD-General group to spend significantly longer attending to the eyes at 500ms than individuals who were in the low SAD-General group ($p = .060$).

Table 5.10. Mean (SE) % TFD to the eyes by age group, emotion, exposure time and SAD-General group[7]

			Happy	**Sad**	**Surprised**	**Anger**	**Fear**	**Disgust**	***Total***
Low SAD-General	Adolescents	500ms	6.66 (3.98)	11.40 (5.41)	7.67 (4.70)	5.54 (3.93)	9.41 (4.82)	8.15 (5.02)	8.14 (3.97)
		3000ms	17.40 (4.66)	26.89 (5.04)	21.40 (4.42)	20.56 (4.71)	25.36 (4.46)	21.95 (4.66)	22.26 (4.21)
		10,000ms	19.52 (4.13)	31.95 (4.56)	25.55 (4.01)	28.10 (4.40)	22.45 (3.76)	27.16 (3.71)	25.79 (3.72)
		Total	14.53 (3.49)	23.41 (4.05)	18.21 (3.54)	18.07 (3.62)	19.07 (3.51)	19.09 (3.54)	18.73 (3.38)
	Adults	500ms	11.65 (4.98)	13.07 (6.77)	12.52 (5.88)	10.19 (4.92)	8.01 (6.03)	12.07 (6.28)	11.25 (4.97)
		3000ms	24.48 (5.83)	27.45 (6.30)	29.61 (5.53)	29.21 (5.89)	31.64 (5.58)	28.39 (5.77)	28.41 (5.27)
		10,000ms	31.76 (5.16)	41.74 (5.71)	39.25 (5.01)	41.47 (5.51)	31.87 (4.70)	35.62 (4.65)	36.95 (4.65)
		Total	22.63 (4.36)	27.42 (5.07)	27.02 (4.42)	26.96 (4.53)	23.84 (4.39)	25.36 (4.43)	25.54 (4.23)
	Overall	500ms	9.15 (3.40)	12.24 (4.62)	10.09 (4.02)	7.87 (3.36)	8.72 (4.12)	10.11 (4.29)	9.70 (3.34)
		3000ms	20.94 (4.30)	27.17 (4.30)	25.35 (3.77)	24.88 (4.02)	28.50 (3.81)	25.17 (3.94)	25.34 (3.60)
		10,000ms	25.64 (3.52)	36.84 (3.90)	32.40 (3.42)	34.79 (3.76)	27.16 (3.21)	31.39 (3.17)	31.37 (3.17)
		Total	18.58 (2.98)	25.42 (3.46)	22.61 (3.02)	22.51 (3.09)	21.46 (3.00)	22.23 (3.02)	22.13 (2.89)
High SAD-General	Adolescents	500ms	9.48 (4.11)	30.48 (5.58)	12.77 (4.85)	11.90 (4.06)	17.46 (4.97)	19.43 (5.17)	16.92 (4.09)
		3000ms	31.24 (4.81)	38.97 (5.19)	34.27 (4.55)	29.87 (4.85)	30.82 (4.60)	33.64 (4.76)	33.14 (4.34)
		10,000ms	28.98 (4.25)	26.35 (4.70)	29.34 (4.13)	29.60 (4.54)	29.15 (3.87)	29.98 (3.83)	28.90 (3.83)
		Total	23.23 (3.60)	31.94 (4.18)	25.46 (3.65)	23.79 (3.73)	25.81 (3.62)	27.68 (3.65)	26.32 (3.49)
	Adults	500ms	11.07 (3.66)	20.29 (4.97)	11.84 (4.32)	12.33 (3.61)	14.60 (4.43)	12.50 (4.61)	13.77 (3.64)
		3000ms	20.86 (4.28)	26.36 (4.62)	22.70 (4.10)	20.83 (4.32)	22.93 (4.10)	24.12 (4.24)	22.97 (3.87)
		10,000ms	27.38 (3.79)	32.34 (4.19)	26.28 (3.68)	29.16 (4.04)	27.01 (3.45)	28.82 (3.41)	28.61 (3.41)
		Total	19.77 (3.20)	26.33 (3.72)	20.27 (3.25)	20.77 (3.33)	21.74 (3.22)	21.81 (3.25)	21.78 (3.11)
	Overall	500ms	10.27 (2.89)	25.39 (3.92)	12.31 (3.41)	12.12 (2.85)	16.03 (3.50)	15.97 (3.64)	15.35 (2.88)
		3000ms	26.05 (3.38)	32.67 (3.65)	28.48 (3.20)	25.35 (3.41)	26.87 (3.24)	28.88 (3.35)	28.05 (3.06)
		10,000ms	28.18 (2.99)	29.35 (3.31)	27.81 (2.91)	29.38 (3.19)	28.43 (2.73)	29.40 (2.69)	28.76 (2.70)
		Total	21.50 (2.53)	29.13 (2.94)	22.87 (2.57)	22.28 (2.63)	23.78 (2.55)	24.75 (2.57)	24.05 (2.46)

[7] Controlling for depression, FNE, SAD-New and laterality quotient [actual scores].

TFD by SAD- New group

TFD on facial features

A mixed ANCOVA was run, with emotion and exposure time as within subject's measures and sex, age group, and SAD-New group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There was no significant difference in percentage of time fixating at features for high (M = 41.03, SE = 4.14) and low (M = 45.53, SE = 1.76) SAD-New individuals, $F(1, 52) < 0.01$, $p = .924$, $\eta^2 < .01$. There was no significant interaction between emotion and SAD-New group on the percentage of fixation duration to features, $F(3.99, 207.70) = 2.00$, $p = .096$, $\eta^2 = .04$. There was no significant interaction between exposure time and SAD-new group on the percentage of fixation duration to features, $F(1.35, 70.01) = 0.06$, $p = .876$, $\eta^2 < .01$, as well as no three-way interaction between exposure time, SAD-new group and emotion, $F(6.33, 329.37) = 0.54$, $p = .790$, $\eta^2 = .01$. There were no significant interactions between SAD-New group and age group, *Fs* < .1, *ps* > .050. Full table of descriptives is available in Appendix 6, Table 7.33.

TFD on the eyes

A mixed ANCOVA was run, with emotion and exposure time as within subject's measures and sex, age group, and SAD-New group as between subject's measures. Mean centred scores on other social anxiety variables, depression and laterality quotient were entered as covariates. There was no significant difference in percentage fixation duration to the eyes for high (M = 20.01, SE = 3.45) and low (M = 26.59, SE = 2.54) SAD-New individuals, $F(1, 52) = 2.14$, $p = .149$, $\eta^2 = .04$. There was no significant interaction between emotion and SAD-New group on the percentage fixation duration to the eyes for high and low SAD-New individuals, *F*(4.04, 210.21) = 0.55, *p* = .701, η^2 = .01. There was no significant interaction between exposure time and SAD-new group on the percentage fixation duration to the eyes, *F*(1.79, 92.86) = 0.08, *p* = .903, η^2 < .01, as well as no three-way interaction between exposure time, SAD-new group and emotion, *F*(6.66, 346.39) = 0.54, *p* =.796, η^2 = .01. There were no significant interactions between SAD-new group and age group, *Fs* < .1, *ps* > .050. Full table of descriptives is available in Appendix 6, Table 7.34.

TFD by Laterality group

TFD on facial features

A mixed ANCOVA was run, with emotion and exposure time as within subject's measures and sex, age group, and laterality group as between subject's measures. Mean centred scores on social anxiety variables and depression were entered as covariates. There was no significant difference in percentage fixation duration to features between the RH (M = 47.45, SE = 1.63) and the BL (M = 45.53, SE = 1.56) laterality groups, *F* 1, 52) = 0.73, *p* = .396, η^2 = .01. Further, there were no significant interactions with laterality group: emotion and laterality group, *F*(4.04, 210.14) = 0.61, *p* = .659, η^2 <.01; exposure time and laterality group, *F*(1.38, 71.76) = 0.72, *p* =.440, η^2 = .01; emotion, exposure time and laterality group; *F*(6.49, 337.23) = 1.30, *p* =.252, η^2 = .02. There were no significant interactions between laterality group and age group, *Fs* < .1, *ps* > .050. Full table of descriptives is available in Appendix 6, Table 7.35.

TFD on the eyes

A mixed ANCOVA was run, with emotion and exposure time as within subject's measures and sex, age group, and laterality group as between subject's measures. Mean centred scores on all social anxiety variables, and depression were entered as covariates. There was a significant difference in percentage fixation duration to the eyes between the two laterality groups, $F(1, 52) = 4.64$, $p = .036$, $\eta^2 = .08$, with the RH group (M = 26.46, SE = 2.25) spending significantly longer looking at the eyes than the BL group (M = 19.81, SE = 2.14). There was a significant interaction between laterality group and sex on the percentage fixation duration to the eyes, $F(1, 52) = 5.71$, $p = .020$, $\eta^2 = .10$, see Figure 5.12. Simple effects analysis showed that males who were more RH dominant in their emotion processing showed significantly longer percentage of time viewing the eyes than males who were more BL ($p = .006$), while for females there was no significant difference in percentage of time spent looking for the eyes between the two laterality conditions ($p = .776$).

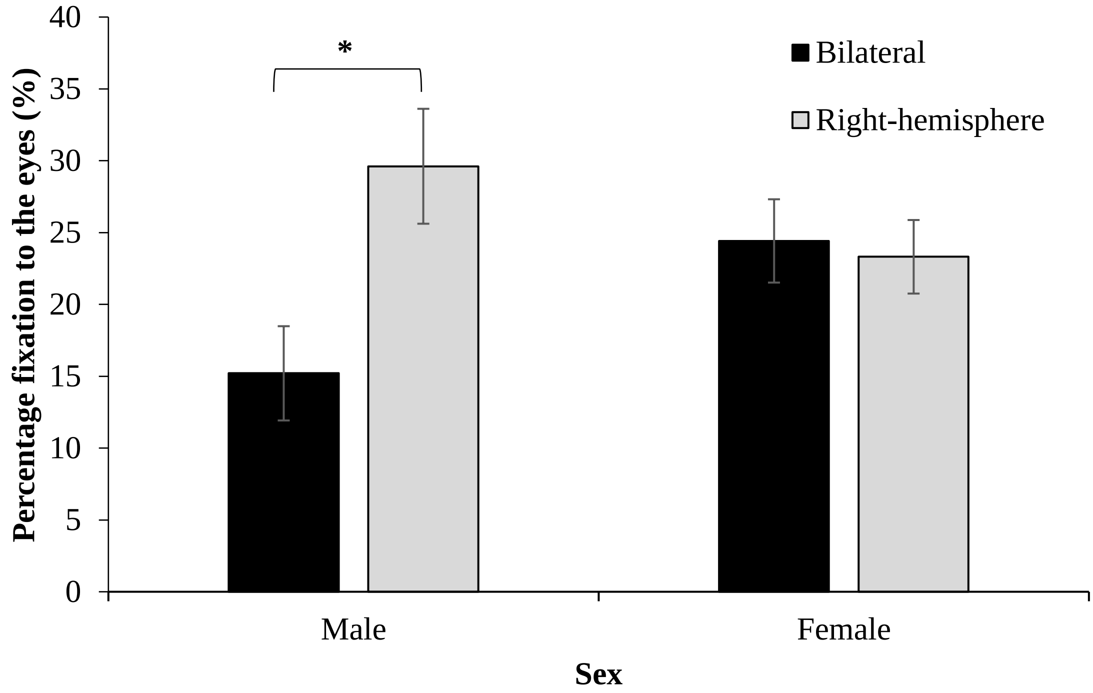

Figure 5.12. Mean (SE) percentage fixation duration to the eye region for BL and RH groups for males and females separately. Note: * p <.050.

There was no significant interaction between emotion and laterality group on the percentage fixation duration to the eyes, $F(4.03, 209.60) = 1.07$, $p = .375$, $\eta^2 = .02$. There was no significant interaction between exposure time and laterality group on the percentage fixation duration to the eyes, $F(2, 104) = 1.03$, $p = .357$, $\eta^2 = .02$, as well as no three-way interaction between exposure time, laterality group and emotion, $F(6.88, 357.70) = 0.57$, $p = .779$, $\eta^2 = .01$. There were no significant interactions between laterality group and age group, *Fs* < .1, *ps* > .050. Full table of descriptives is available in Appendix 6, Table 7.36.

5.3.4 Discussion

The aims of this study were to examine whether there were differences in unbiased hit rates of emotional expressions presented at different exposure times, in groups of individuals who were high or low in their level of depression, social anxiety (specifically, FNE, SAD-General, SAD-New) and either RH or BL in their degree of laterality for emotion processing. Secondly, this study aimed to examine whether these groups differed in their amount of time spent examining facial features and the eyes during FER. Lastly, this study compared a group of participants in early to mid-adolescent to a group of late adolescents and emerging adults to examine if there were any differences in FER and attention depending on age group.

5.3.4.1 The role of exposure time in FER and attention

Contrary to expectations there were no significant differences in FER depending on exposure time, as well as no interactions between exposure time and social anxiety, depression or laterality groups. These findings are in contrast to previous research: that individuals high in depression may show poorer FER under brief exposure (Surguladze et al., 2004) and that those higher in social anxiety may make more misinterpretations (so lower accuracy) under restricted viewing times (Heuer et al., 2010). It is possible that the brief exposure time here of 500ms was not short enough. In fact, emotions can be recognised very quickly: Calvo and Lundqvist (2008) showed similar performance in the recognition of the basic emotions at 250ms than under free-viewing conditions; Damaskinou and Watling (2018) showed, using EEG, that there were early differences in emotion processing for different emotional expressions at 170ms; and, Surguladze et al. (2004) showed that depressions groups differed in FER at 100ms but not 2000ms. Together, these past findings suggest that the current study may not have been sensitive enough to detect differences in early processing between groups.

Interestingly, there were differences in FER for between the age groups depending on emotion and exposure time; late adolescents/ emerging adults performed better than early-mid adolescents for happy faces at 500ms and 3000ms, for anger at 3000ms and for surprise at 3000ms. These findings reflect that there are continued developments in FER throughout adolescents and into adulthood, and specifically when given longer viewer times. It should be noted that performance was generally poor, and that this may have reduced differences between age groups. Future research would benefit from a closer examination of age-related differences in FER at different exposure times.

There was a significant difference in the percentage of time spent viewing the eyes depending on exposure time. Participants showed a lower percentage of time fixating to the eyes at 500ms compared to 3000 and 10,000ms. These findings are perhaps unsurprising given that participants would have had reduced time to move fixation to look at the eyes when under the shorter duration. Further, it was found that for anger only, participants spent a larger percentage of time looking at the eyes at 10,000ms compared to 3000ms. These findings may be explained by task difficulty in the recognition of low intensity emotional expressions regardless of exposure time; in fact, performance for anger was poorer compared to all other emotions (regardless of exposure time) and therefore the higher percentage of time spent fixating to eye region for anger could reflect the difficulty of the recognition of this emotion during the task. In support, researchers have found evidence of an inverse relationship between viewing time to the eyes, nose and mouth regions and emotional intensity, with more time viewing facial features at lower emotional intensities (Guo, 2012).

5.3.4.2 Social Anxiety, FER and Attention

The results of this study show that individuals high and low in facets of social anxiety (FNE, SAD-General, SAD-New) showed no significant differences in their overall FER nor in their FER of different emotions or at different exposure times. Further, there were no significant differences between high and low SA groups in the percentage of time spent fixating to facial features and the eyes during FER; although, for sad faces only, there was a trend in that individuals higher in SAD-General (compared to lower in SAD-General) fixated longer to the eyes when faces were presented very briefly (500ms,), with no group differences found under longer exposure times.

Whilst some research shows that individuals with heightened levels of social anxiety spend less time scanning the eyes when viewing emotional stimuli (Horley et al., 2003, 2004), the findings from this work point towards the idea that individuals high in generalised social avoidance may show hypervigilance to the eyes when viewing sad stimuli under brief exposure (likely to be the location of initial fixations). This is in line with the hypervigilance avoidance hypothesis (Mogg & Bradley, 2002, see

Section 2.1.1.3). In fact, individuals higher on social anxiety have been found to show initial hypervigilance to emotional stimuli (compared to neutral) during the initial stages of visual processing (Gamble & Rapee, 2010; Wieser et al., 2009).

The results of this study point to initial hypervigilance to the eyes; in particular, when emotional faces are viewed in singular. Given that eye contact may signal the start of a social interaction and thus trigger feelings of anxiety (Driver et al., 1999; Emery, 2000), the eyes are a signal of social threat in facial expressions (Ohman, 1986). These findings are in line with models of social anxiety that emphasise that individuals with social anxiety may show a bias for threat detection in their environments (Rapee & Heimberg, 1997). Notably, whilst there were differences in time spent examining the eyes of sad stimuli under brief exposure, no significant differences in FER were found for sad stimuli under longer exposure times. These findings highlight that differences in early attention may not be able to account for FER in individuals differing in their level of generalised avoidance.

Past research has found hypervigilance to the eyes is more prominent for emotions that are linked to threat (i.e., anger, disgust; Wieser et al., 2009; Mogg & Bradley, 2002). Interestingly, for groups differing in their level of FNE, I did not find this effect for these emotions, which may be due to task difficulty. In fact, recognition of both anger and disgust was generally quite poor in this study, in comparison to findings with sadness. This may have resulted in lack of sensitivity to picking up group differences. Further research is needed to examine whether attentional biases may be further pronounced when the emotions expressed are of high emotional intensity.

Of particular interest was that for early to mid-adolescents who were in the high FNE group spent less time viewing the eyes for happiness and surprise under short exposure time (500ms) compared to longer exposure times. These findings highlight that adolescents higher in FNE may show some avoidance of looking at the eyes for positive emotional stimuli during initial processing. These findings are consistent with patterns of avoidance found for individuals high in social anxiety when looking at positive facial stimuli (Mansell et al., 1999; Muhlberger, Wiesier & Pauli, 2008). In fact, researchers have often emphasised the importance of happy faces in social anxiety, as happy faces may indicate the initiation of a social interaction; therefore, happy faces are often viewed as threatening for individuals high on social anxiety (Rapee & Heimberg, 1997; Wallace & Alden, 1995; Weeks et al., 2008). In fact, level of social anxiety has been found to be negatively related to approachability ratings of happy faces (Campbell et al., 2009) and individuals with social anxiety have been found to show avoidance of happy stimuli during an approach-avoidance tasks (Heuer, Rinck & Becker, 2007). Taken together, with the findings of this study, it may be that for individuals higher in FNE that attention may not automatically be directed towards the eyes of positive emotional stimuli, but over exposure time individuals with higher levels of social anxiety are able to direct their attention to meet the task demands. Importantly, the aforementioned findings were only seen for early to mid-adolescents high in FNE but not late adolescents and emerging adults. It is possible that these findings do not reflect differences in level of FNE, given that the older age group in this study were typically higher in levels of FNE, but may instead be reflective of early-mid adolescent’s enhanced sensitivity to social evaluation (Sebastian et al., 2010; Somerville et al., 2013).

Individuals in the high and low depression groups did not differ in their overall FER or in their FER at different exposure times. These findings are in contrast to previous research suggesting that individuals high in depression may have general difficulties, or specific difficulties in their FER (for review, see Bourke et al., 2010), that may be more pronounced under shorter exposure times (Surguladze et al., 2004). Interestingly, patterns for males and females in their recognition of specific emotions differed according to depression group.

The finding of sex differences is somewhat consistent with patterns previously observed in depressed individuals (e.g., Bannerman et al., 2010; Bento de Souza et al., 2014; Gollan et al., 2008; 2010). In particular, females in the high depression group demonstrated better recognition of sadness than females in the low depression group. This is in line with findings that women with major depression show better recognition of sadness at low emotional intensities (Bento de Souza et al., 2014). Further, males in the high depression group demonstrated poorer recognition of fear than males in the low depression group. Findings are consistent with research showing that children and adolescents with depression show poorer fear recognition (Lenti et al., 2000), albeit they did not assess sex differences.

It is possible that the interaction between sex and depression is due to differences in amygdala function. As highlighted in Section 1.3.2, the amygdala plays an important role in the processing of emotions and has been found to be specialised in the recognition and processing of fear (Breiter et al., 1996; Morris et al., 1996; Phan et al., 2002; Whalen et al., 2001). Sex differences have been found in amygdala activation for depressed individuals, with females showing greater activation than males when viewing negative emotional stimuli (Andreano et al., 2014). It is also found that females with depression have increased amygdala volume when compared to males (van Elst et al., 2000). These findings may suggest that the poorer recognition of fear by males in the high depression group may be associated with differences in amygdala activation; this warrants further investigation. Alternatively, such differences may be in part explained by other co-morbidity in males. As is mentioned in Section 5.3.1, whilst females with depression are likely to experience co-morbid anxiety, males are more likely to experience externalising disorders. In fact, males with externalising disorders have often been found to show poorer recognition of fear expressions (Aspan, Vida, Gadoros & Halasz, 2013) and show hypo-activity in the amygdala in response to fear faces (Jones et al., 2009). Future research should further examine sex differences in the recognition of specific emotions for individuals differing in their level of depression.

When examining the effects of exposure time on FER for individuals in the high and low depression groups, no differences were found in FER when faces were presented at different exposure times. This finding is in contrast to Surguladze et al. (2004) who showed that under short (100ms), but not long (2000ms), exposure times individuals with depression show poorer FER. Importantly, in the current study the shortest exposure time was 500ms, which may not be affected by initial or early processing of FER. Interestingly, this study did find that for male early to mid-adolescents only (not females and not late adolescents/emerging adults) that individuals in the high depression group performed more poorly on FER than the low depression group when faces were presented at 3000ms (no differences at 500ms or 10,000ms). This appears in contrast to Surgulandze et al., but may be due to the variation of task difficulty (lower intensities within the task). Taken together, both studies point to a link between having more depressive symptoms and poorer FER, which was specifically the case for males within the current study.

In exploring time spent examining facial features when making FER judgments, this study found that those higher in depression spent significantly less time examining features than those lower in depression during FER. These findings are consistent with research that suggests that individuals with depression show more avoidance of facial features when viewing emotional faces (Loughland et al., 2012) and less time viewing facial features during FER tasks (Wu et al., 2012). Wu et al. (2012) suggested that the less time spent viewing features may be a consequence of overall less time spent viewing the images (faster reaction times); however, in the current study overall looking time is accounted for, strengthening the evidence in this area that depressive symptoms may be linked to differences in scanning of faces more generally. Importantly, whilst overall those in the high depression group spent significantly less time examining features during FER, they did not show overall poorer FER. It is possible that reduced scanning of the features per se does not lead to poorer FER.

Interestingly, whilst individuals in the current study who were higher in depression spent significantly less time examining features than those lower in depressive symptoms, this also interacted with age group and sex. Female early- mid adolescents, but not late-adolescents/emerging adults, in the high depression group showed less time examining the features during FER than those in the low depression group. Male late-adolescents/emerging adults, but not early- mid adolescents, in the high depression group showed less time examining the features during FER than those in the low depression group. Whilst it is not clear why sex differences may emerge for different age groups, for both age groups it appears that individuals higher in levels of depressive symptoms spend significantly less time viewing facial features during FER. Further examination of sex and age differences are needed to fully understand the specific patterns of findings.

When looking at fixations to the eye regions only, those in the high and low depressive symptoms groups did not differ in the amount of time spent fixating to the eye regions. This is one of the first studies to establish that individuals with higher depressive symptoms do not show avoidance of the eyes during FER; research to date has focused more specifically on the amount of time spent on facial features more generally (e.g., Wu et al., 2012). These findings may suggest that whilst individuals higher on depressive symptoms may show avoidance of facial features during FER, it is not specifically the eye region that is being viewed less.

The emotion context insensitivity hypothesis (ECI; Rottenberg & Gotlib, 2004) may help to explain avoidance of facial features in individuals higher in depressive symptoms. The ECI argues that individuals higher in depression may have a reduced reactivity to emotional stimuli (Rottenberg & Gotlib, 2004); this hypothesis has received much empirical support (see Bylsma, Morris & Rottenberg, 2008; Rottenberg, Gross & Gotlib, 2005). Alongside reduced emotional reactivity, the ECI hypothesis posits that increased depression is associated with reductions in motivation (Champion & Power, 1995; Rottenberg & Gotlib, 2004). Importantly, it is known that gaze may be influenced by motivation (see Wadlinger & Isaacowitz, 2006), and as such it could be that individuals higher in depression spend less time fixating to facial features due to reduced social and emotional motivation. Although it has been suggested that this reduction in motivation and goal-directed attention may lead to inaccuracy in FER (Noiret et al., 2015), this may not exclusively be able to explain the patterns of FER found in this study. For example, whilst it was found that males who experienced more depression symptoms (compared to lower) spent less time scanning facial features during FER, they were only poorer in their recognition of fear. This suggests that differences in attention of facial features during FER is not able to entirely explain why individuals differing in their level of depression show specific patterns of differences in their FER.

Further research is needed to examine what particular facial features individuals with depression may be viewing less during FER and how this might relate to FER performance.

5.3.4.3 Laterality, FER and Attention

Generally, individuals who were more RH dominant in their emotion processing did not perform better overall in FER compared to individuals who were more BL. However, sex differences were found. Males who were RH dominant showed stronger recognition of fear, while females who were RH dominant showed poorer recognition of surprise. Further, lateralisation groups did not differ in their recognition of emotions presented at varying exposure times. Whilst at first this may suggest that lateralisation for emotion processing may not be related to task difficulty, it is noteworthy that there was no significant main effect of exposure time on FER – participants were equally able to recognise emotions under short exposure times (500ms) than under longer exposure times (10,000ms), implying that FER at 500ms was not more difficult. As highlighted earlier, future research exploring differences in degree of lateralisation may also benefit from using shorter exposure times in order to examine how increased task difficulty may affect RH dominant individuals FER performance.

Further to general FER performance, this study demonstrated that individuals who were RH dominant in their emotion processing did not differ from individuals who were more BL in the percentage of time spent viewing facial features during FER; this is consistent with the findings of Study 4. Interestingly, males (not females) who were more RH dominant fixated significantly longer on the eyes than those who were BL in their processing of emotion during FER. Past research has found that males are more strongly lateralised to the RH for emotion processing, and research has shown that males are poorer at emotion recognition; it has been proposed that being more strongly RH lateralised may be compensating for poorer FER (e.g., Connolly et al., 2018; Hoffman et al., 2005; Montagne et al., 2005). However, there was not an interaction between laterality group and overall FER. This suggests that whilst males who were more RH dominant spent more time examining the eye region compared to males who were more BL that this did not result in benefits to FER.

5.3.5 Overall Discussion

The aims of this Chapter were to examine to what extent individuals differing in their level of depression, social anxiety (specifically facets) and their degree of lateralisation for emotion processing may show differences in their FER at different emotional intensities and at different exposure times. Importantly, the set of studies also examined whether these groups differed in the relative amount of time spent fixating to facial features and the eyes during FER.

5.3.5.1 Individual differences and emotion recognition

Within the two studies presented, individuals allocated to the high and low depressive symptoms group did not significantly differ in their overall FER. However, it was found that those higher in depressive symptoms did show differences in their FER of some emotions, with some patterns differing by sex. Regardless of sex, individuals higher in depressive symptoms were significantly poorer in their recognition of happiness (Study 4). Males higher in depressive symptoms were found to be poorer in their recognition of fear (Study 5) and females higher in depressive symptoms showed better recognition of sadness (Study 5). Indeed, these findings highlight that individuals higher in depressive symptoms may show some differences in their ability to recognise emotions. These findings support previous research that has found differences in the recognition of happiness, sadness and fear in individuals differing in their level of depression (see Section 2.1.2.2), thus supporting that these differences in FER between individuals differing in their level of depression may be specific to particular emotions.

Further to FER accuracy, when the FER task was self-paced (Study 4) there was no significant difference in the relative amount of time individuals high and low in depressive symptoms groups spent fixating to facial features and to the eyes during FER. However, it was found that when exposure time was fixed (Study 5), regardless of exposure time, individuals in the high depression group spent significantly less time scanning facial features than those in the low depression group during FER. Further, patterns differed depending on sex and age, for late adolescents/ emerging adults.

These findings could inform us that instructions about exposure time may have affected scanning patterns. In fact, previous researchers have shown that task instructions can alter where individuals attend to during face scanning (Yarbus, 1967). The discrepancies in findings in this chapter may therefore be a consequence of the methodological differences between the two studies. When individuals know they have a limited time (Study 5) they may have looked differently than when they know they have unlimited time (Study 4). It could be that under finite exposure times (compared to free-viewing unlimited time), some individuals may have experienced task anxiety which may have influenced scanning patterns. As well as this, participants may have had less time to implement strategic/voluntary control (especially under shorter durations, i.e., 500ms). However, under shorter exposure times (especially 500ms), the restricted viewing time may have reduced strategic processing, but instead reflect a more automatic control; for instance, under short exposure participants may not have time to inhibit any strategic or compensatory attentional processes that may occur under longer viewing. Alternatively, the differences in the findings between the two studies may be the result of an increased power to detect a smaller effect in Study 5 due to the increased sample size.

Unlike the findings in depression, in these two studies individuals who are high or low in different facets of social anxiety did not show any differences in their FER; further, there were no significant differences between social anxiety groups in their FER at different levels of intensity and exposure times. These findings suggest that individuals higher in, compared to lower in, the three facets of social anxiety do not show differences in their FER. One possibility is that through using the unbiased hit rate in these two studies, it may have accounted for general group differences that are typically found when looking at overall performance measured through number correct for each emotion. For example, many of the past studies that showed individuals higher on FNE have stronger FER performance did not consider if this was due to a negative response bias. When accounting for response bias, differences in performance between the groups may be reduced. This should be explored further in future research; in particular, comparing findings with and without the use of unbiased hit rates to see if the social anxiety groups differ.

Contrary to expectations and past research, the findings in these studies did not show that individuals higher on SA had increased sensitivity (Arrais et al., 2010) or decreased sensitivity (Montagne et al., 2006) to FER. Through manipulating exposure time, we had expected, consistent with past research, that individuals with social anxiety may be slower to recognise emotions (e.g., Tseng et al., 2017) and consequently show reduced accuracy under shorter exposure times. The findings from Study 5 suggest that when given a set exposure time, individuals differing in their levels of social anxiety (specifically the three facets) are able to perform equally as well as their less socially anxious peers on FER.

Interesting, consistent with the findings for general FER performance (no differences depending on social anxiety group), findings show that across the two studies participants in the low or high social anxiety groups did not show differences in the relative amount of time spent fixating to features during FER. These findings are in contrast to previous research that has found evidence that individuals higher on social anxiety spent less time fixating to salient features when passively viewing emotional faces (Horley et al., 2003, 2004). Further, within these two studies individuals low and high in levels of social anxiety did not show eye avoidance during FER. These findings at first appear in contrast to other research (e.g., Horley et al., 2003, 2004) that suggests that social phobic individuals show increased eye avoidance when viewing emotional faces; however, the differences in findings may be attributed to methodological differences.

In the set of studies presented here the task demands may impact how faces were scanned, as in previous tasks no instruction was provided (free viewing of faces). It may be that when instructed to recognise facial affect, individuals differing in their level of social anxiety do not show differences in the amount of time spent examining the eyes and, more generally, the facial features. Importantly, introducing differences in exposure time to the design resulted in individuals who were higher in avoidance (compared to lower) fixating significantly longer to the eye region for sad faces under brief exposure (500ms), but no group differences were found under longer exposure. This is in line with research that suggests that individuals higher in levels of social anxiety may show initial hypervigilance to the eye region when scanning faces (Wieser et al., 2009). These findings highlight the importance of instructions and design when exploring differences in FER ability for those with differing levels of social anxiety, and that further research is needed in this area.

Importantly, this work examined adolescents' FER ability. Of interest, late adolescents did not differ in their relative amount of time spent examining the eye region during FER when the task was self-paced; however, early-mid adolescents, but not late-adolescent/ emerging adults, high in FNE showed some differences in their scanning of the eye region during FER depending on exposure time. These findings suggest that when early-mid adolescents who are higher in FNE are given limited time to view emotional faces (500ms) than they may show less scanning of the eyes to positive stimuli during initial processing, which may reflect an automatic avoidance of the eyes in stimuli that may initiate social interactions. In fact, researchers have suggested that happiness may be interpreted as non-genuine in socially anxious individuals or could elicit threat due to feelings of social expectations (Campbell et al., 2009; Clark & Wells, 1995).

Further to the findings with the social emotional factors that may affect FER, this research explored how the degree of lateralisation for emotion processing may also affect FER. Findings showed that whilst there were no overall differences in FER, individuals who were more RH dominant (compared to BL) had stronger recognition of surprise and poorer recognition of sadness (Study 4). Further, females who were more RH dominant (compared to BL) had poorer recognition of surprise while males who were more RH dominant had stronger recognition of fear (Study 5). These findings suggest that an individual's degree of lateralisation for emotion processing may impact FER. Interestingly, some of the patterns observed are contradictory to research that has found that an increased RH dominancy for emotion processing is related to overall better FER (Watling & Damaskinou, 2018; Workman et al., 2006). An important consideration is that within the studies presented here an overall laterality quotient, across all emotions, was created for each participant. Whilst the two laterality groups' laterality quotients differed significantly, it has been demonstrated that there are differences in the strength of RH lateralisation patterns for specific emotions (see Watling et al., 2012). Future research would benefit from examining how individuals differing in their laterality scores for specific emotions may be related to the recognition of the corresponding emotions.

Interestingly, differences were found regarding fixations to features, specifically the eye region, depending on the laterality group of the participants, but only when the participants were aware of having a fixed amount of viewing time. Importantly, when the task was self-paced, individuals who were more RH dominant, compared to BL, showed no significant difference in the percentage of time fixating to facial features or to the eye region during FER. However, under conditions where exposure times of stimuli differed, those who were more RH dominant, compared to BL, fixated significantly longer to the eye region, regardless of exposure time. Importantly this was specifically the case for males. These findings suggest that males, who have typically been found to be more strongly lateralised to the RH (see Section 2.2.2.2), may spend longer examining the eye region during FER than males who are more BL in their processing of emotions. Given that RH dominancy has been typically found to relate to better FER, this may support the compensatory mechanism idea. For instance, males who are more RH dominant may be benefitting from an increased focus of attention on information that is most relevant to FER, such as the eyes. These findings may have not been found in Study 4 due to the lack of power to detect an effect (smaller sample size).

5.3.5.2 Limitations and future directions

Several limitations for the set of studies above should be noted. The studies suffered from relatively small sample sizes (N = 39 and N = 71, for Study 4 and 5 respectively), which may have meant there was not enough power to detect effects. Future research should therefore re-examine with larger samples to ensure that these findings replicate. Further, whilst the aims of this thesis were to examine whether there were significant differences in FER and in attention to facial features and to the eyes during FER depending on group differences – social anxiety (sub-facets), depression and groups differing in their degree of lateralisation for emotion processing – it is important to note that when running these analyses exploring participant group differences, the scores for the remaining variables were controlled for. Although this was a conscious decision to assess independent contributions and to ensure that any differences that emerged were not as a consequence of differences in these factors, given the interrelatedness of these variables. However, through controlling for many factors, this may have controlled out variability. This might also explain why some of the findings may differ to those previously found, in fact, in one study, LeMoult and Joormann (2012) showed that patterns of attention to emotional stimuli differed in individuals with social anxiety with and without comorbid depression, which may explain some of the discrepancies in previous work.

An important consideration is that a median split was used to create the high and low social anxiety facet groups, the high and low level of depression symptoms groups, and the BL and RH patterns of lateralisation for emotion processing groups. Each of these contrasting groups was found to significantly differ from one another. However, it is unclear if these groups do in fact represent what it is expected that they represent. Although, when comparing the mean depression scores for the high and low depressive symptoms groups created with the cut-offs provided by Moon et al. (2017), for both studies the mean low group score represents non-depressed individuals, and the mean high group score reflects moderate and severe depression for Study 4 and Study 5, respectively. These comparisons do suggest that the groups created may reflect differences in depression severity, and may explain differences for the high depressive symptoms groups found in Study 4 in comparison to Study 5. To my knowledge, there are no clinical cut offs for the SAS-A (La Greca & Lopez, 1998) for each subscale; however, overall, individuals in the high SA facet groups for both studies had a mean total social anxiety score >50, which corresponds to high levels of social anxiety (La Greca & Lopez, 1998); but, it should be noted that there was often more variance in the high groups created. Nonetheless the groups created within the set of studies do appear to significantly differ from one another and reflect low and higher group means according to criteria previously published (La Greca & Lopez, 1998; Moon et al., 2017). For the laterality groups, it was found that the two groups differed from one another, but also that the BL group did not differ from zero, and the RH group was significantly greater than zero (indicating bias); this gives confidence in the two groups created. Whilst we have confidence in the groups created, future research may wish to apply a stricter group criterion to ensure greater differentiation between the groups or to meet cut off criterion.

In addition to the considerations around participants and groups created, it is important to consider the FER tasks used. First, the task used to assess FER was difficult, which is visible from some of the low unbiased hit rates, particularly the case for anger, and low intensity emotional expressions (those presented at 30%). Through increasing task difficulty, it was expected that this would increase any group differences; however, it could be that given the difficulty of the task that it may have masked potential differences between the groups. This may also explain why patterns were present for some emotions (happiness, surprise) but not others, given that these emotions were better recognised during FER. Second, in Study 5, when examining the role of exposure time on FER and attention, the shortest timing used was 500ms. This was selected given previous research on attentional biases within the first 500ms of processing (Mogg & Bradley, 2004; Wieser et al., 2009), and to ensure that differences in attention could be detected using eye-tracking. However, this timing may have been too long to detect any behavioural differences in FER performance in these groups. For example, when examining exposure time on FER in depression, previous researchers have often used shorter exposure times (e.g., 100ms, Surguladze et al., 2004). Third, in Study 5, given the inclusion of three different exposure time blocks, the number of unique stimuli was reduced. Given the smaller numbers, it was not possible to analyse the effects of emotional intensity within this same study as exposure time, even though stimulus intensity was adjusted (as in Study 4); future research may wish to examine independently the role of exposure time with high intensity emotions. For example, exposure time and intensity might interact, such that as intensity increases further differences in attention may be evident. Lastly, in Study 5 participants were made aware that exposure time was manipulated and this may have affected how they attended to the facial features.

Whilst research has previously examined attention to faces in social anxiety and depression, these tasks were often passive viewing tasks. Given that task instructions are known to alter scanning paths (Yarbus, 1967), it should be noted that the patterns of eye-movements seen in these tasks may differ from those in naturalistic social exchanges. In the set of studies, participants were asked to detect the emotion that the face was showing and were also made aware of how long they had, this may have directly impacted how participants viewed the face. In day to day life, individuals high in their level of depression and social anxiety may show social avoidance and/or lack of social motivation to engage in social interactions to begin with, which may impact their FER.

5.3.6 Conclusions

In conclusion, Study 4 and Study 5 have examined the roles of social anxiety, depression and the lateralisation for emotion processing on the ability to recognise facial emotions at (1) different levels of intensity and (2) different exposure times, respectively. The role of these factors has also been examined in relation to facial scanning during FER, particularly (1) the scanning of facial features (2) the scanning of the eyes. The results of these studies revealed independent roles of depression and lateralisation for emotion processing, but not social anxiety, in the recognition of specific emotions. Further differences were found in attention to facial features depending on levels of social anxiety, depression and degree of lateralisation for emotion processing were found during FER. Findings have implications for how specific task instructions may affect viewing behaviour, but not necessarily impact FER ability, of adolescents.

6 General Discussion

6.1 Overview

The main aim of this thesis was to examine the extent to which facial emotion recognition (FER) in adolescents could be predicted from social-emotional factors (i.e., social anxiety and depression) and lateralisation for emotion processing in the brain. Specifically, this thesis aimed to examine if changes in an individual's scores for the social anxiety, depressive symptoms, and degree of lateralisation for emotion processing predicted FER, and if relationships changed over time (predicting later FER). Given the interest in these relationships, I explored what may influence these. In particular, I examined the role of exposure time and intensity on both FER and on attention to faces during FER tasks for individuals differing in their level of social anxiety, depression and degree of hemispheric laterality for emotion processing. This thesis further aimed to examine if an individual's scores for the different facets of social anxiety (social avoidance of general situations, social avoidance of new situations, and fear of negative evaluation) may be differentially related to FER, as opposed to looking at the overall construct of social anxiety.

In Study 1 it was shown that the developed NimStim Chimeric Face Test (CFT) was closely related to patterns of lateralisation obtained from a previous well-used CFT (e.g., Bourne & Maxwell, 2010; Bourne & Vladeanu, 2013; Workman et al., 2000, 2006) using the Pictures of Facial Affect (Ekman & Friesen, 1976). There were however a couple of differences that emerged, particularly, scores on the NimStim CFT showed less hemispheric dominance; this measure may therefore provide a more conservative indication of patterns of lateralisation., 2011). The NimStim CFT was identified as being a reliable behavioural measure to assess patterns of lateralisation for emotion processing.

In Chapter 4, it was found in Study 2 and Study 3 that social-emotional factors were important in predicting FER in adolescence. Importantly these relationships only existed for females but not males, which may be a consequence of females scoring high on all social-emotional measures and/or the increased size of the female sample within this study. As highlighted in Section 2.1.1, researchers often differentiate between subjective and behavioural components of social anxiety; this is supported in this thesis with the two differentially being related to FER skills. For example, whilst general avoidance and distress negatively predicted FER, higher levels of FNE positively predicted FER. Such findings may help to explain inconsistencies in relationships found between social anxiety and FER in previous research. These findings will be examined in more depth in Section 6.1.1.

Little research to date has examined how level of depression in adolescence may relate to FER skills. This gap was addressed in Study 2 and Study 3, where I found that female adolescents higher in depression were poorer in their FER, highlighting that depressive symptoms in adolescence may play a role in FER skills. These findings are consistent with findings in the adult literature that depression may have a general impact on FER skills (Bourke et al., 2010; Mikhailova et al., 1996).

Within Study 2, the role of lateralisation for emotion processing in predicting FER was examined. It was not found to be a significant predictor of FER. This finding is in contrast to previous research with children that has found increased RH dominance to be associated with stronger FER (e.g., Watling & Bourne 2013; Workman et al., 2006). However, given the age sample in our study, this effect may have not been found because adolescents were already RH dominant in their processing of emotions. Importantly, changes in strength of lateralisation for emotion processing is a significant predictor of changes in FER ability over time (Study 3; discussed below).

To gain an understanding of how changes in social emotional factors and changes in lateralisation patterns for emotion processing may impact FER, within this thesis, one aim was to examine longitudinal predictors of FER in adolescents with assessments after six and again after 12 months. It was demonstrated that FER performance at six months was predicted by changes in both social-emotional factors (depression, generalised avoidance) and degree of lateralisation for emotion processing (towards the RH [RH]). FER performance at 12 months was predicted by initial laterality and depression, with changes in lateralisation for emotion processing towards the RH approaching as a significant predictor. Taken together these findings highlight an interplay between social-emotional factors and lateralisation for emotion processing in adolescent FER and imply that changes in both social-emotional factors and degree of lateralisation across the adolescent period may impact FER at this time. These findings will be explained in more depth in Section 6.1.2.

In Chapter 5, the role of intensity and exposure time in the recognition of emotional faces (FER) and in the attention to emotional faces was investigated, depending on individuals level of social anxiety (specifically in the sub-facet scores), depression and lateralisation for emotion processing. Across Study 4 and Study 5, no significant differences were found in the overall recognition of emotions for individuals differing in their level of social anxiety (specifically sub-facets). Further, there were no differences in their recognition of emotions at different intensities, or at different exposure times depending on level of social anxiety. These findings suggest that individuals differing in their level of social anxiety do not show increased or decreased sensitivity to emotional expressions and do not differ in their ability to recognise emotions under different exposure times; these findings are inconsistent with previous research (Gutierrez-Garcia and Calvo, 2017; Montagne et al., 2006).

Individuals differing in their level of social anxiety showed no overall differences in the amount of time spent examining general facial features or the eyes only during the FER task. These findings are in contrast to previous research which has demonstrated that individuals with social anxiety may show avoidance of the eyes and hyper scanning of non-features when passively viewing emotional stimuli (e.g., Horley et al., 2003, 2004). Of particular interest is that it was shown that under brief exposure time that individuals higher in generalised avoidance (compared to lower) did show hypervigilance to the eyes of sad stimuli, with no group differences present under longer exposure times; further, adolescents in the high FNE spent significantly less time examining the eyes for positive stimuli (happiness, surprise) under brief exposure (500ms) compared to under longer exposure times. These findings indicate the importance of looking at how patterns may differ depending on the different facets of social anxiety.

Taken together, findings suggest that whilst individuals differing in their level of social anxiety may show differences in early attention to particular emotional stimuli, these differences in attention do not appear to be reflected in FER accuracy. These findings will be explored in more depth in Section 6.1.4.

Within both Study 4 and Study 5 individuals differing in their level of depression did not show differences in their overall FER. This suggests that individuals higher in depression do not have a general impairment in their FER. Instead, individuals differing in their level of depression showed specific patterns in the recognition of specific emotions. In Study 4 it was found that those higher in depressive symptoms showed poorer recognition of happiness. In Study 5 there were sex differences found, with females in the high depressive symptoms group showing stronger recognition of sadness and males in the high depressive symptoms group showing poorer recognition of fear in comparison to the females and males, respectively, in the low depressive symptom groups. These findings are consistent with patterns that have been documented for depression in the adult literature (see Bourke et al., 2010).

Within Study 4, there was no effect of intensity; individuals differing in their level of depression did not show differences in their recognition of emotions depending on intensity level. This is in contrast to previous research where individuals with high levels of depression show increased sensitivity (Bento de Souza et al., 2014; Gollan et al., 2008; 2010) or decreased sensitivity (Bannerman et al., 2010; Gollan et al., 2008; 2010) in the recognition of specific emotions. Previous research has also suggested that individuals higher in depression may show poorer FER under brief exposure time, but not under longer exposure times (Surguladze, 2004). This was not supported in Study 5, where there were no overall differences in their recognition of emotions at different exposure times for individuals differing in their level of depression; although, specific patterns of findings emerged for male late adolescent/emerging adults. Males in the higher, as opposed to lower, depressive symptoms group were significantly poorer in their FER for emotions that were displayed at 3000ms, but not at 500ms or 10,000ms. These findings support that individuals differing in their level of depression may differ in their recognition of emotions under specific exposure times.

When examining attention to faces during FER, in Study 4 it was shown that when the task was self-paced, individuals differing in their level of depressive symptoms showed no differences in the amount of time spent examining facial features during FER. However, when exposure time was introduced in Study 5, it was shown that those higher in depressive symptoms spent significantly less time examining facial features during FER; this finding was regardless of exposure time. The finding that individuals higher on depressive symptoms may spend significantly less time scanning facial features during FER may be explained through the context insensitivity hypothesis (Rottenberg & Gotlib, 2004) – posits that individuals higher in depressive symptoms may show a reduced reactivity to emotional stimuli (see Section 5.3.5.1). Alongside this, individuals higher in depressive symptoms may show reduced motivation, which may influence gaze behaviour and subsequently the ability to successfully recognise facial affect.

While individuals differing in their level of depression did show differences in the amount of time examining facial features during FER, across both studies in Chapter 5, individuals differing in their level of depression showed no differences in the amount of time spent examining the eye region. These findings imply that the eyes may therefore not be what individuals are examining less during FER. This may partially explain why individuals with higher levels of depressive symptoms within the two studies did not show overall poorer FER. Importantly, within Study 2 and 3, level of depression did predict poorer overall FER, however in these studies individual emotions were not examined, these findings will be examined more closely in Section 6.1.4.

When examining individuals differing in their degree of lateralisation for emotion processing, there were differences found in the recognition of specific emotions.

Specifically, those who were more RH dominant showed stronger FER of surprise in Study 4 (although when accounting for familywise error this was not significant) and of fear (males only) in Study 5. In contrast, those who were more RH dominant showed poorer FER of sadness in Study 4 (although when accounting for familywise error this was not significant) and of surprise (females only) in Study 5. Whilst these findings suggest a role of lateralisation for emotion processing in FER, it is important to note that different emotional expressions are lateralised to different degrees (see Section 2.2.2). Therefore, it may be more appropriate to examine how differences in the degree of laterality for processing individual emotions are related to the recognition of the specific individual emotions.

More importantly for the scope of this thesis, it was examined how individuals who differ in their degree of lateralisation for emotion processing differed in their recognition of emotions presented at different intensities and at different exposure times (i.e., when task demands may be more difficult). There was no effect of laterality group in terms of the groups' recognition of emotions at different intensities or at different exposure times. This indicates that those who were more RH dominant in their processing of emotions did not show stronger FER under what may be seen as more difficult conditions. These findings may indicate that laterality of emotion processing may not relate to task difficulty. However, it should be noted that emotions at 30% were generally recognised more poorly by all participants; low accuracy may have masked any effects of laterality group due to the task being too difficult. Further, there were no differences in FER under different exposure times, implying that recognition of emotions under briefer exposure was not more difficult in Study 5. Further research should examine whether degree of laterality for emotion processing may support FER when task demands are more difficult.

In relation to attention during FER, across both studies individuals who were more RH dominant (compared to bilateral [BL]) did not show any differences in the amount of time spent examining facial features during FER. However, in Study 5 it was found that those who were more RH dominant compared to BL spent significantly longer examining the eyes during FER; in particular, this was the case for males. Such findings may imply a compensatory mechanism for males who are more RH, who may look more at the eyes to gain better FER. In contrast to these findings, in Study 4 there were no differences in laterality group and amount of time spent examining the eye region. Methodological differences between the two studies may shed light on the patterns of results. Participants in Study 5 were restricted in the amount of time viewing of the emotional stimuli, which may have impacted how faces were scanned, while participants in Study 4 freely viewed the faces without any time restrictions. Task instructions may have therefore impacted face scanning across these studies. Whilst instructions may have influenced what information was attended to in the faces, it is also possible that the significant findings were due to the increased power in Study 5.

6.1.1 Can social-emotional factors and lateralisation for emotion processing predict facial emotion recognition in adolescence?

In Study 2, it was shown that FER of 11- to 17-year-olds could be predicted by social-emotional factors but not lateralisation for emotion processing. However, the specific patterns that emerged were specific to females, for whom social-emotional factors significantly predicted FER. Within this, this thesis has shown that behavioural and subjective aspects of social anxiety may relate in different ways to FER. These findings may help to explain inconsistencies in previous literature, who fail to account for the multifaceted nature of social anxiety.

This thesis has demonstrated that facets of social anxiety differentially predicted FER, thereby indicating that it is important to look at relationships for the individual facets rather than a total score of social anxiety. Whilst adolescents who have higher levels of generalised avoidance showed poorer FER, adolescents who have higher fear of negative evaluation showed stronger FER (approaching significance in Study 2 and significant in Study 3). These findings highlight the importance of social exposure (i.e., avoidance of social situations) in the development and maintenance of FER skills, as well as how subjective aspects of social anxiety (i.e., FNE) may be important in explaining variance in adolescent FER. Taken together, these findings add to our knowledge of how specific aspects of social anxiety may relate to social skills – specifically FER. Such findings may help us to understand emotion development, emphasising the importance of not only social exposure (see Section 1.3.1) but also highlighting how social avoidance may be importance in the maintenance of FER, specifically at a time where FER abilities are still developing. Importantly, whilst generalised avoidance negatively predicted FER, avoidance specific to new situations was not a significant predictor of FER. Individuals who only avoid new (or specific) situations, may still have the opportunity for interaction and exposure in a familiar context; in fact, these individuals have been found to display less profound social impairments (Golda et al., 1998; La Greca & Stone, 1993).

The results from both Study 2 and Study 3 show that adolescents (specifically females) higher in depressive symptoms have poorer FER. These findings are consistent with the adult literature. Importantly, the findings of this thesis suggest that depressive symptoms may impact FER in adolescence when FER is still developing. This highlights the need for further research of how social-emotional factors may impact FER at this time.

For both males and females, degree of lateralisation for emotion processing was not a significant predictor of FER. As suggested in Section 4.2.5, this may have been because males and females had both already developed a RH dominance for emotion processing. This is in contrast to findings that increased RH dominancy relate to FER have often been demonstrated in younger children (Watling & Bourne, 2013; Workman et al., 2006) when hemispheric lateralisation dominance is still developing. Importantly, it is known that are likely to be factors that may impact degree of lateralisation throughout the lifespan (i.e., hormones, social-emotional factors; see Section 2.2.2.2). In the next section, I will examine how changes (fluctuations) over time in the degree of lateralisation for emotion processing across adolescence may be more important in predicting later FER skills.

Limitations and considerations

There are several considerations that should be taken into account when reflecting upon the findings in relation to the research question. Firstly, it should be acknowledged that the male sample was significantly smaller than the female sample within Study 2, it may therefore be that a larger sample size may be needed to detect a predictive relationship for males. Future research would therefore benefit from examining these factors in a larger male adolescent sample. Despite this limitation, it is noteworthy, that some researchers have highlighted that social-emotional factors in females may be more closely related to social functioning than patterns found in males (La Greca & Lopez, 1998; Yonkers et al., 2001). Further, within our subset of males they typically experienced fewer depressive symptoms and lower levels social anxiety than females; it may therefore be important to recruit males who have higher levels social-emotional factors to assess if these are related to FER.

In summary, the findings of Study 2 and Study 3 (time 1) suggest that social-emotional factors (i.e., social anxiety and depression) but not degree of lateralisation for emotion processing are able to predict FER in adolescents. I have highlighted that it is important to assess relationships for the three different facets of social anxiety (behavioural versus subjective), as this impacts conclusions that may be drawn about the role of social anxiety in FER in adolescence. Lastly, the findings highlight that the predictive relationship may differ by sex (important for females but not males); although, it is important to further explore relationships in a larger sample of males.

6.1.2 Do changes in social-emotional factors and degree of lateralisation for emotion processing predict later FER in adolescents?

Study 3 examined if changes in social-emotional factors and lateralisation for emotion processing over time could predict FER 6 and 12 months after initial testing with females only. It was found that changes in both social-emotional factors and lateralisation for emotion processing were important in predicting later FER.

In exploring social-emotional factors, it was shown that FER at 6 months was predicted from initial depression scores, indicating that depressive symptoms in adolescents may have lasting impact on FER skills. This is in line with adult research (e.g., LeMorh et al., 2009), which found that patients in remission for depression still show some FER difficulties. Further, changes in depressive symptoms predicted later FER at 6 months, with adolescents who increased in depressive symptoms showing poorer FER later on. As previously mentioned, research examining how level of depression in adolescence may relate to FER is scarce. The findings presented in this thesis highlight that during adolescence an adolescent's level of depression and changes in depressive symptoms may play an important role in FER. This research therefore contributes to the understanding of how depressive symptoms may impact FER.

In addition to the findings with depressive symptoms, it was also found that changes in level of generalised avoidance across a 6-month period predicted later FER, with those who increased in avoidance showing later poorer FER. These findings are consistent to those reported above where there was a relationship between generalised avoidance and FER at the initial time point (Study 2). This adds further support for the social theories of emotion development that emphasise the role of exposure and experience in the development of and the maintenance of social skills (Biggs et al., 2012; Parker & Gottman, 1989; see also Section 1.3.1).

Interestingly, whilst initial laterality did not predict initial FER, becoming more RH dominant over time was a significant predictor of later FER. These findings highlight that fluctuations in the degree of hemispheric lateralisation across adolescence may help affect FER. In fact, past researchers have found links between lateralisation for emotion processing and different hormonal stages (e.g., Bourne & Gray, 2009; Hausmann & Gunturkun, 2000), as well as relationship status (Fussell, Rowe & Mohr. 2012). Adolescence is known for having hormonal changes and relationships changes that are likely to explain fluctuations in the degree of laterality at this time. These findings highlight that emotion processing in the brain may be important to understand in order to understand changes in FER over time.

Notably, whilst changes in social emotional factors and laterality for emotion processing predicted FER at 6 months, this was not the case in predicting FER at twelve months. Instead, it was found that initial depression and initial degree of laterality predicted FER 12 months after initial testing, but that changes in these factors did not predict later FER. In looking at the finding across the three time points of data collection, there are various conclusions that may be drawn. Firstly, it appears that depression is a stable predictor of FER skills in adolescents. Secondly, it may be that when looking at one time point that it appears that social-emotional factors are the dominant predictors; however, when looking over time it may be that being more RH to begin with may be a protective factor against the negative effects of social-emotional factors on FER. Importantly, these findings suggest that both changes in social-emotional factors and degree of lateralisation for emotion processing may both be important in predicting FER in adolescents. Further research would benefit from further longitudinal and cross-lagged research to further understand how these factors may interact over the course of adolescence. Importantly, future research would also benefit from examining longitudinally in males, how these factors may explain variance in later FER across adolescence.

Limitations and considerations

The findings reported above must be considered in light of the limitations. One notable limitation is that there was a high attrition rate during the longitudinal study in Study 3. High attrition rates can lead to lost variability within the dataset. Importantly, when comparing those who did not take part in all three time points to those who did, there was only significant difference in age but not in their scores on the other predictors. It is therefore unlikely that the patterns found are specific to the drop-out; although it may have impacted the ability to detect effects. Future research is needed to enhance the understanding of how these factors interplay, particularly in examining development patterns for older adolescents.

In addition to the attrition rates, the decision had been made to include female adolescents only in the longitudinal study. This was decided as females tend to have higher social-emotional scores (APA, 2013), which was expected to have greater variability. However, it is known that research with adults tends to find that males are more RH dominant (e.g., Bourne, 2005, 2008; Schneider et al., 2011) and research tends to find that males have poorer emotion recognition skills (e.g., Montagne et al., 2005; Hoffman et al., 2010. It would be important to understand the role of social-emotion factors and lateralisation for emotion processing play in male adolescents. Further, whilst in Study 2, social-emotional factors were not significant predictors of FER, it should be noted that male specific findings emerged in later studies (Study 5), supporting that it may be important to further examine longitudinal associations of FER in males.

6.1.3 Do individuals high and low in social anxiety facets and depression and those who are more RH or BL in their processing of emotions differ in their FER?

Chapter 5 (Study 4 and Study 5) allowed for a further examination of how social-emotional factors may impact the recognition of specific emotions and allowed investigation of whether these groups may be characterised by general difficulties in FER or whether there were more specific differences as a function of specific emotion.

Across both Study 4 and 5, there were no significant difference in overall FER for individuals differing in their level of social anxiety (specifically sub-facets), as well as no group differences in their recognition of specific emotions. There was no evidence found to suggest that individuals differing in their level of social anxiety performed differently in their recognition of emotions at different intensities (Study 4) or exposure time (Study 5). These findings are in contrast to previous research which has found increased (Arrais et al., 2010) or decreased (Montagne et al., 2006) sensitivity to less intense emotional expressions in social anxiety, as well as research that finds that socially anxious individuals may make misinterpretations under restricted viewing times (Heuer et al., 2010).

These findings highlight that when accounting for response bias, adolescents differing in their level of social anxiety are not characterised by differences in FER. Difference in findings from previous research cited may be a consequence of controlling for related variables (i.e., controlling for depression, laterality), which may have minimised any effect of SA on FER. Taken together, Study 4 and 5 show that participants (primarily adolescents) high and low in social anxiety facets do not differ in their FER, emotions, intensity or exposure time.

When examining group differences in level of depression, across both studies no overall group differences were found in overall FER, thus indicating that differences in FER by level of depression may be more specific to individual emotions and differ by sex. In particular, there was evidence to support that those higher in depressive symptoms showed poorer recognition of happiness and showed patterns of both stronger (sadness) and weaker (fear) recognition of some of the negative emotions, depending on sex. These are consistent with patterns reported in previous work (see Section 2.1.2.2), but also highlight the inconsistency of findings when examining the role of depression on FER. Indeed, these findings are likely to play a role in the maintenance of depression, leading individuals with depression to interpret social situations more negatively, which may subsequently affect social relationships. In light of these findings, it would be important to examine more closely the effect of emotion and sex on adolescent FER.

When examining the role of emotional intensity (Study 4) and exposure time (Study 5), within these studies no evidence was found to suggest that groups differing in their level of depression differed in their FER as a function of these factors. These findings are in contrast to past empirical research that has found that individuals higher in depression may require greater or less emotional intensity to recognise some emotions (e.g., Bannerman et al., 2010; Bento de Souza et al., 2014; Gollan et al., 2008; 2010) and research that finds that exposure time may impact FER in depression (Surguladze et al., 2004).

Given the specific findings with depression and FER by emotion, the findings presented in this thesis suggest that adolescents higher on depressive symptoms may show emotion-specific difficulties in FER, but not in their sensitivity to emotional expressions, or their recognition of FER under different exposure times.

The findings from Study 4 and Study 5 showed that individuals who were more RH dominant (compared to BL) did not show overall stronger FER. While some differences in the recognition of specific emotions were present based on laterality group, it is important to note that different emotional expressions are lateralised to different degrees (see Section 2.2.3). Therefore, it may be more appropriate to examine how differences in the degree of laterality for processing for specific emotions are related to the recognition of that specific emotion.

As highlighted earlier, it was predicted that individuals who were more strongly lateralised to the RH compared to BL may show stronger FER under more difficult conditions (i.e., lower intensities, shorter exposure times). This was not found within the set of studies presented in this thesis. There was equivalent performance in the recognition of emotions at different intensities and exposure times for groups differing in their degree of lateralisation for emotion processing. As such, these findings imply that stronger lateralisation towards the RH is not related to better FER performance when the task is more difficult. These findings imply that stronger lateralisation towards the RH is not related to better FER performance when the task increases difficulty with different intensities of facial emotion presented and different exposure times.

Limitations and considerations

The findings for this research question should be considered in light of the methods used within these studies. In this work, in order to examine eye-movements alongside FER the shortest exposure time used for emotional stimuli was 500ms. However, there is evidence that emotions can be recognised very quickly. For example, Calvo and Lundqvist (2008) found that the six basic emotions could be recognised equivalently at 250ms. Therefore, it is perhaps unsurprising that within our study there was no evidence found to suggest that FER at the shorter exposure times was more difficult (found equivalent performance across exposure times). Future research may wish to examine whether using shorter durations may change the findings. For example, as highlighted in Chapter 5, Surguladze et al. (2004) found poorer FER for individuals with depression at 100ms but not at 2000ms; it may be that shorter exposure tasks than those used in these studies are needed to detect group differences.

6.1.4 Do individuals high and low in social anxiety facets and depression and those who are more RH or BL in their processing of emotions differ in their scanning of faces, specifically the amount of time spent examining to facial features and the eyes during FER?

Within Study 4 and 5, it was examined whether individuals differing in their level of social anxiety (specifically for the three subfacets), depression and degree of lateralisation for emotion processing differed in the amount of time spent examining facial features and the eyes during FER.

In exploring group differences for those higher compared to lower in facets of social anxiety there was no difference in the amount of time spent examining facial features or the eyes during FER. These findings are inconsistent with previous research (i.e., Horley et al., 2003, 2004) that has found that individuals higher in levels of social anxiety show more avoidance of facial features and the eyes when scanning emotional faces. As highlighted earlier, differences may in part be explained by task demands; previous work has typically asked individuals to passively view faces without instructions (e.g., Horley et al., 2003, 2004). Given that instructions are known to alter scan paths (Yarbus, 1967), it may be that when instructed that individuals higher in levels of social anxiety behave differently than in naturalistic situations. An important question lies in whether individuals with higher levels of social anxiety would automatically engage in this process when not instructed to do so.

While an overall group difference in the scanning of facial features and the eyes was not present, some patterns emerged depending on specific subfacets of social anxiety regarding the amount of time spent examining the eyes under brief exposure times (500ms). Specifically, those higher on generalised avoidance (compared to lower) showed hypervigilance to the eyes for sad faces; and, adolescents higher on FNE spent significantly less time scanning the eyes under briefer exposure times for positive emotional stimuli, that was not present under longer exposure times. These findings suggest that individuals higher in generalised avoidance may show hypervigilance to the eyes for sad faces compared to peers who are less socially avoidant. The findings also suggest that adolescents higher in FNE may not initially attend to the eyes for positive emotional stimuli, but over time they do attend to the eyes. These findings may help us to understand adolescent FER, by demonstrating that individuals higher on social anxiety (specifically sub-facets) may be characterised by differences in early attention to specific emotional stimuli, however, this does not appear to be related to FER accuracy. One explanation could be that the lack of initial viewing to the eyes for happiness and surprise may not effect accuracy; in fact, the mouth region has been argued to be the most important feature in the recognition of happiness (Eisenbarth & Alpers, 2011) and researchers have found that surprise is equally recognisable from the upper and lower half of the face respectively (e.g., Boucher and Ekman, 1975). Future research is needed to examine this more closely.

Across Study 4 and 5, individuals differing in their level of depressive symptoms showed no difference in the amount of time spent examining the eyes. To date, little research has examined how individuals with depression may scan faces during FER. As highlighted earlier, Wu et al. (2012) demonstrated that, consistent with the findings in Study 5 (when exposure time was accounted for), students scoring higher on depression spent less time scanning facial features during FER. One important distinction between the two studies is that Wu and colleagues used a free-viewing task, and did not account for how long the participant viewed the face, concluding that those higher in depressive symptoms spent less time viewing facial features due to overall quicker reaction times. Importantly, within Study 5, it was found that after accounting for stimulus exposure time, individuals higher in depressive symptoms still spent significantly less time examining facial features, implying that less time spent viewing features in Wu et al's study may not be due to quicker reaction times but a more general pattern observed in those higher in depressive symptoms. As discussed in Chapter 5, these findings may be explained through motivational processes; individuals with higher levels of depression may lack the social motivation which may subsequently impact scanning patterns. In a real-life social interaction, individuals higher in depressive symptoms may experience less social motivation to engage in these processes when not instructed to do so.

Importantly, whilst individuals higher in depression spent less time examining features during FER, they did not show poorer overall FER. There are several explanations that might explain these findings. It may be that whilst individuals with higher levels of depression spend less time examining the facial features during FER, they are still engaging enough to extract the necessary information essential for FER. Alternatively, it may be that there is a linear relationship between depressive severity and time spent examining facial features during FER, which may be more evident using clinical samples. Finally, it may be that whilst individuals with higher levels of depression show differences in their scanning of faces, these differences may not be able to explain differences in FER performance. If true, then the FER differences observed between the depression group may not be attributed to attentional processes but may reflect in interpretation of emotional stimuli more generally.

Importantly, to my knowledge, this is the first study to examine how degree of lateralisation for emotion processing may relate to scanning of faces during FER. Within Study 4 and 5, it was shown that individuals differing in their degree of laterality did not show differences in the amount of time spent examining facial features during FER. These findings indicate that the degree of laterality for emotion processing may not be associated with general scanning to facial features during FER. Therefore, it is unlikely that attention to facial features accounts for the relationship between degree of laterality for emotion processing and FER that has been reported in previous research with children (e.g., Watling & Bourne, 2013, Workman et al., 2006).

Interestingly, in Study 5, it was shown that individuals who were more RH dominant in their processing of emotions (compared to BL) spent significantly longer viewing the eyes during FER (regardless of exposure time). This effect was specifically the case for males. Being more RH dominant may help males to make greater use of the eye-region during FER, which research has shown to be related to stronger FER performance (e.g., Watling & Bourne, 2013; Workman et al., 2006), thereby compensating for sex differences in FER (see Section 1.4.1). Taken together, the findings show that overall degree of lateralisation for emotion processing does not appear to effect time spent examining features during FER; however, degree of lateralisation for emotion processing may play a role in how individuals, particularly males, scan the eye region. These findings emphasise and highlight the need for further research with males.

Limitations and considerations

It is important to note that there was no direct analysis linking attention to FER accuracy in this thesis. Given previous research emphasising the links between visual attention and FER, it was expected that patterns that emerged in attention would also be present in FER accuracy; this was not always the case in the studies conducted. For example, whilst individuals higher in FNE spent less time examining the eye region for positive emotional stimuli, this was in the absence of any differences in FER. It is important to note that the lack of mapping attentional differences with FER performance differences may in part be due to the use of instructions; in previous research the tasks often require participants to passively view the faces, without any instructions or decisions. It may therefore be that when instructions are introduced, individuals with higher levels of social anxiety are able to direct their attention in order to make accurate judgements on the emotion of a facial stimulus. An important question lies in whether individuals with higher levels of social anxiety and depression would automatically engage in this process when not instructed to do so. Future research may therefore wish to compare these groups during passive viewing and instructed FER task to assess any differences in attention.

6.2 General Limitations

Within this thesis I set out to explore how individual differences may influence FER performance, and under what conditions performance may be impacted (emotion, intensity, exposure time). Throughout this discussion, I have highlighted limitations with regards to addressing each research question (e.g., female participants only in the longitudinal study, not integrating findings on attention and FER performance). In addition to these, there are two larger limitations of the designs used that may impact the application of the finding and should be considered in the development of future research in this area. These include the measures used – specifically the use of self-report, behavioural tasks of emotion processing and the morphing of stimuli for the FER task. A further consideration is the use of overfitting models throughout this thesis. Each of which will be addressed below.

6.2.1 Measures used

6.2.1.1 Self-report measures

Throughout this thesis when examining social-emotional factors questionnaire measures were used to assess social anxiety and depression within a community sample of participants. This allows for subjective measurement of thoughts and feelings, with no objective measure or external validation of this (e.g., having a clinical diagnosis or not). Patterns of results may differ or be greater when examining individuals with clinical diagnoses. It may therefore be difficult to extrapolate the findings within this thesis to clinical samples. However, whilst this is a limitation that must be considered, both social anxiety and depression are largely underdiagnosed in adolescents (Katzelnick & Greist, 2001; Lubman et al., 2007; Lydiard, 2001) and researchers have frequently suggested that both are best viewed as continuums (Hankin, Fraley, Lahey, & Waldman, 2005). This supports the importance of exploring these questions in a community sample.

Within the sample of participants in the studies conducted there was large variation in the levels of social anxiety and depression found, with evidence that there were individuals who met clinical cut-offs on these measures for social anxiety and depression. In fact, when creating groups on level of social anxiety and depression in Studies 4 and 5, the high groups' mean scores represented clinical cut-offs on both social anxiety and depression. Nonetheless, further research would benefit from a closer examination of how these factors may play a role in adolescents who are formally diagnosed with these disorders, given that these individuals may have different social experiences as a result of their diagnosis.

6.2.1.2 Assessing Emotion processing

Within this thesis I used the Chimeric face test, a behavioural measure, to assess degree of lateralisation for emotion processing. This measure has been shown to be a good indicator of an individuals' patterns (strength) of lateralisation of emotion processing (see Section 2.2.2.1); however, the chimeric face test is not able to provide details of localization of the processing of faces within the RH (Bourne & Vladeanu, 2013). Whilst this was beyond the scope of this thesis to examine the specific neural network involved in the processing of emotions, further longitudinal research should examine how specific brain areas implicated in emotion processing and emotion recognition are lateralised to explore how social-emotional factors may influence lateralisation for emotion processing in the brain within specific regions of the brain.

6.2.1.3 Facial Emotion Recognition stimuli

The current thesis used static emotional stimuli to assess FER that used morphing techniques (common within this research field) to develop a set of emotional expression varying in their level of intensity (see Chapter 3 for stimuli development). Whilst subjective ratings of emotional intensity using morphed stimuli have been found to be related to emotional intensity (Calder et al., 2000; Hess et al., 1997; Matsumoto et al., 2002), in recent years some researchers have critiqued this method. For instance, it has been argued that whilst morphing emotional stimuli provides a linear way to assess FER, in real-life, facial action units do not move in a linear configuration (Krumhuber & Scherer, 2011; Scherer & Ellgring, 2007). It may therefore be argued that linear morphing techniques may not truly represent the facial muscular of less intense emotional expressions (see Korolkova, 2018). In addition to the morphed stimuli, the current research did not include full-blown (100%)

emotional expressions in order to reduce ceiling effects in performance and examine more subtle emotional expressions. However, a comparison with 100% emotion may have been beneficial as many other researchers who have found group differences with social-emotional factors (e.g., Simonian et al., 2001; Persad & Polivy, 1993) used 100% emotion.

Another consideration is whether subtle emotional intensities (i.e., those presented at 30%) should be considered incorrect if the participant selected no emotion as their response. Researchers have often argued that neutral expressions represent an absence of emotion (Isaacowitz et al., 2007), it can therefore be implied that any shift away from the neutral baseline represents a subtle expression of emotion in the direction of the shift (i.e., 30% anger and 70% neutral represents a subtle anger expression). As highlighted in section 3.1.1.1, with age children become increasingly competent in their recognition of expressions of subtle emotions, and researchers using the NimStim facial set (Tottenham et al., 2009) have found that the threshold for detecting basic emotional expressions is below 30%, suggesting that subtle emotional expressions are correctly identified as depicting emotional expressions away from neutral.

Emotion descriptors

Throughout this thesis, during the FER tasks, participants were asked to judge the emotion that the face was showing, however one consideration refers to the inconsistent use of nouns (i.e., happiness) and adjectives (i.e., happy) for emotion descriptors during the FER tasks (see Table 6.1 for use within this thesis). According to the cognitive science of religion literature (e.g., Barrett, 2009; Douglas, Sutton, Callan, Dawtry, & Harvey, 2016) using adjectives (i.e., agency) may lead to hypersensitive agency detection – consistent with the belief that humans have evolved to be sensitive to detect very subtle cues on intentional agency (Rosset, 2008). In contrast, using non-agentic descriptors (i.e. nouns) would not have this same effect. To date, there is an absence of research examining the effects of agency of emotion descriptors on FER, with researcher's being inconsistent in their use agentic and non-agentic descriptors during forced-choice paradigms on FER tasks. It may be that FER accuracy may be confounded with agency, such that participants may be better at detecting emotion when the agentic linguistic descriptor is used. In future work, researchers should ensure consistency in the use of nouns or adjectives for emotion descriptors, and examine whether FER performance may be effected by the use of agentic versus non-agentic descriptors.

Table 6.1. Emotion descriptor used for FER tasks within the current thesis.

Study	FER descriptors used
2, 3	Happy (adj), Sad (adj), Fear (noun) Surprised (adj), Anger (noun), Disgust (noun) No emotion (adj)
4, 5	Happiness (noun), Sadness (noun), Fear (noun) Anger (noun), Surprised (adjective), Disgust (noun) No emotion (adj)

Note: (adj) = adjective, agentic descriptor, (noun) = noun, non-agentic descriptor.

6.2.2 Overfitting models

The aim within this thesis was to examine the independent effects of social anxiety (sub-facets), depression and lateralisation for emotion processing on FER and attention to faces during FER. To achieve this, when examining the effect of one factor (i.e., social anxiety subfacets, depression, lateralisation for emotion processing), all other factors were controlled for. Although this allowed us to examine the unique contribution of each factor, the relationships between these variables deserve a more in-depth investigation in future work. In fact, the differences in findings from previous research may in part be reflected by the inability for previous researchers to control for other interrelated factors. Although a strength, in controlling for comorbidity, may have reduced power to detect effects. Future work is therefore needed to untangle the independent effects of social anxiety, depression and lateralisation for emotion processing on FER in adolescence.

6.3 Future directions

6.3.1 Social emotions

This thesis focused exclusively on the recognition of the six basic emotions. However, there are more emotions that should be explored in future work, such as complex ‘social’ emotions. In contrast to the basic emotions, social emotions require an individual to represent the mental state of another (e.g., embarrassment, shame; Burnett et al., 2015). Given that social emotions are linked to social evaluation (Burnett et al., 2015), future research would benefit from examining how individuals differing in their level of social anxiety may recognise social emotions. Further, research has found that patterns of hemispheric lateralisation for social emotions (Tamietto, Adenzato, Geminiani & Gelder, 2007) differs from patterns of lateralisation for basic emotions (explored within the current thesis). Therefore, we would expect that social emotional factors and lateralisation for emotion processing would be related to the recognition of more complex social emotions; thus, highlighting the need to expand the current research.

6.3.2 Dynamic not statistic stimuli

In addition to the types of emotions I chose to use throughout this thesis, I also chose to use static images rather than dynamic images to assess FER. Whilst common in the literature, in recent years, researchers have begun to move towards using more dynamic stimuli that are more ecologically valid. Reliance on static emotional stimuli have been argued to underestimate the importance of dynamic information in FER (Torro-Alvez, 2016; Dobs et al., 2019). Indeed, the use of different type of stimuli (static vs. dynamic) may lead to differences in findings. Generally, across the lifespan it has been found that individuals tend to show greater accuracy in the recognition of dynamic stimuli (Richoz, Lao, Pascalis & Caldara, 2018). In fact, Alves, Bezerra, Claudino and Rodrigues (2016) reported that individuals with social anxiety showed differences in the recognition of static images but not in the recognition of dynamic stimuli, and Bomfim, Ribeiro and Chagas (2019) found that individuals with depression differed in their recognition of FER for static and dynamic stimuli. Further, Kilts, Egan, Fideon, Ely and Hoffman (2003) found increased RH lateralisation using PET, differential neural activation for dynamic over static emotional stimuli. Given that emotional expressions emerge over time, the use of dynamic stimuli may be more appropriate to examine attentional processes, especially given evidence of biases in the scanning of faces over time that have been documented in both social anxiety and depression (see Section 2.1.1.3 and 2.1.2.3). More generally, the use of static stimuli may therefore underestimate the effect and impact on social interactions. Moving forward, it is recommended that future research employ the use of more ecologically valid stimuli (i.e., through the use of dynamic emotional stimuli).

6.4 Summary: The role of social-emotional factors and lateralisation for emotion processing in adolescent FER

Taken together, the results of this thesis suggest that both social-emotional factors and lateralisation for emotion processing may be important in explaining individual differences in FER in adolescents.

The role of social anxiety in adolescent FER remains unclear; although, evidence is provided that when looking at relationships, different facets of social anxiety may be related to FER in different ways. It is suggested that future researchers would benefit from differentiating between ‘behavioural’ and ‘subjective’ components of SA when examining FER. Importantly, although evidence was found to suggest a role for social anxiety in predicting adolescent FER, when examining the role of intensity and exposure time, no group differences emerged. These findings highlight the complexity of the role of social anxiety on FER in adolescents and suggest that when accounting for response bias, as well as other factors (i.e. depression), the findings may be less clear. Whilst adolescents who differed in their level of social anxiety showed differences in early attention to emotional faces, it is unlikely that these differences in face scanning account for FER in these individuals, given that no differences were found in FER; albeit, further research is needed to examine this more closely.

The role of depression in adolescent FER was more clear-cut throughout this thesis. Given that there has been little work in this area, evidence is provided to suggest a negative relationship between level of depression and FER in adolescents, as well as to suggest that changes in depression over time may be important in explaining individual differences in FER later in adolescents. When examining more closely how level of depression may interact with emotion, intensity and exposure time. It was evident that specific patterns may exist, such that individuals higher in depression show differences in the recognition of specific emotions that differ by sex. From this thesis, it is concluded that early-mid adolescents differing in depressive symptomology are not characterised by differences in their sensitivity at recognising emotions are lower intensities (although later-adolescence/ emerging adult males were). Individuals higher in depression also did not show any differences in FER under different exposure times. Importantly, evidence was found to suggest that under finite exposure time (not free viewing), individuals higher in depressive symptoms spend significantly less time examining facial features during FER. These findings may highlight a reduced social motivation in those with higher depressive symptoms and may aid us in explaining why individuals higher in depressive symptoms may show some differences in FER. Although, given that we did not directly compare this and only specific patterns emerged, future research is needed to examine this in more depth.

The role of lateralisation for emotion processing to date has been largely neglected in understanding adolescent FER. This thesis shows that whist initial degree of lateralisation for emotion processing and differences between RH and BL groups do not appear to be associated with adolescent FER, changes in degree of laterality over time was related to FER. These findings indicate that with increasing degree of laterality towards to the RH there was better later FER performance. This finding is consistent with explanations that children become more RH dominant over time and this plays an important role in performance more difficult FER tasks (e.g., Watling & Damaskinou, 2018). However, when examining more closely how task difficulty may play a role in FER for individuals differing in their degree of laterality for emotion processing, the findings did not point to this being the case – but instead suggest that the role of emotion processing is less clear. A novel finding from this thesis was that males who were more RH appeared to spend significantly longer examining the eyes during FER, in the absence of specific patterns in FER accuracy.

6.5 Conclusions

In summary, this thesis aimed to assess the role of social-emotional factors and lateralisation for emotion processing in adolescent facial emotion recognition (FER). This thesis adds to what is already known by showing that: (1) social emotional factors can predict FER in adolescents, and that different facets of social anxiety may be differentially related to FER; (2) changes in social-emotional factors and lateralisation over time can predict later FER; (3) adolescents higher in depression may show specific difficulties in the recognition of particular emotions, which may differ by sex; (4) individuals with higher levels of depressive symptoms (compared to lower levels) show reduced scanning of facial features during FER; (5) males who are more RH dominant spend significantly longer scanning the eyes during FER. Taken together, these findings emphasise the need for further research in understanding how social-emotional factors and lateralisation for emotion processing may affect FER throughout the adolescent period. Through understanding the factors that might impact FER throughout adolescence, the knowledge gained from continuing this work will allow for early intervention to protect against poor FER, given that social skills deficits in children are the strongest predictor of mental health problems in adulthood (Cowen et al., 1973).

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7 Appendices

7.1 Appendix 1. Questionnaire Measures

7.1.1 Handedness Questionnaire

I am:

Left handed ☐ **Right handed** ☐ **Ambidextrous** ☐

A number of activities are listed below. Please tick the appropriate response for each activity. Some of the activities require both hands, in which case the hand for which preference is required is indicated in brackets. If you have no experience with the task imagine the task and respond appropriately.

	Always with left	**Almost always with left**	**More often with left**	**Equally with left or right**	**More often with right**	**Almost always with right**	**Always with right**
Writing							
Drawing							
Throwing							
Scissors							
Comb							
Toothbrush							
Spoon							
Hammer							
Knife (with fork)							
Knife (without fork)							
Broom (upper hand)							
Striking match (match)							
Opening a box (lid)							

7.1.2 Child Depression Inventory

Instructions:

People sometimes have different feelings and ideas.

This form lists the feelings and ideas in groups. From each group, pick one sentence that describes you best for the past two weeks. After you pick a sentence from the first group, go on to the next group.

There is no right answer or wrong answer. Just pick the sentence that best describes the way you have been recently. Circle the number next to your answer, like this:

EXAMPLE:

I read books all the time	(1)
I read books once in a while.	2
I never read books	3

Remember, pick out the sentence that describes your feelings and ideas in the **PAST TWO WEEKS.**

1.	I am sad once in a while	1
	I am sad many times.	2
	I am sad all the time	3

2.	Nothing will ever work out for me	1
	I am not sure if things will work out for me.	2
	Things will work out for me O.K.	3

3.	I do most things O.K.	1
	I do many things wrong	2
	I do everything wrong.	3

4.	I have fun in many things	1
	I have fun in some things.	2
	Nothing is fun at all.	3

5.	I am bad all the time.	1
	I am bad many times	2
	I am bad once in a while.	3

6.	I think about bad things happening to me once in a while	1
	I worry that bad things will happen to me.	2
	I am sure that terrible things will happen to me.	3

7.	I hate myself	1
	I do not like myself	2
	I like myself	3

8.	All bad things are my fault	1
	Many bad things are my fault.	2
	Bad things are not usually my fault	3

9.	I do not think about killing myself	1
	I think about killing myself but I would not do it.	2
	I want to kill myself.	3

10.	I feel like crying every day	1
	I feel like crying many days.	2
	I feel like crying once in a while	3

11.	Things bother me all the time	1
	Things bother me many times	2
	Things bother me once in a while.	3

12.	I like being with people.	1
	I do not like being with people many times	2
	I do not want to be with people at all	3

13.	I cannot make up my mind about things	1
	It is hard to make up my mind about things.	2
	I make up my mind about things easily	3

14.	I look O.K.	1
	There are some bad things about my looks	2
	I look ugly	3

15.	I have to push myself all the time to do my schoolwork.	1
	I have to push myself many times to do my schoolwork	2
	Doing schoolwork is not a big problem	3

16.	I have trouble sleeping every night	1
	I have trouble sleeping many nights	2
	I sleep pretty well	3

17.	I am tired once in a while.	1
	I am tired many days	2
	I am tired all the time.	3

18.	Most days I do not feel like eating	1
	Many days I do not feel like eating	2
	I eat pretty well	3

19.	I do not worry about aches and pains	1
	I worry about aches and pains many times.	2
	I worry about aches and pains all the time.	3

20.	I do not feel alone.	1
	I feel alone many times.	2
	I feel alone all the time	3

21.	I never have fun at school	1
	I have fun at school only once in a while	2
	I have fun at school many times.	3

22.	I have plenty of friends	1
	I have some friends but I wish I had more.	2
	I do not have any friends	3

23.	My schoolwork is all right.	1
	My schoolwork is not as good as before.	2
	I do very badly in subjects I used to be good in.	3

24.	I can never be as good as other kids	1
	I can be as good as other kids if I want to.	2
	I am just as good as other kids	3

25.	Nobody really loves me.	1
	I am not sure if anybody loves me	2
	I am sure that somebody loves me.	3

26.	I usually do what I am told	1
	I do not do what I am told most times.	2
	I never do what I am told	3

27.	I get along with people.	1
	I get into fights many times.	2
	I get into fights all the time	3

7.1.3 Social Anxiety Scale for Children- Revised (La Greca & Stone, 1993).

In this section, you will hear a number of different sentences. For each sentence, you have to click on the line to show **HOW MUCH YOU FEEL** the sentence is true for you.

This is not a test. There are no right or wrong answers.

	Not at all	Hardly ever	Sometimes	Most of the time	All of the time
I worry about doing something new in front of other children					
I like to play with other children					
I worry about being teased					
I feel shy around children I don't know					
I only talk to children that I know really well					
I feel that other children talk about me behind my back					
I like to read					
I worry about what other children think of me					
I'm afraid that others will not like me					
I get nervous when I talk to children I don't know very well					
I like to play sports					

	Not at all	Hardly ever	Sometimes	Most of the time	All of the time
I worry about what others say about me					
I get nervous when I meet new children					
I worry that other children don't like me					
I’m quiet when I’m with a group of children					
I like to do things by myself					
I feel that other children make fun of me					
If I get into an argument with another child, I worry that he or she will not like me					
I’m afraid to invite other children to do things with me because they might say no					
I feel nervous when I’m around certain children					
I feel shy even with children I know well					
It’s hard for me to ask other children to do things with me					

7.1.4 Center for Epidemiological Studies Depression Scale (CES-D), NIMH

Below is a list of the ways you might have felt of behaved. Please tell me how often you have felt this way during the past week.

	Rarely or none of the time (less than 1 day)	Some or a little of the time (1-2 days)	Occasionally or a moderate amount of time (3-4 days)	Most or all of the time (5-7 days)
1. I was bothered by things that usually don't bother me.				
2. I did not feel like eating; my appetite was poor.				
3. I felt that I could not shake off the blues even with help from my family or friends.				
4. I felt I was just as good as other people.				
5. I had trouble keeping my mind on what I was doing.				
6. I felt depressed.				
7. I felt that everything I did was an effort.				
8. I felt hopeful about the future.				
9. I thought my life has been a failure.				
10. I felt fearful.				
11. My sleep was restless.				
12. I was happy.				
13. I talked less than usual.				
14. I felt lonely.				
15. People were unfriendly.				
16. I enjoyed life.				
17. I had crying spells.				
18. I felt sad.				
19. I felt that people dislike me.				
20. I could not get "going".				

7.2 Appendix 2. Stimuli selection

Table 7.1. Reliability, validity and kappas for models for stimuli selected for use within this thesis.

Model No.	**Emotion**	**Sex**	**Validity**	**Kappas**	**Reliability**	**Task**
1^{+}	Happy	F	0.98	0.97	0.88	CFT
6^{+}	Happy	F	0.91	0.92	0.91	FER
11*	Happy	F	0.88	0.83	0.91	FER
14*	Happy	F	0.98	0.98	0.97	CFT
20^{+}	Happy	M	0.95	0.96	0.90	CFT
33^{+}	Happy	M	0.93	0.96	0.94	CFT
36^{+}	Happy	M	0.95	0.96	1.00	FER
43*	Happy	M	0.93	0.91	0.97	FER
1^{+}	Sad	F	0.95	0.89	0.94	FER/CFT
18$^{\cdot}$	Sad	F	0.95	0.92	0.94	FER
3$^{\cdot\cdot}$	Sad	F	0.95	0.95	0.88	CFT
20^{+}	Sad	M	0.84	0.83	0.85	CFT
26^{+}	Sad	M	0.93	0.90	0.94	FER
27^{+}	Sad	M	0.95	0.92	0.97	CFT
40*	Sad	M	0.86	0.91	0.84	FER
3$^{\cdot\cdot}$	Anger	F	0.82	0.86	0.87	CFT
13*	Anger	F	0.87	0.83	0.87	FER
11*	Anger	F	0.90	0.81	0.90	FER
17$^{\bullet}$	Anger	F	0.93	0.91	0.81	CFT
20^{+}	Anger	M	0.99	0.89	1.00	CFT
34^{+}	Anger	M	0.98	0.90	1.00	CFT
36^{+}	Anger	M	1.00	0.93	1.00	FER
38*	Anger	M	0.83	0.81	0.81	FER
14*	Fear	F	0.90	0.86	0.94	FER/CFT
10^{+}	Fear	F	0.85	0.81	0.82	FER/CFT
36^{+}	Fear	M	0.89	0.80	1.00	FER/CFT
43*	Fear	M	0.86	0.81	0.81	FER/CFT
13*	Disgust	F	0.89	0.89	0.82	FER
16$^{\cdot}$	Disgust	F	0.90	0.93	1.00	FER/CFT
19$^{\bullet}$	Disgust	F	0.91	0.80	0.82	CFT
20^{+}	Disgust	M	0.98	0.85	0.91	CFT
23^{+}	Disgust	M	0.91	0.81	0.88	FER
36^{+}	Disgust	M	0.94	0.94	1.00	FER/CFT

7[+]	Surprise	F	0.92	0.81	0.90	CFT
10[+]	Surprise	F	0.96	0.86	0.84	FER
14[*]	Surprise	F	0.91	0.91	0.91	FER/CFT
36[+]	Surprise	M	0.89	0.81	1.00	FER/CFT
43[*]	Surprise	M	0.86	0.81	0.82	FER/CFT
1[+]	Neutral	F	0.88	0.91	0.84	FER
3[¨]	Neutral	F	0.98	0.86	0.97	CFT
6[+]	Neutral	F	0.89	0.87	0.88	FER
7[+]	Neutral	F	0.95	0.96	0.97	CFT
11[*]	Neutral	F	0.94	0.85	0.97	FER
13[*]	Neutral	F	0.89	0.86	0.90	FER
14[*]	Neutral	F	0.93	0.87	0.97	FER
10[+]	Neutral	F	0.85	0.89	0.88	FER
20[+]	Neutral	M	0.93	0.92	0.97	CFT
23[+]	Neutral	M	0.95	0.96	0.97	FER
27[+]	Neutral	M	0.91	0.93	0.94	CFT
36[+]	Neutral	M	0.93	0.90	1.00	FER
38[*]	Neutral	M	0.91	0.85	0.97	FER
43[*]	Neutral	M	1.00	0.96	1.00	FER
40[*]	Neutral	M	0.95	0.93	0.97	FER
17[•]	Neutral	F	0.98	0.91	0.97	CFT
18[•]	Neutral	F	0.95	0.92	0.94	FER
19[•]	Neutral	F	0.95	0.94	0.97	CFT
26[+]	Neutral	M	0.89	0.87	0.97	FER
16[•]	Neutral	F	0.90	0.80	0.97	FER
33[+]	Neutral	M	0.95	0.96	0.97	CFT
34[+]	Neutral	M	1.00	0.96	1.00	CFT

Note: Model number refers to the Model numbers given in the original set, task refers to the task in which the stimuli were used within the thesis. Ethnicities: [+] Caucasian, [*] African-American, [•]Asian-American [¨]Latino-American.

7.3 Appendix 3. Descriptive Statistics for Study 2

Table 7.2. Percentage of male and female participants who identified within each ethnic group.

	Males (*n* = 77)	Females (*n* = 464)	Total (*N*=541)
White Caucasian	71.4	79.7	78.6
Asian	16.8	10.3	11.3
Mixed	7.8	6.0	6.3
Black	1.3	1.7	1.7
Other	1.3	0.2	0.4
Missing	1.3	2	1.8

7.4 Appendix 4. Descriptive Statistics for Study 3

Table 7.3. Percentage of participants by handedness.

	Time 1 (*N*=389)	Time 2 (*N*=201)	Time 3 (*N*=194)
Right-handed	85	86	84
Left-handed	10	10	11
Ambidextrous	2	2	2
Missing	3	2	3

Table 7.4. Percentage of male and female participants who identified within each ethnic group

	Males (n = 19) M_{age} = SD =	Females (n = 20) M_{age} = SD =	Total (N=39) M_{age} = SD =
White Caucasian	73.7	60.0	66.7
Asian	15.8	30.0	23.1
Mixed	5.3	0.0	2.6
Black	5.3	5.0	5.1
Other	0.0	5.0	2.6

7.5 Appendix 5. Descriptive Statistics for Study 4

Table 7.5. Relationships between social-emotional factors and laterality quotient (N = 39)

	FNE	Sad-General	SAD-New	Laterality Quotient
Depression	.61**	.58**	.48**	-.04
FNE		.66**	.70**	-.10
SAD- General			.74**	.10
SAD-New				.02

Note: $^{**}p < .001$

Table 7.6. Percentage of male and female participants who identified within each ethnic group

	Males (*n* = 19) M_{age} = *SD* =	Females (*n* = 20) M_{age} = *SD* =	Total (*N*=39) M_{age} = *SD* =
White Caucasian	73.7	60.0	66.7
Asian	15.8	30.0	23.1
Mixed	5.3	0.0	2.6
Black	5.3	5.0	5.1
Other	0.0	5.0	2.6

Table 7.7. Unbiased hit rates Estimated Marginal Means (SE) for each emotion at each intensity for low and high depression groups[8].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low Depression	30%	0.92 (0.09)	0.39 (0.05)	0.66 (0.09)	0.19 (0.05)	0.36 (0.07)	0.56 (0.09)	0.51 (0.04)
	50%	1.41 (0.09)	1.11 (0.94)	0.94 (0.10)	0.60 (0.09)	0.79 (0.11)	0.81 (0.11)	0.94 (0.07)
	70%	1.54 (0.08)	1.05 (0.11)	1.03 (0.10)	0.85 (0.11)	0.94 (0.12)	0.95 (0.12)	1.06 (0.07)
	Total	1.29 (0.07)	0.85 (0.07)	0.88 (0.08)	0.55 (0.07)	0.70 (0.08)	0.77 (0.08)	0.84 (0.05)
High Depression	30%	0.49 (0.10)	0.25 (0.06)	0.83 (0.10)	0.22 (0.06)	0.45 (0.08)	0.63 (0.10)	0.48 (0.05)
	50%	1.33 (0.10)	0.71 (0.10)	1.05 (0.11)	0.63 (0.10)	0.79 (0.12)	0.86 (0.12)	0.89 (0.07)
	70%	1.27 (0.09)	1.06 (0.12)	1.14 (0.11)	0.93 (0.13)	1.02 (0.14)	0.85 (0.13)	1.05 (0.08)
	Total	1.03 (0.07)	0.67 (0.07)	1.01 (0.08)	0.59 (0.07)	0.75 (0.09)	0.78 (0.09)	0.81 (0.06)

[8] Controlling for SA facets and laterality quotient [actual scores].

Table 7.8. Unbiased hit rates Estimated Marginal Means (SE) for each emotion at each intensity for low and high FNE groups[9].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low FNE	30%	0.67 (0.12)	0.29 (0.06)	0.80 (0.10)	0.23 (0.06)	0.43 (0.08)	0.62 (0.11)	0.51 (0.05)
	50%	1.33 (0.11)	0.86 (0.10)	1.05 (0.12)	0.71 (0.10)	0.76 (0.13)	0.93 (0.13)	0.94 (0.08)
	70%	1.53 (0.10)	1.03 (0.13)	1.11 (0.13)	0.88 (0.14)	0.97 (0.15)	1.07 (0.14)	1.10 (0.09)
	Total	1.18 (0.09)	0.73 (0.08)	0.98 (0.09)	0.61 (0.08)	0.72 (0.10)	0.87 (0.10)	0.85 (0.06)
High FNE	30%	0.77 (0.12)	0.33 (0.06)	0.64 (0.10)	0.20 (0.06)	0.39 (0.08)	0.56 (0.11)	0.48 (0.05)
	50%	1.44 (0.11)	0.96 (0.12)	0.93 (0.12)	0.50 (0.10)	0.81 (0.12)	0.72 (0.12)	0.89 (0.07)
	70%	1.30 (0.10)	1.08 (0.13)	1.01 (0.12)	0.90 (0.13)	0.99 (0.15)	0.80 (0.13)	1.02 (0.08)
	Total	1.17 (0.08)	0.79 (0.08)	0.88 (0.09)	0.53 (0.08)	0.73 (0.09)	0.69 (0.09)	0.80 (0.06)

[9] Controlling for depression, SAD-General, SAD-New and laterality quotient [actual scores].

Table 7.9. Unbiased hit rates Estimated Marginal Means (SE) for each emotion at each intensity for low and high SAD-General groups[10].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low SAD-General	30%	0.69 (0.13)	0.36 (0.07)	0.91 (0.11)	0.24 (0.07)	0.47 (0.09)	0.61 (0.12)	0.55 (0.05)
	50%	1.43 (0.13)	1.07 (0.13)	1.06 (0.13)	0.74 (0.11)	0.91 (0.14)	0.92 (0.14)	1.02 (0.08)
	70%	1.50 (0.11)	1.18 (0.14)	1.28 (0.14)	0.97 (0.15)	1.20 (0.14)	0.99 (0.15)	1.19 (0.10)
	Total	1.21 (0.09)	0.87 (0.09)	1.09 (0.10)	0.65 (0.09)	0.86 (0.11)	0.84 (0.11)	0.92 (0.07)
High SAD-General	30%	0.73 (0.12)	0.28 (0.07)	0.57 (0.10)	0.19 (0.06)	0.34 (0.08)	0.58 (0.11)	0.45 (0.05)
	50%	1.34 (0.11)	0.79 (0.12)	0.95 (0.12)	0.50 (0.10)	0.70 (0.13)	0.76 (0.13)	0.84 (0.08)
	70%	1.34 (0.10)	0.96 (0.13)	0.94 (0.12)	0.83 (0.14)	0.81 (0.15)	0.85 (0.14)	0.96 (0.09)
	Total	1.14 (0.11)	0.67 (0.08)	0.92 (0.09)	0.51 (0.08)	0.62 (0.10)	0.73 (0.10)	0.75 (0.06)

[10] Controlling for depression, FNE, SAD-New and laterality quotient [actual scores].

Table 7.10. Unbiased hit rates Estimated Marginal Means (SE) for each emotion at each intensity for low and high SAD-New groups[11].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low SAD-New	30%	0.80 (0.12)	0.30 (0.07)	0.47 (0.11)	0.14 (0.07)	0.42 (0.08)	0.45 (0.11)	0.44 (0.05)
	50%	1.35 (0.12)	0.94 (0.12)	0.88 (0.13)	0.48 (0.11)	0.69 (0.14)	0.73 (0.13)	0.84 (0.08)
	70%	1.27 (0.10)	0.98 (0.14)	1.03 (0.13)	0.75 (0.14)	0.84 (0.16)	0.86 (0.15)	0.96 (0.09)
	Total	1.14 (0.08)	0.74 (0.08)	0.82 (0.10)	0.45 (0.08)	0.65 (0.10)	0.68 (0.10)	0.75 (0.06)
High SAD-New	30%	0.64 (0.11)	0.35 (0.07)	0.88 (0.10)	0.27 (0.06)	0.38 (0.08)	0.72 (0.10)	0.54 (0.05)
	50%	1.38 (0.11)	0.90 (0.12)	1.10 (0.12)	0.73 (0.11)	0.88 (0.13)	0.92 (0.13)	0.99 (0.08)
	70%	1.54 (0.10)	1.12 (0.13)	1.15 (0.13)	1.02 (0.14)	1.12 (0.15)	0.96 (0.15)	1.15 (0.09)
	Total	1.19 (0.08)	0.79 (0.08)	1.04 (0.09)	0.67 (0.08)	0.80 (0.10)	0.67 (0.10)	0.89 (0.06)

[11] Controlling for depression, FNE, SAD-General and laterality quotient [actual scores].

Table 7.11. Unbiased hit rates Estimated Marginal Means (SE) for each emotion at each intensity for BL and RH laterality groups[12].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Bilateral	30%	0.80 (0.10)	0.34 (0.06)	0.60 (0.08)	0.14 (0.05)	0.34 (0.07)	0.59 (0.09)	0.47 (0.04)
	50%	1.36 (0.09)	1.04 (0.10)	0.94 (0.10)	0.67 (0.09)	0.76 (0.11)	0.96 (0.10)	0.95 (0.06)
	70%	1.44 (0.08)	1.21 (0.10)	0.98 (0.11)	1.01 (0.11)	0.92 (0.12)	1.00 (0.12)	1.09 (0.07)
	Total	1.20 (0.07)	0.86 (0.07)	0.84 (0.08)	0.61 (0.07)	0.67 (0.08)	0.85 (0.08)	0.84 (0.05)
Right- hemisphere	30%	0.66 (0.10)	0.31 (0.06)	0.87 (0.09)	0.27 (0.05)	0.46 (0.07)	0.61 (0.09)	0.53 (0.04)
	50%	1.38 (0.10)	0.82 (0.10)	1.06 (0.10)	0.56 (0.09)	0.84 (0.11)	0.69 (0.11)	0.89 (0.06)
	70%	1.39 (0.09)	0.89 (0.11)	1.20 (0.11)	0.76 (0.12)	1.06 (0.13)	0.81 (0.12)	1.02 (0.07)
	Total	1.14 (0.07)	0.67 (0.07)	1.04 (0.08)	0.53 (0.07)	0.79 (0.08)	0.70 (0.08)	0.81 (0.05)

[12] Controlling for depression and SA facets [actual scores].

Table 7.12. Mean Percentage of Total Fixation Duration (TFD; Standard Errors) examining facial features during FER by emotion, intensity and depression group[13].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low Depression	30%	64.21 (5.70)	64.76 (5.77)	65.86 (6.22)	65.26 (5.40)	66.15 (5.40)	61.77 (5.63)	64.67 (5.31)
	50%	63.26 (5.96)	69.23 (5.67)	62.07 (5.81)	58.71 (5.23)	61.49 (5.62)	63.41 (5.38)	63.03 (4.95)
	70%	64.82 (5.76)	61.84 (5.37)	62.93 (5.55)	60.47 (5.82)	62.85 (5.77)	63.22 (6.16)	62.69 (5.19)
	Total	64.10 (5.51)	65.28 (5.35)	63.62 (5.32)	61.48 (5.05)	63.49 (5.07)	62.80 (5.34)	63.46 (5.09)
High Depression	30%	78.37 (6.71)	75.65 (6.80)	73.99 (7.32)	71.91 (6.36)	75.22 (6.36)	77.11 (6.63)	75.37 (6.25)
	50%	72.34 (7.02)	76.97 (6.68)	71.99 (6.85)	74.88 (6.18)	74.65 (6.43)	80.56 (6.34)	75.23 (5.83)
	70%	76.99 (6.79)	75.45 (6.33)	72.88 (6.53)	76.91 (6.85)	72.22 (6.80)	73.47 (7.26)	74.65 (6.11)
	Total	75.90 (6.49)	76.02 (6.30)	72.95 (6.26)	74.57 (5.95)	74.03 (5.97)	77.05 (6.29)	75.09 (5.99)

[13] Controlling for SA facets and laterality quotient [actual scores].

Table 7.13. Mean Percentage of Total Fixation Duration (TFD; Standard Errors) examining the eyes during FER by emotion, intensity and depression group[14].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low Depression	30%	22.03 (4.45)	24.32 (4.34)	25.40 (5.02)	26.81 (4.56)	25.27 (4.43)	26.84 (4.45)	25.11 (4.21)
	50%	25.06 (5.09)	27.95 (4.33)	19.74 (3.59)	27.16 (4.47)	23.18 (4.28)	24.54 (4.34)	24.61 (3.96)
	70%	23.81 (5.46)	23.20 (3.83)	22.08 (4.39)	24.62 (4.49)	23.09 (4.52)	20.27 (4.09)	22.85 (4.02)
	Total	23.64 (4.75)	25.16 (3.97)	22.41 (3.95)	26.20 (4.22)	23.85 (4.17)	23.88 (4.00)	24.19 (4.00)
High Depression	30%	24.46 (5.24)	20.73 (5.11)	21.49 (5.92)	24.82 (5.36)	23.06 (5.22)	23.75 (5.24)	23.05 (4.960
	50%	20.07 (5.99)	22.62 (5.10)	22.90 (4.23)	26.21 (5.27)	21.97 (5.04)	18.67 (5.11)	22.07 (4.66)
	70%	19.73 (6.43)	23.33 (4.51)	19.80 (5.17)	24.74 (5.27)	23.55 (5.32)	17.14 (4.82)	21.34 (4.74)
	Total	21.42 (5.59)	22.23 (4.67)	21.40 (4.65)	25.26 (4.96)	22.86 (4.92)	19.89 (4.71)	22.17 (4.72)

[14] Controlling for SA facets and laterality quotient [actual scores].

Table 7.14. Mean Percentage of Total Fixation Duration (TFD; Standard Errors) examining facial features during FER by emotion, intensity and FNE group[15].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low FNE	30%	70.04 (7.51)	70.01 (7.52)	71.87 (7.99)	66.28 (7.04)	68.18 (6.96)	67.83 (7.41)	69.03 (6.91)
	50%	64.74 (7.71)	73.02 (7.35)	66.02 (7.60)	65.33 (7.04)	68.56 (7.12)	71.67 (7.16)	68.22 (6.49)
	70%	74.53 (7.56)	70.47 (6.97)	65.35 (7.18)	68.99 (7.64)	69.28 (7.46)	68.60 (7.82)	69.54 (6.76)
	Total	69.77 (7.15)	71.16 (6.96)	67.75 (6.92)	66.87 (6.67)	68.67 (6.59)	69.36 (6.93)	68.93 (6.64)
High FNE	30%	71.10 (6.62)	68.77 (6.62)	68.15 (7.04)	69.40 (6.20)	71.90 (6.13)	70.01 (6.53)	69.89 (6.09)
	50%	69.18 (6.80)	72.07 (6.47)	66.15 (6.70)	66.81 (6.21)	67.37 (6.28)	70.86 (6.31)	68.74 (5.72)
	70%	67.44 (6.66)	66.47 (6.66)	69.45 (6.33)	64.97 (6.74)	64.62 (6.58)	69.38 (6.89)	67.05 (5.95)
	Total	69.24 (6.30)	69.10 (6.13)	67.92 (6.10)	67.06 (5.87)	67.96 (5.80)	70.08 (6.11)	68.56 (5.83)

[15] Controlling for depression, SAD-General, SAD-New and laterality quotient [actual scores].

Table 7.15. Mean Percentage of Total Fixation Duration (TFD; Standard Errors) examining the eyes during FER by emotion, intensity and FNE group[16].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low FNE	30%	27.45 (5.61)	26.76 (5.50)	28.76 (6.47)	31.82 (5.91)	27.87 (5.66)	27.35 (5.89)	28.34 (5.44)
	50%	27.72 (6.56)	32.07 (5.67)	28.61 (4.73)	30.39 (5.83)	28.35 (5.58)	25.71 (5.58)	28.81 (5.13)
	70%	32.15 (6.82)	30.76 (4.83)	26.97 (5.57)	30.32 (5.80)	31.75 (5.61)	23.23 (5.36)	29.20 (5.14)
	Total	29.10 (6.00)	29.86 (5.09)	29.11 (5.07)	30.84 (5.53)	29.32 (5.34)	25.43 (5.22)	28.78 (5.17)
High FNE	30%	20.15 (4.94)	18.58 (4.84)	19.63 (5.70)	20.34 (5.21)	20.64 (4.99)	23.82 (5.19)	20.54 (4.80)
	50%	19.82 (5.78)	20.04 (5.00)	15.03 (4.17)	24.36 (5.14)	18.05 (4.91)	18.65 (4.91)	19.32 (4.52)
	70%	14.60 (6.00)	18.13 (4.25)	15.32 (4.91)	19.02 (5.11)	15.15 (4.94)	15.24 (4.72)	16.24 (4.53)
	Total	18.19 (5.29)	18.92 (4.49)	16.66 (4.47)	21.26 (4.87)	17.95 (4.70)	19.24 (4.60)	18.70 (4.55)

[16] Controlling for depression, SAD-General, SAD-New and laterality quotient [actual scores].

Table 7.16. Mean Percentage of Total Fixation Duration (TFD; Standard Errors) examining facial features during FER by emotion, intensity and SAD-General group[17].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low SAD-General	30%	66.81 (7.91)	64.53 (7.89)	63.69 (8.46)	65.55 (7.43)	63.35 (7.20)	63.86 (7.78)	64.63 (7.25)
	50%	64.06 (8.11)	64.09 (7.64)	56.40 (7.70)	62.51 (7.36)	62.16 (7.43)	66.67 (7.49)	62.65 (6.77)
	70%	64.72 (7.81)	60.35 (7.24)	60.09 (7.49)	61.18 (7.94)	58.67 (7.64)	65.65 (8.17)	61.78 (7.01)
	Total	65.20 (7.55)	62.99 (7.52)	60.06 (7.19)	63.08 (6.98)	61.39 (6.77)	65.39 (7.28)	63.02 (6.93)
High SAD-General	30%	73.33 (6.68)	73.24 (6.66)	74.69 (7.14)	69.75 (6.28)	75.86 (6.08)	72.62 (6.57)	73.25 (6.12)
	50%	69.00 (6.85)	78.44 (6.45)	72.97 (6.50)	69.24 (6.22)	72.05 (6.28)	74.63 (6.33)	72.71 (5.71)
	70%	74.53 (6.60)	74.09 (6.11)	72.66 (6.32)	72.09 (6.71)	73.20 (6.46)	71.43 (6.90)	73.00 (5.92)
	Total	72.29 (6.38)	75.26 (6.12)	73.41 (6.07)	70.36 (5.90)	73.70 (5.72)	72.89 (6.15)	72.99 (5.85)

[17] Controlling for depression, FNE, SAD-New and laterality quotient [actual scores].

Table 7.17. Mean Percentage of Total Fixation Duration (TFD; Standard Errors) examining the eyes during FER by emotion, intensity and SAD-General group[18].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low SAD- General	30%	20.96 (5.76)	20.97 (5.71)	21.21 (6.90)	25.82 (6.08)	20.10 (5.86)	20.64 (6.03)	21.62 (5.62)
	50%	23.55 (6.93)	20.43 (5.79)	17.07 (4.82)	20.82 (5.97)	24.67 (5.86)	21.49 (5.71)	21.34 (5.30)
	70%	18.72 (7.31)	17.43 (5.04)	19.04 (5.84)	18.85 (5.91)	25.19 (5.96)	17.49 (5.51)	19.45 (5.33)
	Total	21.08 (6.30)	19.61 (5.23)	19.11 (5.30)	21.83 (5.63)	23.32 (5.59)	19.87 (5.37)	20.80 (5.33)
High SAD-General	30%	23.81 (4.86)	22.70 (4.83)	25.32 (5.82)	25.28 (5.14)	26.53 (4.95)	28.76 (5.09)	25.40 (4.74)
	50%	21.42 (5.85)	27.95 (4.89)	23.84 (4.07)	30.77 (5.04)	20.94 (4.95)	20.79 (4.82)	24.29 (4.48)
	70%	23.55 (6.17)	27.38 (4.26)	21.60 (4.93)	28.53 (4.99)	20.31 (5.03)	19.49 (4.65)	23.48 (4.50)
	Total	22.93 (5.32)	26.01 (4.42)	23.59 (4.47)	28.19 (4.75)	22.61 (4.72)	23.02 (4.53)	24.39 (4.50)

[18] Controlling for depression, FNE, SAD-New and laterality quotient [actual scores].

Table 7.18. Mean Percentage of Total Fixation Duration (TFD; Standard Errors) examining facial features during FER by emotion, intensity and SAD-New group[19].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low SAD-New	30%	69.46 (7.65)	68.36 (7.72)	74.57 (8.37)	69.38 (7.19)	70.63 (7.27)	67.65 (7.60)	70.01 (7.15)
	50%	63.97 (7.96)	74.45 (7.57)	69.47 (7.71)	63.18 (7.14)	64.99 (7.03)	70.13 (7.20)	67.70 (6.65)
	70%	65.36 (7.57)	65.24 (7.15)	68.90 (7.56)	61.65 (7.66)	66.33 (7.66)	63.44 (8.11)	65.15 (6.88)
	Total	66.26 (7.28)	69.35 (7.17)	70.98 (7.18)	64.74 (6.79)	67.32 (6.74)	67.07 (7.10)	67.62 (6.82)
High SAD-New	30%	71.36 (6.88)	70.31 (6.94)	65.37 (7.52)	66.70 (6.46)	70.11 (6.53)	69.57 (6.83)	68.90 (6.43)
	50%	69.14 (7.16)	70.98 (6.80)	63.75 (6.93)	68.73 (6.41)	70.34 (6.32)	72.13 (6.47)	69.18 (5.97)
	70%	74.31 (6.80)	70.31 (6.42)	66.15 (6.79)	72.32 (6.59)	67.06 (6.88)	71.73 (6.89)	70.31 (6.19)
	Total	71.60 (6.54)	70.54 (6.44)	65.09 (6.45)	69.25 (6.11)	69.17 (6.10)	71.14 (6.38)	69.47 (6.13)

[19] Controlling for depression, FNE, SAD-General and laterality quotient [actual scores].

Table 7.19. Mean Percentage of Total Fixation Duration (TFD; Standard Errors) examining the eyes during FER by emotion, intensity and SAD-New group[20].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low SAD- New	30%	26.92 (5.54)	21.84 (5.68)	28.95 (6.46)	24.86 (5.89)	24.95 (5.75)	27.43 (5.83)	25.82 (5.46)
	50%	23.13 (6.70)	30.32 (5.68)	22.38 (4.64)	27.35 (5.82)	23.00 (5.72)	26.52 (5.67)	25.45 (5.20)
	70%	23.24 (7.06)	26.06 (4.90)	21.22 (5.76)	23.34 (5.80)	21.84 (6.00)	17.57 (5.51)	22.21 (5.26)
	Total	24.43 (6.11)	26.07 (5.17)	24.18 (5.11)	25.18 (5.50)	23.26 (5.50)	23.84 (5.28)	24.50 (5.23)
High SAD-New	30%	19.56 (4.98)	23.19 (5.10)	19.25 (5.81)	26.43 (5.29)	23.91 (5.17)	23.83 (5.24)	22.69 (4.90)
	50%	22.43 (6.02)	21.36 (5.11)	20.62 (4.17)	26.74 (5.23)	22.56 (5.14)	17.69 (5.10)	21.90 (4.67)
	70%	20.63 (6.35)	20.98 (4.41)	20.86 (5.18)	25.82 (5.21)	24.40 (5.40)	19.87 (4.95)	22.09 (4.72)
	Total	20.87 (5.49)	21.84 (4.65)	20.24 (4.60)	26.33 (4.94)	23.62 (4.94)	20.46 (4.75)	22.23 (4.70)

[20] Controlling for depression, FNE, SAD-General and laterality quotient [actual scores].

Table 7.20. Mean Percentage of Total Fixation Duration (TFD; Standard Errors) examining facial features during FER by emotion, intensity and laterality group[21].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Bilateral	30%	66.71 (5.86)	67.00 (5.90)	66.89 (6.31)	62.81 (5.33)	64.23 (5.33)	65.02 (5.77)	65.44 (5.37)
	50%	61.90 (5.91)	68.23 (5.69)	63.69 (5.94)	63.37 (5.52)	62.80 (5.51)	67.68 (5.60)	64.61 (5.04)
	70%	64.36 (5.73)	63.97 (5.47)	60.97 (5.34)	65.25 (5.92)	63.45 (5.79)	61.63 (6.18)	63.27 (5.18)
	Total	64.32 (5.53)	66.40 (5.42)	63.85 (5.37)	63.81 (5.16)	63.49 (5.05)	64.78 (5.43)	64.44 (5.14)
Right-hemisphere	30%	73.83 (5.70)	71.72 (5.74)	71.81 (6.14)	73.23 (5.22)	75.49 (5.18)	71.61 (5.62)	72.95 (5.23)
	50%	72.18 (5.75)	76.72 (5.53)	69.15 (5.78)	67.97 (5.38)	71.18 (5.37)	73.69 (5.45)	71.81 (4.91)
	70%	75.48 (5.58)	71.09 (5.32)	72.98 (5.19)	69.52 (5.76)	70.22 (5.63)	73.16 (6.01)	72.08 (5.04)
	Total	73.83 (5.38)	73.18 (5.27)	71.31 (5.23)	70.24 (5.02)	72.30 (4.92)	72.82 (5.28)	72.28 (5.00)

[21] Controlling for depression and SA facets [actual scores].

Table 7.21. Mean Percentage of Total Fixation Duration (TFD; Standard Errors) examining the eyes during FER by emotion, intensity and laterality group[22].

		Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Bilateral	30%	25.10 (4.61)	24.19 (4.56)	25.81 (5.19)	26.09 (4.65)	23.92 (4.51)	25.81 (4.65)	25.15 (4.38)
	50%	21.82 (5.26)	26.65 (4.56)	23.01 (3.77)	26.91 (4.58)	25.72 (4.44)	24.62 (4.54)	24.79 (4.14)
	70%	22.02 (5.53)	22.95 (3.85)	21.59 (4.48)	25.70 (4.65)	24.50 (4.64)	20.20 (4.33)	22.83 (4.14)
	Total	22.98 (4.86)	24.60 (4.11)	23.47 (4.09)	26.24 (4.37)	24.71 (4.32)	23.54 (4.22)	24.26 (4.16)
Right-hemisphere	30%	21.23 (4.49)	21.50 (4.43)	21.84 (5.05)	25.92 (4.52)	24.81 (4.39)	25.36 (4.52)	23.44 (4.26)
	50%	24.11 (5.11)	24.95 (4.44)	19.36 (3.67)	26.80 (4.46)	19.79 (4.32)	19.70 (4.42)	22.45 (4.03)
	70%	22.04 (5.38)	23.57 (3.74)	20.59 (4.35)	23.77 (4.53)	22.42 (4.51)	17.88 (4.21)	21.71 (4.03)
	Total	22.46 (4.73)	23.34 (4.00)	20.60 (3.98)	25.49 (4.25)	22.34 (4.21)	20.98 (4.11)	22.53 (4.05)

[22] Controlling for depression and SA facets [actual scores].

7.6 Appendix 6. Descriptive Statistics for Study 5

Table 7.22. Relationships between social-emotional factors and laterality quotient (N = 71)

	FNE	Sad-General	SAD-New	Laterality Quotient
Depression	.54**	.55**	.46**	.03
FNE		.55**	.53**	-.09
SAD- General			.74**	<.01
SAD-New				.02

Note: $^{**}p < .001$

Table 7.23. Percentage of male and female in each age group who identified within each ethnic group (N = 71).

	Early-mid adolescents (*n* = 35) M_{age} = 14.06 *SD* = 2.06			**Late-adolescents adults (*n* = 36)** M_{age} = 19.28 *SD* = 1.68			**Total**
	Males (*n* = 18)	Females (*n* = 17)	*Total*	Males (*n* = 10)	Females (*n* = 26)	*Total*	
White Caucasian	88.9	88.2	88.6	80	65.4	69.4	78.9
Asian	0.0	5.9	2.9	20	15.4	16.7	9.9
Mixed	5.6	0.0	2.9	0.0	11.5	8.3	5.6
Other	0.0	5.9	2.9	0.0	3.8	2.8	2.8
Missing	5.6	0.0	2.9	0.0	3.8	2.8	2.8

Table 7.24. Mean (SE) unbiased hit rates for each emotion at each exposure time, by age and depression group[23].

			Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low Depression	Adolescents	500ms	0.99 (0.09)	0.45 (0.09)	1.06 (0.11)	0.35 (0.08)	0.54 (0.08)	0.62 (0.10)	0.67 (0.06)
		3000ms	0.99 (0.09)	0.44 (0.09)	0.76 (0.09)	0.36 (0.06)	0.47 (0.09)	0.71 (0.09)	0.62 (0.05)
		10,000ms	1.10 (0.09)	0.54 (0.09)	1.11 (0.10)	0.35 (0.06)	0.74 (0.08)	0.81 (0.09)	0.77 (0.05)
		Total	1.02 (0.07)	0.48 (0.07)	0.98 (0.08)	0.35 (0.05)	0.58 (0.07)	0.71 (0.07)	0.69 (0.04)
	Adults	500ms	1.28 (0.11)	0.82 (0.12)	0.96 (0.14)	0.48 (0.11)	0.65 (0.10)	0.94 (0.13)	0.85 (0.07)
		3000ms	1.25 (0.11)	0.73 (0.11)	1.29 (0.11)	0.68 (0.07)	0.89 (0.11)	0.92 (0.12)	0.96 (0.06)
		10,000ms	1.26 (0.12)	0.67 (0.11)	1.28 (0.13)	0.44 (0.08)	0.97 (0.10)	0.90 (0.12)	0.92 (0.06)
		Total	1.26 (0.08)	0.74 (0.09)	1.17 (0.10)	0.53 (0.06)	0.83 (0.09)	0.92 (0.10)	0.91 (0.05)
	Overall	500ms	1.13 (0.07)	0.63 (0.08)	1.01 (0.09)	0.41 (0.07)	0.59 (0.07)	0.78 (0.09)	0.76 (0.05)
		3000ms	1.12 (0.07)	0.58 (0.07)	1.02 (0.07)	0.52 (0.05)	0.68 (0.07)	0.82 (0.08)	0.79 (0.04)
		10,000ms	1.18 (0.08)	0.61 (0.08)	1.19 (0.08)	0.40 (0.05)	0.85 (0.07)	0.86 (0.08)	0.85 (0.04)
		Total	1.14 (0.06)	0.61 (0.06)	1.07 (0.06)	0.44 (0.04)	0.71 (0.06)	0.82 (0.06)	0.80 (0.03)
High Depression	Adolescents	500ms	1.17 (0.11)	0.62 (0.13)	0.97 (0.14)	0.36 (0.11)	0.56 (0.11)	0.65 (0.14)	0.72 (0.07)
		3000ms	1.34 (0.12)	0.81 (0.11)	1.07 (0.12)	0.35 (0.08)	0.63 (0.12)	0.85 (0.12)	0.84 (0.06)
		10,000ms	1.21 (0.12)	0.64 (0.12)	0.92 (0.14)	0.43 (0.11)	0.44 (0.11)	0.73 (0.12)	0.73 (0.07)
		Total	1.24 (0.09)	0.69 (0.10)	0.98 (0.10)	0.38 (0.07)	0.54 (0.09)	0.74 (0.10)	0.76 (0.06)
	Adults	500ms	1.18 (0.08)	0.74 (0.09)	0.95 (0.10)	0.46 (0.07)	0.62 (0.07)	0.85 (0.10)	0.80 (0.05)
		3000ms	1.30 (0.08)	0.72 (0.08)	1.15 (0.08)	0.53 (0.05)	0.67 (0.08)	0.77 (0.08)	0.86 (0.04)
		10,000ms	1.22 (0.08)	0.81 (0.08)	0.94 (0.09)	0.53 (0.06)	0.62 (0.07)	0.82 (0.08)	0.83 (0.05)
		Total	1.25 (0.06)	0.76 (0.07)	1.01 (0.07)	0.51 (0.04)	0.63 (0.06)	0.82 (0.07)	0.83 (0.04)
	Overall	500ms	1.17 (0.07)	0.68 (0.08)	0.96 (0.09)	0.41 (0.07)	0.59 (0.07)	0.75 (0.09)	0.76 (0.05)
		3000ms	1.32 (0.7)	0.76 (0.07)	1.11 (0.07)	0.44 (0.05)	0.65 (0.07)	0.81 (0.08)	0.85 (0.04)
		10,000ms	1.21 (0.08)	0.73 (0.08)	0.93 (0.09)	0.48 (0.05)	0.53 (0.07)	0.78 (0.08)	0.78 (0.04)
		Total	1.24 (0.06)	0.72 (0.06)	1.00 (0.06)	0.44 (0.04)	0.59 (0.06)	0.78 (0.06)	0.80 (0.03)

[23] Controlling for SA facets and laterality quotient [actual scores].

Table 7.25. Mean (SE) unbiased hit rates for each emotion at each exposure time, by age and FNE group[24].

			Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Low FNE	Adolescents	500ms	1.08 (0.08)	0.62 (0.09)	1.15 (0.10)	0.32 (0.07)	0.65 (0.08)	0.69 (0.10)	0.75 (0.05)
		3000ms	1.13 (0.08)	0.70 (0.08)	0.93 (0.09)	0.42 (0.06)	0.57 (0.90)	0.84 (0.08)	0.76 (0.05)
		10,000ms	1.05 (0.09)	0.67 (0.08)	0.95 (0.10)	0.37 (0.06)	0.67 (0.08)	0.93 (0.09)	0.76 (0.05)
		Total	1.09 (0.06)	0.66 (0.07)	1.01 (0.08)	0.37 (0.05)	0.63 (0.07)	0.78 (0.07)	0.76 (0.40)
	Adults	500ms	1.29 (0.09)	0.80 (0.11)	0.98 (0.12)	0.54 (0.09)	0.64 (0.09)	0.97 (0.12)	0.87 (0.06)
		3000ms	1.32 (0.10)	0.71 (0.09)	1.20 (0.11)	0.58 (0.07)	0.76 (0.11)	0.97 (0.10)	0.92 (0.06)
		10,000ms	1.22 (0.10)	0.79 (0.10)	1.16 (0.12)	0.56 (0.07)	0.82 (0.09)	0.93 (0.10)	0.91 (0.06)
		Total	1.24 (0.07)	0.76 (0.08)	0.93 (0.10)	0.56 (0.05)	0.74 (0.08)	0.96 (0.08)	0.90 (0.05)
	Overall	500ms	1.18 (0.06)	0.71 (0.08)	1.06 (0.08)	0.43 (0.06)	0.65 (0.06)	0.83 (0.08)	0.81 (0.04)
		3000ms	1.23 (0.07)	0.70 (0.06)	1.06 (0.08)	0.50 (0.05)	0.66 (0.07)	0.90 (0.07)	0.84 (0.04)
		10,000ms	1.13 (0.07)	0.73 (0.07)	1.06 (0.08)	0.47 (0.05)	0.74 (0.06)	0.88 (0.07)	0.83 (0.04)
		Total	1.18 (0.05)	0.71 (0.05)	1.06 (0.06)	0.47 (0.04)	0.68 (0.05)	0.87 (0.06)	0.83 (0.03)
High FNE	Adolescents	500ms	1.06 (0.10)	0.55 (0.12)	0.90 (0.13)	0.43 (0.10)	0.20 (0.10)	0.65 (0.13)	0.68 (0.07)
		3000ms	1.18 (0.11)	0.57 (0.10)	0.87 (0.12)	0.32 (0.07)	0.52 (0.12)	0.74 (0.11)	0.70 (0.06)
		10,000ms	1.24 (0.11)	0.57 (0.11)	1.03 (0.13)	0.41 (0.07)	0.55 (0.10)	0.76 (0.12)	0.76 (0.06)
		Total	1.16 (0.08)	0.56 (0.09)	0.93 (0.10)	0.39 (0.06)	0.52 (0.09)	0.72 (0.09)	0.71 (0.05)
	Adults	500ms	1.17 (0.09)	0.71 (0.10)	0.90 (0.11)	0.41 (0.08)	0.60 (0.08)	0.80 (0.11)	0.77 (0.06)
		3000ms	1.21 (0.09)	0.65 (0.09)	1.08 (0.10)	0.56 (0.06)	0.68 (0.10)	0.71 (0.09)	0.81 (0.05)
		10,000ms	1.34 (0.09)	0.69 (0.09)	1.00 (0.11)	0.42 (0.06)	0.71 (0.09)	0.76 (0.10)	0.82 (0.05)
		Total	1.24 (0.07)	0.68 (0.07)	0.99 (0.08)	0.46 (0.05)	0.66 (0.07)	0.76 (0.07)	0.80 (0.04)
	Overall	500ms	1.11 (0.07)	0.63 (0.08)	0.90 (0.09)	0.42 (0.07)	0.55 (0.07)	0.73 (0.09)	0.72 (0.05)
		3000ms	1.19 (0.07)	0.61 (0.07)	0.97 (0.08)	0.44 (0.05)	0.60 (0.08)	0.73 (0.07)	0.76 (0.04)
		10,000ms	1.29 (0.08)	0.63 (0.07)	1.02 (0.09)	0.42 (0.05)	0.63 (0.07)	0.76 (0.08)	0.79 (0.04)
		Total	1.20 (0.05)	0.62 (0.06)	0.96 (0.07)	0.42 (0.04)	0.59 (0.06)	0.74 (0.06)	0.76 (0.04)

[24] Controlling for depression, SAD-General, SAD-New and laterality quotient [actual scores].

Table 7.26. Mean (SE) unbiased hit rates for each emotion at each exposure time, by age and SAD- General group[25].

			Happy	**Sad**	**Surprised**	**Anger**	**Fear**	**Disgust**	***Total***
Low SAD-General	Adolescents	500ms	0.95 (0.08)	0.41 (0.11)	1.13 (0.12)	0.27 (0.09)	0.51 (0.09)	0.58 (0.11)	0.64 (0.06)
		3000ms	1.09 (0.09)	0.64 (0.09)	0.93 (0.11)	0.30 (0.06)	0.51 (0.10)	0.68 (0.10)	0.69 (0.06)
		10,000ms	1.03 (0.10)	0.53 (0.10)	0.97 (0.11)	0.30 (0.07)	0.48 (0.09)	0.70 (0.10)	0.67 (0.05)
		Total	1.02 (0.07)	0.52 (0.08)	1.01 (0.09)	0.30 (0.05)	0.50 (0.08)	0.65 (0.08)	0.67 (0.05)
	Adults	500ms	1.34 (0.10)	0.67 (0.12)	0.92 (0.13)	0.37 (0.10)	0.52 (0.10)	0.81 (0.13)	0.77 (0.07)
		3000ms	1.29 (0.11)	0.73 (0.11)	1.24 (0.12)	0.43 (0.07)	0.83 (0.11)	0.82 (0.11)	0.89 (0.06)
		10,000ms	1.37 (0.11)	0.67 (0.11)	1.01 (0.13)	0.35 (0.07)	0.70 (0.10)	0.78 (0.12)	0.81 (0.06)
		Total	1.33 (0.07)	0.69 (0.09)	1.06 (0.10)	0.38 (0.06)	0.68 (0.09)	0.80 (0.09)	0.82 (0.05)
	Overall	500ms	1.15 (0.07)	0.54 (0.09)	1.02 (0.10)	0.32 (0.07)	0.51 (0.07)	0.70 (0.09)	0.71 (0.05)
		3000ms	1.19 (0.08)	0.68 (0.08)	1.09 (0.09)	0.36 (0.05)	0.67 (0.08)	0.75 (0.08)	0.79 (0.05)
		10,000ms	1.20 (0.08)	0.60 (0.08)	0.99 (0.09)	0.32 (0.05)	0.59 (0.07)	0.74 (0.08)	0.74 (0.04)
		Total	1.18 (0.05)	0.61 (0.06)	1.03 (0.07)	0.33 (0.04)	0.59 (0.06)	0.73 (0.07)	0.75 (0.04)
High SAD-General	Adolescents	500ms	1.13 (0.09)	0.78 (0.11)	0.98 (0.12)	0.49 (0.09)	0.71 (0.09)	0.78 (0.12)	0.81 (0.06)
		3000ms	1.15 (0.10)	0.58 (0.10)	0.84 (0.11)	0.45 (0.06)	0.61 (0.11)	0.85 (0.10)	0.75 (0.06)
		10,000ms	1.23 (0.10)	0.66 (0.10)	0.91 (0.11)	0.45 (0.07)	0.80 (0.09)	0.91 (0.11)	0.85 (0.06)
		Total	1.17 (0.07)	0.67 (0.08)	0.95 (0.09)	0.46 (0.05)	0.71 (0.08)	0.85 (0.09)	0.80 (0.05)
	Adults	500ms	1.15 (0.07)	0.82 (0.09)	0.94 (0.11)	0.52 (0.08)	0.68 (0.08)	0.92 (0.10)	0.84 (0.05)
		3000ms	1.21 (0.08)	0.67 (0.08)	1.08 (0.10)	0.67 (0.06)	0.65 (0.09)	0.81 (0.09)	0.85 (0.05)
		10,000ms	1.20 (0.09)	0.80 (0.09)	1.08 (0.10)	0.57 (0.06)	0.80 (0.08)	0.86 (0.09)	0.89 (0.05)
		Total	1.19 (0.06)	0.76 (0.07)	1.03 (0.08)	0.59 (0.04)	0.71 (0.07)	0.87 (0.07)	0.86 (0.04)
	Overall	500ms	1.14 (0.06)	0.80 (0.08)	0.96 (0.09)	0.50 (0.06)	0.69 (0.06)	0.85 (0.08)	0.82 (0.04)
		3000ms	1.18 (0.07)	0.63 (0.07)	0.96 (0.08)	0.56 (0.07)	0.63 (0.07)	0.83 (0.07)	0.80 (0.04)
		10,000ms	1.22 (0.07)	0.73 (0.07)	1.05 (0.08)	0.51 (0.05)	0.80 (0.06)	0.89 (0.07)	0.87 (0.04)
		Total	1.18 (0.05)	0.72 (0.06)	0.99 (0.06)	0.52 (0.04)	0.71 (0.06)	0.86 (0.06)	0.83 (0.03)

[25] Controlling for depression, FNE, SAD-New and laterality quotient [actual scores].

Table 7.27. Mean (SE) unbiased hit rates for each emotion at each exposure time, by age and SAD- New group[26].

			Happy	Sad	Surprised	Anger	Fear	Disgust	***Total***
Low SAD-New	Adolescents	500ms	1.00 (0.09)	0.56 (0.10)	1.16 (0.11)	0.37 (0.09)	0.64 (0.09)	0.63 (0.09)	0.73 (0.06)
		3000ms	1.17 (0.09)	0.62 (0.09)	0.97 (0.10)	0.41 (0.06)	0.55 (0.10)	0.69 (0.10)	0.73 (0.06)
		10,000ms	1.05 (0.09)	0.73 (0.10)	0.98 (0.11)	0.48 (0.07)	0.62 (0.09)	0.87 (0.10)	0.79 (0.06)
		Total	1.07 (0.07)	0.64 (0.08)	1.04 (0.09)	0.42 (0.05)	0.60 (0.08)	0.73 (0.08)	0.75 (0.05)
	Adults	500ms	1.18 (0.09)	0.98 (0.11)	0.97 (0.12)	0.50 (0.09)	0.65 (0.09)	0.81 (0.12)	0.85 (0.07)
		3000ms	1.26 (0.10)	0.70 (0.98)	1.15 (0.11)	0.63 (0.07)	0.85 (0.11)	0.84 (0.11)	0.90 (0.06)
		10,000ms	1.44 (0.10)	0.86 (0.10)	1.04 (0.12)	0.83 (0.07)	0.76 (0.10)	0.81 (0.11)	0.90 (0.06)
		Total	1.29 (0.07)	0.85 (0.08)	1.05 (0.09)	0.55 (0.06)	0.75 (0.08)	0.82 (0.09)	0.89 (0.05)
	Overall	500ms	1.09 (0.07)	0.77 (0.08)	1.06 (0.09)	0.44 (0.06)	0.65 (0.07)	0.72 (0.08)	0.79 (0.05)
		3000ms	1.21 (0.07)	0.66 (0.07)	1.06 (0.08)	0.52 (0.05)	0.70 (0.07)	0.76 (0.07)	0.82 (0.04)
		10,000ms	1.24 (0.07)	0.79 (0.07)	1.01 (0.08)	0.50 (0.51)	0.69 (0.07)	0.84 (0.08)	0.85 (0.04)
		Total	1.18 (0.05)	0.74 (0.06)	1.04 (0.06)	0.49 (0.04)	0.68 (0.06)	0.77 90.06)	0.82 (0.01)
High SAD-New	Adolescents	500ms	1.10 (0.09)	0.58 (0.10)	0.95 (0.11)	0.35 90.09)	0.55 (0.09)	0.71 (0.11)	0.71 (0.06)
		3000ms	1.11 (0.09)	0.57 (0.09)	0.81 (0.10)	0.31 (0.06)	0.54 (0.10)	0.83 (0.10)	0.70 (0.05)
		10,000ms	1.24 (0.09)	0.46 (0.10)	1.01 (0.11)	0.29 (0.07)	0.65 (0.91)	0.78 (0.10)	0.74 (0.06)
		Total	1.15 (0.07)	0.54 (0.08)	0.92 (0.09)	0.32 (0.05)	0.58 (0.08)	0.77 (0.08)	0.71 (0.05)
	Adults	500ms	1.11 (0.12)	0.61 (0.14)	0.93 (0.16)	0.40 (0.12)	0.60 (0.12)	0.95 (0.15)	0.77 (0.08)
		3000ms	1.15 (0.13)	0.74 (0.13)	1.02 (0.14)	0.61 (0.08)	0.58 (0.14)	0.89 (0.14)	0.83 (0.08)
		10,000ms	1.01 (0.13)	0.82 (0.13)	1.02 (0.15)	0.46 (0.09)	0.76 (0.13)	0.84 (0.14)	0.82 (0.08)
		Total	1.09 (0.09)	0.72 (0.11)	0.99 (0.12)	0.49 (0.07)	0.65 (0.11)	0.89 (0.11)	0.81 (0.06)
	Overall	500ms	1.10 (0.08)	0.60 (0.09)	0.94 (0.10)	0.37 (0.08)	0.58 (0.08)	0.83 (0.10)	0.74 (0.05)
		3000ms	1.13 (0.08)	0.65 (0.08)	0.91 (0.09)	0.46 (0.05)	0.56 (0.09)	0.86 (0.09)	0.76 (0.05)
		10,000ms	1.13 (0.08)	0.64 (0.09)	1.02 (0.10)	0.37 (0.06)	0.71 (0.08)	0.81 (0.09)	0.78 (0.05)
		Total	1.12 (0.06)	0.63 (0.07)	0.96 (0.08)	0.40 (0.05)	0.62 (0.07)	0.83 (0.07)	0.76 (0.04)

[26] Controlling for depression, FNE, SAD-General and laterality quotient [actual scores].

Table 7.28. Mean (SE) unbiased hit rates for each emotion at each exposure time, by age and laterality group[27].

			Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Bilateral	Adolescents	500ms	1.03 (0.08)	0.66 (0.10)	1.00 (0.10)	0.26 (0.08)	0.61 (0.07)	0.60 (0.10)	0.69 (0.05)
		3000ms	1.09 (0.09)	0.62 (0.08)	1.02 (0.09)	0.30 (0.06)	0.51 (0.08)	0.66 (0.09)	0.70 (0.05)
		10,000ms	1.10 (0.09)	0.57 (0.09)	1.05 (0.10)	0.36 (0.06)	0.56 (0.08)	0.82 (0.09)	0.75 (0.05)
		Total	1.08 (0.07)	0.62 (0.07)	1.02 (0.08)	0.31 (0.05)	0.56 (0.06)	0.69 (0.07)	0.71 (0.04)
	Adults	500ms	1.27 (0.10)	0.78 (0.12)	1.00 (0.12)	0.56 (0.09)	0.61 (0.09)	1.00 (0.12)	0.87 (0.06)
		3000ms	1.25 (0.10)	0.78 (0.10)	1.07 (0.10)	0.66 (0.06)	0.61 (0.09)	0.91 (0.10)	0.88 (0.06)
		10,000ms	1.28 (0.11)	0.79 (0.10)	1.10 (0.11)	0.51 (0.07)	0.76 (0.09)	0.90 (0.11)	0.89 (0.06)
		Total	1.27 (0.08)	0.78 (0.08)	1.06 (0.09)	0.57 (0.05)	0.66 (0.07)	0.93 (0.08)	0.88 90.05)
	Overall	500ms	1.15 (0.06)	0.72 (0.08)	1.00 (0.08)	0.41 (0.06)	0.61 (0.06)	0.80 (0.08)	0.75 (0.04)
		3000ms	1.17 (0.07)	0.70 (0.06)	1.04 (0.07)	0.48 (0.04)	0.56 (0.06)	0.79 (0.07)	0.79 (0.04)
		10,000ms	1.20 (0.07)	0.68 (0.06)	1.07 (0.07)	0.44 (0.05)	0.66 (0.06)	0.86 (0.07)	0.82 (0.04)
		Total	1.17 (0.05)	0.70 (0.05)	1.04 (0.06)	0.44 (0.03)	0.61 (0.04)	0.81 (0.06)	0.80 (0.03)
Right-hemisphere	Adolescents	500ms	1.04 (0.09)	0.61 (0.11)	1.18 (0.11)	0.50 (0.08)	0.78 (0.08)	0.75 (0.11)	0.81 (0.06)
		3000ms	1.14 (0.09)	0.63 (0.09)	0.84 (0.10)	0.39 (0.06)	0.73 (0.09)	0.79 (0.09)	0.75 (0.05)
		10,000ms	1.13 (0.10)	0.62 (0.09)	1.02 (0.11)	0.67 (0.07)	0.77 (0.08)	0.77 (0.10)	0.78 (0.05)
		Total	1.10 (0.07)	0.62 (0.08)	1.01 (0.08)	0.42 (0.05)	0.75 (0.06)	0.77 (0.07)	0.45 (0.04)
	Adults	500ms	1.17 (0.08)	0.69 (0.10)	0.79 90.10)	0.39 (0.07)	0.58 (0.07)	0.79 (0.10)	0.75 (0.05)
		3000ms	1.24 (0.08)	0.61 (0.08)	1.14 (0.09)	0.52 (0.05)	0.78 (0.08)	0.76 (0.09)	0.84 (0.05)
		10,000ms	1.26 (0.09)	0.73 (0.08)	1.01 (0.10)	0.46 (0.06)	0.75 (0.07)	0.75 (0.09)	0.83 (0.05)
		Total	1.22 (0.06)	0.68 (0.07)	1.02 (0.07)	0.46 (0.04)	0.70 (0.06)	0.77 (0.07)	0.81 (0.04)
	Overall	500ms	1.10 (0.06)	0.65 (0.07)	1.04 (0.07)	0.44 (0.06)	0.66 (0.05)	0.77 (0.07)	0.78 (0.04)
		3000ms	1.19 (0.06)	0.62 (0.06)	0.99 (0.06)	0.46 (0.04)	0.75 (0.06)	0.77 (0.06)	0.80 (0.04)
		10,000ms	1.20 (0.07	0.67 (0.06)	1.01 (0.07)	0.42 (0.04)	0.76 (0.06)	0.76 (0.07)	0.80 (0.04)
		Total	1.16 (0.05)	0.65 (0.05)	1.01 (0.05)	0.44 (0.03)	0.73 (0.04)	0.77 (0.05)	0.79 (0.03)

[27] Controlling for depression and SA facets [actual scores].

Table 7.29. Mean (SE) % TFD to facial features by age group, emotion, exposure time and depression group[28].

			Happy	Sad	Surprised	Anger	Fear	Disgust	***Total***
Low Depression	Adolescents	500ms	47.60 (5.35)	46.06 (4.51)	56.47 (4.20)	45.59 (5.11)	42.02 (4.59)	49.19 (4.45)	47.84 (3.42)
		3000ms	51.38 (3.69)	56.84 (3.77)	55.76 (3.20)	51.57 (3.61)	53.95 (3.19)	51.09 (3.37)	53.43 (2.85)
		10,000ms	48.94 (3.55)	52.24 (4.28)	53.66 (3.33)	53.01 (3.79)	50.72 (3.82)	49.11 (3.22)	51.28 (3.24)
		Total	49.31 (2.40)	51.71 (2.80)	55.33 (2.23)	50.06 (2.81)	48.90 (2.30)	49.80 (2.03)	50.85 (2.00)
	Adults	500ms	43.01 (6.97)	37.11 (5.89)	34.00 (5.48)	32.15 (6.67)	37.36 (5.99)	30.41 (5.81)	35.67 (4.46)
		3000ms	53.41 (4.81)	57.31 (4.92)	55.05 (4.17)	55.40 (4.72)	57.57 (4.17)	56.62 (4.40)	55.89 (3.72)
		10,000ms	53.77 (4.63)	61.61 (5.58)	56.63 (4.34)	62.83 (4.94)	58.76 (4.98)	56.82 (4.20)	58.57 (4.23)
		Total	50.06 (3.14)	52.34 (3.66)	48.56 (2.91)	50.13 (3.66)	39.93 (2.35)	47.95 (2.65)	50.05 (2.61)
	Overall	500ms	45.31 (4.51)	41.58 (3.81)	42.29 (3.54)	38.87 (4.31)	39.69 (3.87)	39.80 (3.76)	41.76 (2.88)
		3000ms	52.40 (3.11)	57.08 (3.18)	55.40 (2.69)	53.49 (3.05)	55.76 (2.69)	53.86 (2.84)	54.66 (2.40)
		10,000ms	51.36 (2.99)	57.43 (3.61)	55.14 (2.80)	57.92 (3.19)	54.74 (3.22)	52.96 (2.71)	54.93 (2.73)
		Total	49.69 (2.03)	52.03 (2.36)	51.94 (1.88)	50.09 (2.37)	50.07 (1.94)	48.87 (1.71)	50.45 (1.68)
High Depression	Adolescents	500ms	35.69 (7.21)	44.32 (6.09)	37.29 (5.67)	40.29 (6.89)	42.10 (6.20)	42.37 (6.01)	40.34 (4.61)
		3000ms	44.80 (4.97)	59.04 (5.09)	51.39 (4.31)	51.52 (4.88)	48.44 (4.31)	47.35 (4.55)	50.42 (3.84)
		10,000ms	45.19 (4.79)	47.67 (5.78)	49.47 (4.49)	44.43 (5.15)	44.43 (5.15)	43.83 (4.34)	46.52 (4.38)
		Total	41.89 (3.24)	50.34 (3.78)	46.05 (3.01)	46.78 (3.79)	44.99 (3.11)	44.52 (2.74)	45.76 (2.69)
	Adults	500ms	33.17 (5.46)	33.18 (4.62)	29.93 (4.30)	29.45 (5.22)	27.74 (4.69)	32.88 (4.56)	31.06 (3.50)
		3000ms	43.31 (3.77)	46.10 (3.86)	46.74 (3.27)	44.86 (3.69)	48.64 (3.26)	45.77 (3.45)	45.90 (2.91)
		10,000ms	45.44 (3.63)	49.39 (4.38)	50.89 (3.40)	49.36 (3.87)	43.40 (3.90)	46.27 (3.29)	47.46 (3.32)
		Total	40.64 (2.46)	42.89 (2.89)	42.52 (2.28)	41.22 (2.87)	39.93 (2.35)	41.64 (2.08)	41.47 (2.04)
	Overall	500ms	34.43 (4.68)	38.75 (3.95)	33.61 (3.68)	34.87 (4.47)	34.92 (4.02)	37.62 (3.90)	35.70 (2.99)
		3000ms	44.05 (3.22)	52.57 (3.30)	49.07 (2.79)	48.19 (3.16)	48.54 (2.79)	46.56 (2.95)	48.16 (2.49)
		10,000ms	45.31 (3.10)	48.53 (3.74)	50.18 (2.91)	48.95 (3.31)	43.92 (3.34)	45.05 (2.82)	46.99 (2.84)
		Total	41.27 (2.10)	46.62 (2.45)	44.29 (1.95)	44.01 (2.46)	42.46 (2.01)	43.08 (1.78)	43.62 (1.75)

[28] Controlling for SA facets and laterality quotient [actual scores].

Table 7.30. Mean (SE) % TFD to the eyes by age group, emotion, exposure time and depression group[29]

			Happy	Sad	Surprised	Anger	Fear	Disgust	Total
Low Depression	Adolescents	500ms	8.29 (3.46)	19.66 (4.90)	9.68 (4.16)	9.90 (3.47)	13.19 (4.24)	13.30 (4.51)	12.34 (3.52)
		3000ms	23.37 (4.15)	34.77 (4.58)	27.58 (4.14)	24.50 (4.20)	30.14 (4.11)	27.50 (4.21)	27.98 (3.87)
		10,000ms	24.05 (3.75)	32.28 (4.10)	26.71 (3.82)	30.58 (3.96)	27.99 (3.50)	31.04 (3.29)	28.77 (3.39)
		Total	18.57 (3.13)	28.90 (3.62)	21.32 (3.35)	21.66 (3.25)	23.78 (3.19)	23.95 (3.21)	23.03 (3.08)
	Adults	500ms	14.62 (4.51)	27.27 (6.39)	20.48 (5.43)	18.34 (4.53)	19.91 (5.53)	15.92 (5.88)	19.42 (4.59)
		3000ms	24.97 (5.41)	35.32 (5.98)	30.24 (5.40)	28.72 (5.48)	32.98 (5.36)	31.87 (5.49)	30.68 (5.05)
		10,000ms	34.92 (4.89)	41.19 (5.35)	33.03 (4.98)	40.93 (5.17)	36.64 (4.57)	37.26 (4.30)	37.33 (4.42)
		Total	24.84 (4.08)	34.60 (4.73)	27.92 (4.36)	29.33 (4.24)	29.84 (4.16)	28.35 (4.19)	29.15 (4.02)
	Overall	500ms	11.45 (2.92)	23.47 (4.13)	15.08 (3.51)	14.12 (2.92)	16.55 (3.57)	14.61 (3.80)	15.88 (2.96)
		3000ms	24.17 (3.50)	35.05 (3.86)	28.91 (3.49)	26.61 (3.54)	31.56 (3.46)	29.68 (3.55)	29.33 (3.26)
		10,000ms	29.48 (3.16)	36.73 (3.46)	29.87 (3.22)	35.76 (3.34)	32.32 (2.95)	34.15 (2.78)	33.05 (2.86)
		Total	21.70 (2.63)	31.75 (3.06)	24.62 (2.82)	25.49 (2.74)	26.81 (2.69)	26.15 (2.71)	26.09 (2.60)
High Depression	Adolescents	500ms	4.79 (4.67)	20.06 (6.61)	9.40 (5.62)	5.92 (4.68)	9.35 (5.72)	10.90 (6.08)	10.40 (4.74)
		3000ms	20.35 (5.60)	31.84 (6.19)	25.68 (5.59)	23.76 (5.67)	24.75 (5.54)	25.58 (5.68)	25.33 (5.22)
		10,000ms	24.92 (5.06)	26.54 (5.53)	30.54 (5.15)	28.08 (5.35)	24.51 (4.72)	26.71 (4.44)	26.89 (4.57)
		Total	16.69 (4.22)	26.81 (4.89)	21.87 (4.51)	19.25 (4.28)	19.54 (4.30)	21.06 (4.33)	20.87 (4.16)
	Adults	500ms	8.40 (3.54)	10.33 (5.01)	5.89 (4.26)	6.57 (3.55)	5.55 (4.33)	9.55 (4.91)	7.72 (3.59)
		3000ms	20.13 (4.24)	19.74 (4.69)	21.17 (4.23)	20.39 (4.29)	20.25 (4.20)	21.05 (4.30)	20.45 (3.96)
		10,000ms	24.38 (3.83)	31.79 (4.19)	30.17 (3.90)	28.13 (4.05)	23.49 (3.58)	27.34 (3.37)	27.55 (3.47)
		Total	17.63 (3.20)	20.62 (3.71)	19.08 (3.42)	18.36 (3.32)	16.43 (3.26)	19.31 (3.28)	18.57 (3.15)
	Overall	500ms	6.59 (3.03)	16.19 (4.29)	7.64 (3.64)	6.25 (3.03)	7.45 (3.71)	10.22 (3.94)	9.06 (3.07)
		3000ms	20.24 (3.63)	25.79 (4.01)	23.42 (3.62)	22.07 (3.67)	22.50 (3.59)	23.32 (3.68)	22.89 (3.38)
		10,000ms	24.65 (3.28)	29.17 (3.59)	30.36 (3.34)	28.10 (3.47)	24.00 (3.06)	27.03 (2.88)	27.22 (2.96)
		Total	23.72 (3.17)	23.72 (3.17)	20.48 (2.93)	18.81 (2.84)	17.98 (2.79)	20.19 (2.81)	19.72 (2.69)

[29] Controlling for SA facets and laterality quotient [actual scores].

Table 7.31. Mean (SE) % TFD to facial features by age group, emotion, exposure time and FNE group[30].

			Happy	Sad	Surprised	Anger	Fear	Disgust	Total
Low FNE	Adolescents	500ms	45.42 (5.02)	46.57 (4.18)	47.11 (4.13)	44.70 (4.13)	46.73 (4.52)	42.50 (4.25)	45.51 (3.32)
		3000ms	47.18 (3.66)	54.52 (3.76)	51.69 (3.24)	47.74 (3.55)	50.93 (3.07)	48.85 (3.28)	50.15 (2.85)
		10,000ms	46.22 (3.43)	53.91 (4.26)	51.27 (3.21)	51.90 (3.74)	51.00 (3.64)	46.83 (3.18)	50.19 (3.20)
		Total	46.27 (2.44)	51.67 (2.81)	50.02 (2.26)	48.11 (2.73)	49.56 (2.26)	46.06 (2.00)	48.62 (2.02)
	Adults	500ms	32.49 (5.93)	40.27 (4.93)	37.43 (4.88)	34.40 (5.83)	37.24 (5.33)	34.95 (5.02)	36.13 (3.91)
		3000ms	48.83 (4.33)	53.80 (4.40)	50.50 (3.83)	50.12 (4.19)	54.09 (3.62)	53.80 (3.87)	51.86 (3.34)
		10,000ms	49.80 (4.05)	55.16 (5.04)	54.58 (3.79)	57.49 (4.41)	52.98 (4.30)	51.71 (3.76)	53.62 (3.78)
		Total	43.71 (2.89)	49.74 (3.32)	47.50 (2.66)	47.34 (3.22)	47.10 (2.67)	46.82 (2.36)	47.20 (2.38)
	Overall	500ms	38.96 (4.00)	43.42 (3.30)	42.27 (3.29)	39.55 (3.94)	41.99 (3.60)	38.73 (3.39)	45.18 (2.47)
		3000ms	48.01 (2.92)	54.16 (3.00)	51.10 (2.59)	48.93 (2.83)	52.51 (2.45)	51.33 (2.61)	51.13 (2.13)
		10,000ms	48.01 (2.74)	54.54 (3.40)	52.92 (2.56)	54.70 (2.98)	51.99 (2.90)	49.27 (2.54)	47.62 (2.38)
		Total	44.99 (1.95)	50.70 (2.24)	48.76 (1.80)	47.73 (2.18)	48.83 (1.80)	46.44 (1.60)	47.91 (1.61)
High FNE	Adolescents	500ms	41.24 (6.50)	44.25 (5.40)	49.05 (5.35)	42.39 (6.39)	42.16 (5.84)	49.98 (5.80)	44.85 (4.29)
		3000ms	48.85 (4.74)	57.21 (4.87)	52.08 (4.20)	55.93 (4.60)	50.60 (3.97)	47.92 (4.24)	52.10 (3.69)
		10,000ms	46.00 (4.44)	42.56 (5.52)	48.72 (4.16)	46.97 (4.83)	41.93 (4.71)	44.06 (4.12)	45.04 (4.14)
		Total	45.37 (3.16)	48.01 (3.64)	49.95 (2.92)	48.43 (3.53)	44.90 (2.92)	47.32 (2.59)	47.33 (2.61)
	Adults	500ms	46.62 (6.67)	26.28 (5.55)	25.38 (5.48)	24.13 (6.56)	24.82 (6.00)	29.16 (5.64)	29.40 (4.40)
		3000ms	46.28 (4.86)	45.74 (4.99)	49.84 (4.30)	47.62 (4.72)	53.05 (4.07)	44.43 (4.35)	47.83 (3.79)
		10,000ms	45.88 (4.56)	51.91 (5.66)	48.53 (4.27)	50.45 (4.96)	43.65 (4.83)	48.33 (4.23)	48.13 (4.25)
		Total	46.26 (3.24)	41.31 (3.73)	41.25 (3.00)	40.73 (3.62)	40.51 (3.00)	40.64 (2.66)	41.78 (2.68)
	Overall	500ms	43.93 (4.81)	35.27 (4.00)	37.22 (3.96)	33.26 (4.31)	33.49 (4.33)	39.57 (4.07)	32.76 (2.90)
		3000ms	47.57 (3.51)	51.47 (3.60)	50.96 (3.11)	51.77 (3.40)	51.83 (2.94)	46.18 (3.14)	49.84 (2.50)
		10,000ms	45.94 (3.29)	47.24 (4.08)	48.63 (3.08)	48.71 (3.58)	42.79 (3.48)	46.20 (3.05)	50.87 (2.80)
		Total	45.81 (2.34)	44.66 (2.69)	45.60 (2.16)	44.58 (2.61)	42.70 (2.16)	43.98 (1.92)	44.56 (1.93)

[30] Controlling for depression, SAD-General, SAD-New and laterality quotient [actual scores].

Table 7.32. Mean (SE) % TFD to facial features by age group, emotion, exposure time and SAD-General group[31].

			Happy	**Sad**	**Surprised**	**Anger**	**Fear**	**Disgust**	***Total***
Low SAD-General	Adolescents	500ms	39.70 (5.86)	40.21 (4.96)	48.60 (4.94)	39.47 (5.77)	37.25 (5.14)	44.23 (5.04)	41.58 (3.83)
		3000ms	48.87 (4.38)	57.03 (4.37)	53.85 (3.73)	48.64 (4.21)	52.50 (3.61)	47.15 (3.93)	51.34 (3.37)
		10,000ms	46.09 (4.08)	52.05 (5.01)	51.82 (3.86)	50.99 (4.43)	46.67 (4.42)	45.26 (3.78)	48.81 (3.81)
		Total	44.88 (2.84)	49.77 (3.26)	51.42 (2.64)	46.37 (3.17)	45.47 (2.69)	45.55 (2.35)	47.24 (2.35)
	Adults	500ms	34.14 (7.34)	35.87 (6.20)	36.05 (6.05)	33.97 (7.23)	31.97 (6.43)	33.60 (6.61)	34.27 (4.80)
		3000ms	51.87 (5.48)	53.21 (5.47)	53.33 (4.67)	50.36 (5.27)	54.54 (4.52)	50.14 (4.92)	52.24 (4.21)
		10,000ms	49.74 (5.10)	56.90 (6.26)	56.29 (4.82)	58.86 (5.54)	49.53 (5.53)	52.05 (4.73)	53.89 (4.77)
		Total	45.25 (3.56)	48.66 (4.08)	48.56 (3.30)	47.73 (3.96)	45.35 (3.37)	45.26 (2.95)	46.80 (2.94)
	Overall	500ms	36.92 (5.01)	38.04 (4.23)	42.32 (4.21)	36.72 (4.93)	34.61 (4.39)	38.92 (4.30)	37.92 (3.27)
		3000ms	50.37 (3.74)	55.12 (3.73)	53.59 (3.19)	49.50 (3.60)	53.52 (3.08)	48.64 (3.36)	51.79 (2.88)
		10,000ms	47.91 (3.48)	54.47 (4.28)	54.06 (3.29)	54.93 (3.78)	48.10 (3.77)	48.65 (3.23)	51.35 (3.26)
		Total	45.07 (2.43)	49.21 (2.78)	49.99 (2.25)	47.05 (2.70)	45.41 (2.30)	45.40 (2.01)	47.02 (2.01)
High SAD-General	Adolescents	500ms	49.08 (6.05)	49.75 (5.11)	47.82 (5.09)	48.17 (5.09)	51.19 (5.30)	47.21 (5.20)	48.87 (3.95)
		3000ms	47.69 (4.52)	54.66 (4.50)	50.74 (3.85)	54.04 (4.34)	49.69 (3.72)	50.11 (4.06)	51.15 (3.47)
		10,000ms	47.26 (4.20)	45.62 (5.16)	48.17 (5.95)	47.72 (4.57)	46.17 (4.55)	45.53 (3.90)	46.63 (3.93)
		Total	47.68 (4.08)	50.01 (3.36)	48.56 (3.30)	47.73 (3.96)	45.35 (3.96)	45.26 (2.95)	48.88 (2.42)
	Adults	500ms	40.03 (5.39)	34.26 (4.55)	29.95 (4.53)	29.57 (5.30)	31.91 (4.72)	31.93 (4.63)	32.94 (3.52)
		3000ms	44.80 (4.02)	48.50 (4.01)	48.08 (3.43)	47.79 (3.87)	51.46 (3.31)	49.66 (3.61)	48.38 (3.09)
		10,000ms	48.23 (3.74)	53.15 (4.60)	50.82 (3.54)	51.96 (4.07)	49.82 (4.06)	49.52 (3.47)	50.58 (3.50)
		Total	44.35 (2.61)	45.30 (2.99)	42.95 (2.42)	43.11 (2.91)	44.10 (2.47)	43.71 (2.16)	43.97 (2.16)
	Overall	500ms	44.56 (4.26)	42.01 (3.60)	38.89 (3.58)	38.87 (4.19)	41.55 (3.73)	39.57 (3.66)	40.91 (2.78)
		3000ms	46.24 (3.18)	51.58 (3.17)	49.41 (2.71)	50.92 (3.06)	50.58 (2.62)	49.89 (2.86)	49.77 (2.44)
		10,000ms	47.24 (2.96)	49.39 (3.63)	49.64 (2.80)	49.84 (3.22)	47.99 (3.21)	47.52 (2.74)	48.61 (2.77)
		Total	46.01 (2.06)	47.66 (2.37)	45.98 (1.91)	46.54 (2.30)	46.71 (1.95)	45.66 (1.71)	46.43 (1.71)

[31] Controlling for depression, FNE, SAD-New and laterality quotient [actual scores].

Table 7.33. Mean (SE) % TFD to facial features by age group, emotion, exposure time and SAD-new group[32].

			Happy	Sad	Surprised	Anger	Fear	Disgust	***Total***
Low SAD-New	Adolescents	500ms	43.87 (5.78)	48.25 (4.49)	51.45 (4.68)	42.28 (5.30)	40.55 (4.99)	42.47 (4.73)	44.81 (3.63)
		3000ms	48.01 (3.99)	57.01 (4.17)	54.28 (3.45)	51.67 (3.86)	52.48 (3.40)	49.02 (3.58)	52.08 (3.12)
		10,000ms	45.45 (3.74)	43.82 (4.61)	50.59 (3.58)	46.02 (4.13)	40.82 (4.06)	41.96 (3.42)	44.78 (3.51)
		Total	45.78 (2.61)	49.69 (3.07)	52.10 (2.47)	46.66 (2.89)	44.62 (2.55)	44.48 (2.25)	47.22 (2.19)
	Adults	500ms	37.08 (7.22)	33.25 (5.61)	34.39 (5.85)	26.94 (6.63)	32.62 (6.24)	34.18 (5.91)	33.08 (4.54)
		3000ms	48.15 (4.47)	50.43 (5.21)	49.08 (4.32)	46.70 (4.83)	52.05 (4.25)	48.15 (4.47)	49.13 (3.90)
		10,000ms	46.59 (4.27)	55.37 (5.76)	50.72 (4.48)	52.53 (5.16)	44.64 (5.07)	46.59 (4.27)	49.29 (4.39)
		Total	43.77 (2.67)	46.35 (3.847)	44.73 (3.09)	42.05 (3.61)	43.10 (3.19)	42.98 (2.81)	43.83 (2.74)
	Overall	500ms	40.47 (4.64)	40.75 (3.60)	42.92 (3.76)	34.61 (4.26)	36.58 (4.01)	38.33 (3.80)	38.94 (2.91)
		3000ms	48.18 (3.21)	53.72 (3.35)	51.68 (2.77)	49.18 (3.10)	52.27 (2.73)	48.89 (2.87)	50.60 (2.51)
		10,000ms	45.66 (3.00)	49.59 (3.70)	50.65 (2.88)	49.27 (3.31)	42.73 (3.26)	44.27 (2.74)	47.03 (2.82)
		Total	44.77 (2.10)	48.02 (2.46)	48.42 (1.99)	44.35 (2.32)	43.86 (2.05)	43.73 (1.80)	45.53 (1.76)
High SAD-New	Adolescents	500ms	46.15 (5.77)	44.88 (4.48)	45.77 (4.68)	46.93 (5.29)	47.69 (4.99)	47.73 (4.72)	46.53 (3.62)
		3000ms	48.70 (3.99)	55.67 (4.16)	50.84 (3.45)	52.66 (3.86)	50.27 (3.39)	49.81 (3.57)	51.33 (3.12)
		10,000ms	46.88 (3.74)	52.84 (4.60)	49.44 (3.58)	52.78 (4.12)	51.79 (4.05)	48.92 (3.42)	50.44 (3.51)
		Total	47.26 (2.61)	51.13 (3.07)	48.68 (2.47)	50.79 (2.88)	49.91 (2.55)	48.82 (2.24)	49.43 (2.19)
	Adults	500ms	37.08 (7.22)	33.25 (5.61)	34.39 (5.85)	29.94 (6.63)	32.62 (6.24)	34.18 (5.91)	30.94 (6.86)
		3000ms	48.36 (4.99)	50.43 (5.21)	49.08 (4.32)	46.70 (4.83)	52.05 (4.25)	48.15 (4.47)	46.98 (5.90)
		10,000ms	45.88 (4.68)	55.37 (5.76)	50.72 (4.48)	52.53 (5.16)	44.64 (5.07)	46.59 (4.27)	45.17 (6.64)
		Total	37.56 (4.94)	42.84 (5.80)	37.51 (4.68)	37.51 (4.68)	43.61 (4.82)	45.18 (4.25)	45.23 (2.39)
	Overall	500ms	40.00 (6.30)	39.66 (4.89)	35.16 (5.10)	36.55 (5.78)	40.29 (5.44)	40.75 (5.15)	38.73 (3.95)
		3000ms	43.31 (4.35)	52.91 (4.54)	46.97 (3.76)	49.24 (4.21)	48.87 (3.70)	53.63 (3.90)	49.15 (3.40)
		10,000ms	43.90 (4.08)	48.39 (5.02)	47.17 (3.91)	49.59 (4.50)	51.14 (4.42)	46.63 (3.73)	47.80 (3.83)
		Total	42.40 (2.85)	46.99 (3.35)	43.10 (2.70)	45.13 (3.14)	46.76 (2.78)	47.00 (2.45)	41.03 (4.14)

[32] Controlling for depression, FNE, SAD-General and laterality quotient [actual scores].

Table 7.34. Mean (SE) % TFD to the eyes by age group, emotion, exposure time and SAD- New group[33].

			Happy	**Sad**	**Surprised**	**Anger**	**Fear**	**Disgust**	***Total***
Low SAD-New	Adolescents	500ms	12.15 (3.65)	23.57 (5.25)	9.09 (4.25)	11.82 (3.82)	13.76 (4.48)	15.43 (4.63)	14.30 (3.71)
		3000ms	24.06 (4.22)	33.41 (4.69)	24.89 (4.20)	25.76 (4.34)	28.14 (4.19)	27.47 (4.32)	27.29 (3.92)
		10,000ms	25.31 (3.92)	26.88 (4.17)	27.01 (3.91)	26.48 (4.22)	22.67 (3.61)	26.27 (3.41)	25.77 (3.50)
		Total	20.50 (3.21)	27.95 (3.74)	20.33 (3.35)	21.35 (3.43)	21.52 (3.32)	23.05 (3.30)	22.45 (3.17)
	Adults	500ms	18.84 (4.56)	25.51 (6.56)	23.49 (5.31)	15.89 (4.78	20.05 (5.59)	22.14 (5.79)	20.99 (4.64)
		3000ms	32.76 (5.28)	36.43 (5.86)	33.75 (5.25)	30.83 (5.43)	35.61 (5.24)	34.73 (5.41)	34.02 (4.90)
		10,000ms	34.50 (4.90)	43.73 (5.21)	38.70 (4.89)	37.85 (5.28)	33.09 (4.51)	35.27 (4.26)	37.19 (4.38)
		Total	28.70 (4.02)	35.22 (4.67)	31.98 (4.19)	28.19 (4.29)	29.58 (4.15)	30.71 (4.12)	30.73 (3.96)
	Overall	500ms	15.50 (2.93)	24.54 (4.21)	16.29 (3.41)	13.85 (3.07)	16.91 (3.59)	18.78 (3.72)	17.65 (2.98)
		3000ms	28.41 (3.39)	34.92 (3.76)	29.32 (3.37)	28.29 (3.49)	31.88 (3.36)	31.10 (3.47)	30.65 (3.15)
		10,000ms	29.90 (3.15)	35.30 (3.35)	32.86 (3.14)	32.16 (3.39)	27.88 (2.89)	30.77 (2.74)	31.48 (2.81)
		Total	24.60 (2.58)	31.59 (3.00)	26.15 (2.69)	24.77 (2.76)	25.55 (2.66)	26.88 (2.65)	26.59 (2.54)
High SAD-New	Adolescents	500ms	3.89 (3.64)	18.96 (5.24)	10.46 (4.24)	6.22 (3.82)	12.00 (4.47)	11.42 (4.63)	10.49 (3.71)
		3000ms	25.27 (4.22)	33.78 (4.68)	31.00 (4.20)	25.80 (4.34)	28.52 (4.19)	29.15 (4.32)	28.91 (3.92)
		10,000ms	23.53 (3.92)	30.58 (4.16)	27.18 (3.90)	30.90 (4.21)	28.93 (3.60)	31.47 (3.40)	28.80 (3.50)
		Total	17.56 (3.21)	27.73 (3.73)	22.98 (3.35)	20.97 (3.43)	23.15 (3.31)	24.02 (3.29)	22.74 (3.17)
	Adults	500ms	5.93 (6.89)	14.95 (9.92)	6.22 (8.03)	7.20 (7.22)	14.84 (8.46)	8.64 (8.76)	9.63 (7.02)
		3000ms	14.86 (7.99)	23.79 (8.86)	18.17 (7.94)	20.23 (8.21)	17.52 (7.92)	21.86 (8.18)	19.42 (7.41)
		10,000ms	21.40 (7.41)	24.66 (7.88)	20.57 (7.39)	26.82 (7.98)	21.20 (6.82)	22.30 (6.44)	22.83 (6.62)
		Total	14.10 (6.08)	21.13 (7.07)	14.99 (6.33)	18.08 (6.49)	17.85 (6.27)	17.60 (6.23)	17.29 (5.99)
	Overall	500ms	4.91 (3.97)	16.95 (5.72)	8.34 (4.63)	6.71 (4.16)	13.42 (4.88)	10.03 (5.05)	10.06 (4.04)
		3000ms	20.17 (4.60)	28.78 (5.11)	24.59 (4.58)	23.01 (4.73)	23.02 (4.57)	25.50 (4.71)	24.17 (4.27)
		10,000ms	22.47 (4.27)	22.47 (4.27)	24.03 (4.60)	28.86 (4.60)	25.07 (3.93)	26.89 (3.71)	25.81 (3.81)
		Total	15.83 (3.50)	24.43 (4.07)	18.99 (3.65)	19.53 (3.74)	20.50 (3.61)	20.81 (3.59)	20.01 (3.45)

[33] Controlling for depression, FNE, SAD-General and laterality quotient [actual scores].

Table 7.35. Mean (SE) % TFD to facial features by age group, emotion, exposure time and laterality group[34].

			Happy	**Sad**	**Surprised**	**Anger**	**Fear**	**Disgust**	***Total***
Bilateral	Adolescents	500ms	39.98 (5.19)	41.30 (4.33)	49.94 (4.24)	49.77 (4.68)	41.54 (4.53)	46.14 (4.35)	44.78 (3.32)
		3000ms	44.92 (3.51)	56.30 (3.82)	51.09 (3.12)	48.45 (3.48)	45.17 (3.05)	45.16 (3.39)	48.51 (2.86)
		10,000ms	47.96 (3.26)	53.19 (4.27)	52.27 (3.28)	53.70 (3.67)	49.65 (3.74)	44.66 (3.20)	50.24 (3.19)
		Total	44.28 (2.43)	50.26 (2.87)	51.10 (2.28)	50.64 (2.69)	45.45 (2.33)	45.32 (2.10)	47.84 (2.05)
	Adults	500ms	39.54 (6.08)	31.80 (5.07)	29.43 (4.97)	26.67 (5.48)	33.75 (5.31)	31.94 (5.09)	32.19 (3.89)
		3000ms	43.33 (4.12)	48.82 (4.48)	48.41 (3.66)	46.78 (4.07)	50.96 (3.58)	47.89 (3.98)	47.70 (3.35)
		10,000ms	46.59 (3.82)	53.38 (5.00)	50.46 (3.84)	51.47 (4.30)	48.40 (4.39)	48.40 (3.75)	49.78 (3.74)
		Total	43.15 (2.84)	44.67 (3.36)	42.74 (2.45)	41.64 (3.15)	44.37 (2.73)	42.74 (2.45)	43.22 (2.40)
	Overall	500ms	39.76 (3.94)	36.55 (3.29)	39.68 (3.23)	38.22 (3.56)	37.64 (3.44)	39.04 (3.31)	38.48 (2.53)
		3000ms	44.12 (2.67)	52.56 (2.91)	49.75 (2.37)	47.62 (2.64)	48.07 (2.32)	46.52 (2.58)	48.11 (2.17)
		10,000ms	47.27 (2.48)	53.29 (3.25)	51.37 (2.49)	52.58 (2.79)	49.03 (2.85)	46.53 (2.43)	50.01 (2.43)
		Total	43.72 (1.85)	47.46 (2.18)	46.93 (1.73)	46.14 (2.05)	44.91 (1.77)	44.03 (1.59)	45.53 (1.56)
Right-hemisphere	Adolescents	500ms	43.89 (5.63)	46.89 (4.69)	44.92 (4.60)	32.98 (5.08)	46.89 (4.91)	44.38 (4.72)	43.32 (3.60)
		3000ms	53.30 (3.81)	54.54 (4.45)	52.01 (3.39)	55.08 (3.77)	55.83 (3.31)	51.85 (3.68)	53.77 (3.10)
		10,000ms	48.23 (3.47)	46.59 (4.63)	49.62 (3.55)	47.20 (3.98)	45.59 (4.06)	46.09 (3.47)	47.22 (3.46)
		Total	48.47 (2.63)	49.34 (3.11)	48.85 (2.47)	45.09 (2.92)	49.44 (2.53)	47.44 (2.27)	48.10 (2.22)
	Adults	500ms	26.17 (6.09)	37.79 (5.08)	34.54 (4.98)	33.86 (5.49)	29.25 (5.32)	33.07 (5.11)	34.11 (3.90)
		3000ms	52.12 (4.12)	52.19 (4.49)	51.69 (3.66)	51.04 (4.08)	55.02 (3.59)	53.00 (3.98)	52.51 (3.36)
		10,000ms	50.38 (3.82)	55.32 (5.01)	55.34 (3.85)	57.40 (4.31)	51.12 (4.40)	52.99 (3.76)	53.76 (3.75)
		Total	46.23 (2.85)	48.44 (3.36)	47.19 (2.67)	47.43 (3.16)	45.13 (2.74)	46.35 (2.46)	46.79 (2.40)
	Overall	500ms	40.03 (4.14)	42.34 (3.45)	39.73 (3.38)	33.42 (3.73)	38.07 (3.61)	38.72 (3.47)	38.72 (2.65)
		3000ms	52.71 (2.80)	53.36 (3.05)	51.85 (2.49)	53.06 (2.77)	55.43 (2.44)	52.42 (2.71)	53.14 (2.28)
		10,000ms	49.31 (2.60)	50.96 (3.41)	52.48 (2.61)	52.30 (2.93)	48.35 (2.99)	49.31 (2.60)	50.49 (2.55)
		Total	47.35 (1.94)	48.89 (2.29)	48.02 (1.82)	46.26 (2.15)	47.28 (1.86)	46.89 (1.67)	47.45 (1.63)

[34] Controlling for depression and SA facets [actual scores].

Table 7.36. Mean (SE) % TFD to the eyes by age group, emotion, exposure time and laterality group[35].

			Happy	Sad	Surprised	Anger	Fear	Disgust	*Total*
Bilateral	Adolescents	500ms	5.83 (3.02)	21.23 (4.62)	8.20 (3.93)	9.29 (3.15)	10.01 (4.15)	9.71 (4.17)	10.71 (3.26)
		3000ms	22.94 (3.79)	31.06 (4.47)	26.36 (3.76)	22.65 (3.91)	22.20 (3.85)	25.22 (3.95)	25.07 (3.61)
		10,000ms	24.01 (3.38)	30.32 (3.95)	29.24 (3.55)	30.90 (3.70)	26.23 (3.24)	27.70 (3.15)	28.07 (3.16)
		Total	17.59 (2.70)	27.54 (3.44)	21.27 (3.04)	20.95 (2.98)	19.48 (2.97)	20.88 (2.95)	21.28 (2.82)
	Adults	500ms	4.54 (3.54)	10.19 (5.41)	5.79 (4.61)	5.67 (3.69)	8.60 (4.86)	5.27 (4.89)	6.68 (3.82)
		3000ms	17.07 (4.44)	23.61 (5.23)	19.35 (4.40)	19.26 (4.59)	22.26 (4.51)	20.70 (4.63)	20.37 (4.23)
		10,000ms	25.49 (3.96)	33.29 (4.63)	26.61 (4.16)	29.01 (4.34)	25.93 (3.79)	27.48 (3.69)	27.97 (3.70)
		Total	15.70 (3.16)	22.36 (4.03)	17.25 (3.57)	17.98 (3.49)	18.93 (3.48)	17.81 (3.46)	18.34 (3.30)
	Overall	500ms	5.19 (2.30)	15.71 (3.51)	7.00 (2.99)	7.48 (2.39)	9.31 (3.16)	7.49 (3.18)	8.67 (2.48)
		3000ms	20.00 (2.88)	27.33 (3.40)	22.85 (2.86)	20.95 (2.98)	22.23 (2.93)	22.96 (3.00)	22.72 (2.75)
		10,000ms	24.75 (2.57)	31.81 (3.00)	27.92 (2.70)	29.95 (2.82)	26.08 (2.46)	27.59 (2.40)	28.02 (2.40)
		Total	16.65 (2.05)	24.95 (2.62)	19.26 (2.32)	19.46 (2.27)	19.20 (2.26)	19.35 (2.24)	19.81 (2.14)
Right-hemisphere	Adolescents	500ms	9.96 (3.28)	23.03 (5.01)	10.40 (4.27)	6.09 (3.41)	19.38 (4.50)	19.45 (4.53)	14.72 (3.54)
		3000ms	28.81 (4.11)	34.47 (4.84)	30.04 (4.08)	27.33 (4.25)	33.25 (4.18)	30.68 (4.29)	30.93 (3.92)
		10,000ms	27.22 (3.67)	29.50 (4.29)	27.07 (3.85)	29.12 (4.02)	26.41 (3.51)	30.09 (3.42)	28.24 (3.42)
		Total	22.00 (2.93)	29.34 (3.73)	22.50 (3.30)	20.85 (3.23)	26.35 (3.22)	26.74 (3.20)	24.63 (3.06)
	Adults	500ms	18.14 (3.55)	24.64 (5.42)	18.79 (4.62)	17.31 (3.69)	15.86 (4.87)	20.35 (4.90)	19.18 (3.83)
		3000ms	27.61 (4.45)	30.57 (5.24)	31.63 (4.41)	29.11 (4.60)	31.31 (4.52)	31.44 (4.64)	30.28 (4.24)
		10,000ms	31.84 (3.97)	38.26 (4.64)	35.73 (4.17)	38.37 (4.35)	32.59 (3.80)	35.87 (3.70)	35.45 (3.70)
		Total	25.86 (3.17)	31.16 (4.04)	28.72 (3.57)	28.26 (3.50)	26.59 (3.49)	29.22 (3.46)	28.30 (3.31)
	Overall	500ms	14.05 (2.41)	23.84 (3.68)	14.60 (3.14)	11.70 (2.51)	17.62 (3.31)	19.90 (3.33)	16.95 (2.60)
		3000ms	28.21 (3.02)	33.02 (3.56)	30.83 (3.00)	28.22 (3.12)	32.28 (3.07)	31.06 (3.15)	30.60 (2.88)
		10,000ms	29.53 (2.70)	33.88 (3.15)	31.40 (2.83)	33.74 (2.96)	29.50 (2.58)	32.98 (2.51)	31.84 (2.52)
		Total	23.93 (2.15)	30.25 (2.75)	25.61 (2.43)	24.55 (2.38)	26.47 (2.37)	27.98 (2.35)	26.46 (2.25)

[35] Controlling for depression and SA facets [actual scores].