EXPLORING COGNITIVE MECHANISMS INVOLVED IN SELF-FACE RECOGNITION

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Abstract

Due to the own face being a significant stimulus that is critical to one's identity, the own face is suggested to be processed in a quantitatively different (i.e., faster and better recognition) and qualitatively different (i.e., processed in a more featural manner) manner compared to other faces. This thesis further explored the cognitive mechanisms (perceptual and attentional systems) involved in the processing of the own face.

Chapter 2 explored the role of holistic and featural processing involved in the processing of self-face (and other faces) with eye-tracking measures in a passive-viewing paradigm and a face identification task. In the passive-viewing paradigm, the own face was sampled in a more featural manner compared to other faces whereas when asked to identify faces, all faces were sampled in a more holistic manner. Chapter 3 further explored the role of holistic and featural processing in the identification of the own face using the three standard measures of holistic face processing: The face inversion task, the composite face task, and the part-whole task. Compared to other faces, individuals showed a smaller "holistic interference" by a task irrelevant bottom half for the own face in the composite face task and a stronger feature advantage for the own face, but inversion impaired the identification of all faces. These findings suggest that self-face is processed in a more featural manner, but the findings do not deny the role of holistic processing.

The final experimental chapter, Chapter 4, explored the modulation effects of cultural differences in one's self-concept (i.e., independent vs. interdependent self-concept) and a negative self-concept (i.e., depressive traits) on the attentional prioritization for the own face with a visual search paradigm. Findings showed that the attentional prioritization for the own face over an unfamiliar face is not modulated by

cultural differences of one's self-concept nor one's level of depressive traits, and individuals showed no difference in the attentional prioritization for both the own face and friend's face, demonstrating no processing advantage for the own face over a personally familiar face. These findings suggests that the attentional prioritization for the own face is better explained by a familiar face advantage.

Altogether, the findings of this thesis suggest that the own face is processed qualitatively different compared to both personally familiar and unfamiliar face, with the own face being processed in a more featural manner. However, in terms of quantitative differences, the self-face is processed differently compared to an unfamiliar face, but not to a familiar face. Although the specific face processing strategies for the own face may be due to the distinct visual experience that one has with their face, the attentional prioritization of the own face is however, better explained by a familiar face advantage rather than a self-specificity effect.

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Declaration

I declare that this thesis is my own work carried out under the normal terms of supervision.

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Chapter 1

General Introduction

Faces are important and salient stimuli for humans. Central to social interaction, faces convey important information, such as an individual's demographics (i.e., age, gender, and race) and emotional state, and this information can be extracted relatively easily from each face. Human faces belong to a homogenous category with a similar basic arrangement of features: a pair of eyes aligned horizontally above a central nose and mouth. Despite little variance among the underlying structure of faces, individuals demonstrate a remarkable expertise for the recognition of familiar faces (e.g., Burton et al., 1999; Hole et al., 2002; Maurer et al., 2002). For instance, an image of a face can vary in visual content through changes in expression, hairstyle, or luminosity, yet individuals are able to show recognition for familiar faces with high accuracy and good reliability (Maurer et al., 2002). Accurate face recognition contributes to both social and evolutionary advantages as it helps us to identify defectors and cooperators (Volstorf et al., 2011). Although the recognition of other people's faces is important for establishing and facilitating social relationships, to be able to distinguish oneself from others is also a fundamental ability for maintaining social interactions and creating a sense of self (Estudillo & Bindemann, 2017b).

This chapter will first delve into the relationship between self-awareness and self-recognition and move on to looking at the processing of the own face and introducing the self-face advantage (SFA). Next, this chapter will explore the quantitative and qualitative differences for the own-face processing wherein the attentional advantages and the distinctive face perceptual mechanism for the own face would be highlighted.

1.1 Self-Awareness and Self-Recognition

Self-awareness, as defined by Morin (2004), refers to the ability of being aware of the self as "the object of attention," comprising "one's public self-aspects (e.g., behaviors and physical appearance) and mental states (e.g., emotions, attitudes, sensations, and perceptions)". In other words, the term 'self-awareness' is construed as an individual's perception and evaluation toward one's physical and internal states (Morin, 2006). Self-awareness can also be characterized on two levels: (1) the explicit recognition of own image (e.g., Keenan, Gallup, et al., 2003) and (2) an implicit prioritization of self-referential information (Ross et al., 1975).

Thus far, it is widely accepted that visual self-recognition is an indication of self-awareness (e.g., Keenan et al., 2005; Sugiura et al., 2005; Uddin et al., 2005; for a review see Morin, 2007), as looking at the self in the mirror directs attention toward the "observable aspect" of the self (i.e., one's own image; Morita et al., 2008). In fact, the ability to recognize one's own face in the mirror (i.e., mirror self-recognition) is one of the most widely used tests of self-awareness. For example, in the "mirror mark test" (Gallup, 1970), participants are unknowingly marked on their face with a pen or a small sticker. Self-face recognition is then inferred when participants in front of a mirror show mark-directed behaviour such as touching the mark directly (Gallup, 1970).

Gallup (1970) theorized that an individual would need to have a concept of the self to be able to recognize their own face in a mirror. In other words, you would need to know who you are to recognize the person being reflected in the mirror. Hence, the ability to recognize their face in the mirror is often asserted to be fundamental in maintaining a coherent identity of the self (Gallup, 1979; Rochat & Zahavi, 2011).

Nevertheless, it should be underscored that in Gallup's view, rather than leading to self-concept, mirror self-recognition simply reflects if an individual or animal already possess a sense of self-identity (Gallup, 1977). Although there is a general consensus that passing the mark test reflects mirror self-recognition, there are also researchers disagreeing on exactly what the mark test measures (e.g., Hobson, 1990; Mitchell, 1997). For example, some children who previously passed the mirror mark test, touched their own nose when they see a red mark on their mother's nose. These observations suggest that passing the mark test does not necessarily imply that children are able to infer that the person in the mirror is 'me' (Mitchell, 1993).

Despite these criticisms, given its easy procedure and high reliability, the mirror-mark test is still considered as one of the most valid measures available for testing and measuring self-awareness (see Kramer et al., 2020). Nevertheless, it is also important to acknowledge that the mirror self-recognition task should not be considered as an "exhaustive and exclusive" measure of self-awareness (see Povinelli, 2001).

On the other hand, self-awareness can also be characterized through an implicit prioritization of self-referential information. Lines of studies have suggested that self-referential information is processed faster and more accurately, capturing attention quickly and automatically (e.g., Alexopoulos et al., 2012). The "self-reference effect" is one of the clearest demonstrations for this processing biases to self-related information, whereby information that is encoded in relation to the self provides a mnemonic advantage over information that are encoded in other different methods (Rogers et al.,1977).

Moray (1959) was the first in testing this claim with the "cocktail party" phenomenon. With a dichotic listening task, participants were asked to repeat aloud a message presented to one ear while being presented with their own name to the unattended ear. Interestingly, 33% of the participants remembered they heard their own name, suggesting that self-referential stimuli, such as the own name, automatically capture one's attention (but see Conway et al., 2001). Similarly, with a visual search task, Mack and Rock (1998) found that the own name "pops out" compared to other names among an array of distractors. Additionally, compared to other strategies, encoding strategies associated with self-referential stimuli (e.g., traits describing self) enhance memory to a greater extent (Grilli & Glisky, 2010; Kihlstrom & Klein, 1997). For instance, individuals are better in remembering target stimuli presented with self-cues compared to those who were presented with other-referent cues, regardless of the cue types (faces or names; Cunningham et al., 2008; for a review, see Symons & Johnson, 1997).

Notably, these self-reference effects do not only influence memory, but also perception (e.g., Sui, He, & Humphreys, 2012). A growing literature has provided converging lines of evidence showing a prioritized processing of one's own face and how the own face is able to grab attention automatically (for review see, Humphreys & Sui, 2016). For instance, individuals respond faster to images of their own faces compared to images of other faces (e.g., Ma & Han, 2010; Sui et al., 2009; Tong & Nakayama, 1999), and images of the own face are harder to ignore relative to familiar (Brédart et al., 2006) and unfamiliar faces (Devue et al., 2009). In other words, the self plays a crucial role in human perception and cognition by exerting influence across a wide range of domains (e.g., Sui & Humphreys, 2015).

As self-referential stimuli entail high social and adaptive value to humans, more attentional resources are therefore allocated and engaged with these stimuli (i.e., attentional prioritization; Tacikowski & Nowicka, 2010). According to Kihlstrom and colleagues (2002), a highly structured self-concept (i.e., a mental representation of knowledge about the self) would allow people to select and filter relevant self-information. Thus, self-relevant information would be processed faster compared to non-relevant self-information.

Nevertheless, in terms of identity, one’s own face generally receives prioritization over other kinds of self-referential information as, in contrast to other self-referential pieces of information (e.g., the own name), the own face is a unique self-referential stimulus that is not shared with others (Devue & Brédart, 2008). Therefore, the ability to recognize one’s own face is generally assumed to be a key indicator of an individual’s level of self-awareness.

1.2 Own-Face Processing: The Self-Face Advantage

The own face is strongly tied to one’s identity and self-awareness (e.g., Estudillo & Bindemann, 2017a) and the ability to recognize one’s own face helps in maintaining a sense of self (Estudillo & Bindemann, 2016, 2017b; Platek, Thomson, et al., 2004). Indeed, the own face is presumably one of our most distinctive physical features (Tsakiris, 2008). Being a significant stimulus critical to one’s identity and the most relevant face to each individual, the own face seems to be processed in a distinctive manner compared to other faces (e.g., Alzueta et al., 2019; Greenberg & Goshen-Gottstein, 2009). Correspondingly, there is considerable evidence that the own face shows a processing advantage compared to other faces.

The self-face advantage (SFA) is generally reflected through individuals demonstrating faster recognition to a self-face than to a stranger’s or a familiar face (e.g., Devue & Brédart, 2008; Tong & Nakayama, 1999). For instance, individuals tend to show a faster and more efficient processing for own faces than for other faces (e.g., Keenan et al., 2000; Tong & Nakayama, 1999) and this advantage persists even for inverted views (Keyes & Brady, 2010, see also Alzueta et al., 2021; Qian et al., 2017). These findings may suggest that, in comparison to other faces, the own face is robustly represented in our mind (Tong & Nakayama, 1999). Additionally, the own face seems to be prioritized in attention; as it is harder to ignore relative to familiar (e.g., Brédart et al., 2006) and unfamiliar faces (e.g., Devue et al., 2009). This preferential processing for the own face persists even when faces are presented subliminally (i.e., without conscious awareness; Geng et al, 2012; Wójcik et al., 2018, 2019). Accordingly, Bola et al (2021) showed that perception of the own face results in a robust prioritization of attention at both the supraliminal and subliminal levels. However, repeated subliminal presentations of stranger faces did not elicit any prioritization effect.

Furthermore, compared to the perception of other faces, the perception of the own face seems to rely on different processing mechanisms (e.g., Greenberg & Goshen-Gottstein, 2009) and evoke differential electrophysiological and blood-oxygen-level-dependent (BOLD) responses (e.g., Alzueta et al., 2019; Devue & Brédart, 2011; Estudillo, 2017; Estudillo et al., 2018). Correspondingly, there is mounting evidence that reported a distinctive pattern of brain activation during self-face recognition compared to the brain activation patterns when recognizing other people's faces (e.g., Apps et al., 2012; Oikawa et al., 2012; Platek et al., 2006; Sugiura et al., 2012, 2015; Uddin, Kaplan, et al., 2005). Recent evidence has also suggested a potential self-face specific ERP component: the P200 component (see Alzueta et al., 2019, 2020; Estudillo., 2017; Estudillo et al., 2018).

1.3 The Quantitative Differences: An Attentional Advantage for the Self-Face

Despite little variance among the underlying structure of faces, studies suggest a processing bias for the own face compared to other faces. For example, in a classic study, Tong and Nakayama (1999) asked their participants to search for their own face or a stranger's face among different sets of foil faces. The results showed that the self-face was consistently detected faster among distractors compared to a stranger's face. Interestingly, this processing advantage was also evident after hundreds of presentations of the unfamiliar face and with different face orientations (i.e., inverted, three-quarter, and profile views). These findings seem to suggest that humans possess a robust mental representation of their own face that allows them to generalize this representation to inverted and atypical profile views of their own face (Tong & Nakayama, 1999; but see Devue et al., 2009).

However, this study only compared search times for a highly familiar face (i.e., the self-face) with an unfamiliar face. Thus, it is not clear whether the results reflect an SFA or a general robust representation for highly familiar faces (Estudillo, 2012). When controlled for possible familiarity effects, Keyes and Brady (2010) showed that, when compared to personally familiar and unfamiliar faces, participants were still faster and more accurate at identifying self-faces. Furthermore, with a face-name interference paradigm study, Brédart et al. (2006) showed that the detection of a classmate's name is strongly interfered by a flanking self-face compared to the reversed condition, suggesting that self-faces have a stronger tendency to capture attention and are harder to ignore. The SFA has been replicated across different experimental paradigms, such as familiarity judgment (e.g., Tacikowski & Nowicka, 2010), orientation judgement (e.g., Liu et al., 2016; Sui et al., 2006), and face matching (e.g., Malaspina et al., 2016) tasks.

However, some evidence suggests an inconclusive effect of the attentional capture properties of self-face (i.e., SFA). For example, adopting a similar visual search paradigm to that of Tong and Nakayama (1999), Devue et al. (2009) examined whether the prioritization of self-faces among highly familiar and unfamiliar faces is a “truly bottom-up” process: whether observers are able to process facial features without the need to process the facial identity. Hence, observers were required to search for a particular mouth configuration (i.e., M or O) in different types of face display (i.e., self, friend, or unfamiliar), while ignoring face identity. Thus, in contrast to previous studies, face identity was irrelevant in this task. When detecting the target (i.e., the mouth shape), there were no differences in the searching performance between the self-face and a friend’s face. Thus, unlike Tong and Nakayama (1999), Devue et al. (2009) found no evidence of SFA and concluded that this effect is only evident when face identity is task relevant.

With a face word paradigm, Keyes and Dlugokencka (2014) also tested the attentional capture properties of the self-face by presenting the faces (self, friend, and stranger) as a distractor in a word naming task, and faces were presented to either to a central or a peripheral location. The findings revealed that when faces are task-irrelevant, the SFA effect is generally not observed. More specifically, the authors suggested that the observed SFA may be dependent on the allocation of attentional resources to regions where the stimuli are.

Altogether, there is inconclusive evidence on the observed SFA, such that the SFA is often not observed when face identity is task irrelevant or that the SFA could reflect a mere effect of familiarity. These findings would suggest the possibility that there might be other factors modulating the SFA, and Chapter 4 will further explore these potential factors.

1.3.2 Attention and The Self

In most of the studies on self-biases in memory and perception that were reviewed above, the stimuli are often task relevant and would have been presented at attended locations (e.g., at the centre of the visual field). However, there is little understanding on how self-biases are related to attention.

There has been considerable debate over how self-related stimuli gainattentional priority. Some have argued that the SFA may be driven by an association between positive self-evaluation and self-related information which reflects a socio-cognitive mechanism involved in self-processing (e.g., Ma & Han, 2010). Specifically, Ma and Han (2010) had put forth the implicit positive association theory to account for the SFA effect. According to this theory, the SFA could be attributed to the "implicit positive attitudes" that one has towards oneself. The implicit positive association theory was built upon the notion that people tend to have a self-positivity bias (Greenwald, 1980; Watson et al., 2007), wherein they view and evaluate themselves in a favourable and positive manner (see Koole & DeHart, 2007 for a review) and self-face recognition is generally associated with positive self-perceptions (Blackwood et al., 2003). For instance, Epley and Whitchurch (2008) showed that when they morphed photographs of participant's faces with attractive or unattractive faces, participants were more likely to identify the attractive morphs as the own face compared to their actual face or the unattractive morphs. DeBruine (2005) also observed that individuals rated morphs of their faces as more trustworthy compared to morphs of other faces, suggesting that people evaluate unfamiliar faces that resembled the self in a more favourable manner.

Another account is that self-related stimuli receive attentional advantage through motivational neural networks associated with rewards (e.g., Northoff &

Hayes, 2011; Yankouskaya et al., 2017). In a recent study, Ota and Nakano (2021) found that ventral tegmental area that is located in the center of the reward pathway was activated by the presentation of the self-face even when individuals were not aware of the presentation of their own face. This line of evidence provided support to the notion that self-face has a positive reward value for oneself (see also Stolte et al., 2017; Sui et al., 2015; Sui & Humphreys, 2015). In sum, positive self-attributes might be activated when viewing the own face, which could explain an SFA at the behavioural level.

On the other hand, it is suggested that individuals tend to develop more robustly stored representations for familiar faces (e.g., Tong & Nakayama, 1999), reinforced over repeated interactions and high levels of contact (di Oleggio Castello & Gobbini., 2015). These robust representations allow individuals to detect familiar face faster even with reduced attention and in the absence of awareness (Bola et al., 2021; Gobbini et al., 2013; Wójcik et al., 2019). This processing advantage, however, may be affected by the levels of exposure with an individual (Burton et al., 2011; Jenkins & Burton, 2011). For instance, because individuals are constantly in contact with their face, they may have a more robust stored representation of their face compared to other familiar faces. In a similar vein, because of its significance and the extensive visual experience, the self-face might be detected automatically, requiring fewer cognitive resources or little involvement of cortical processing (Geng et al., 2012), altogether accounting for a processing advantage for the own face.

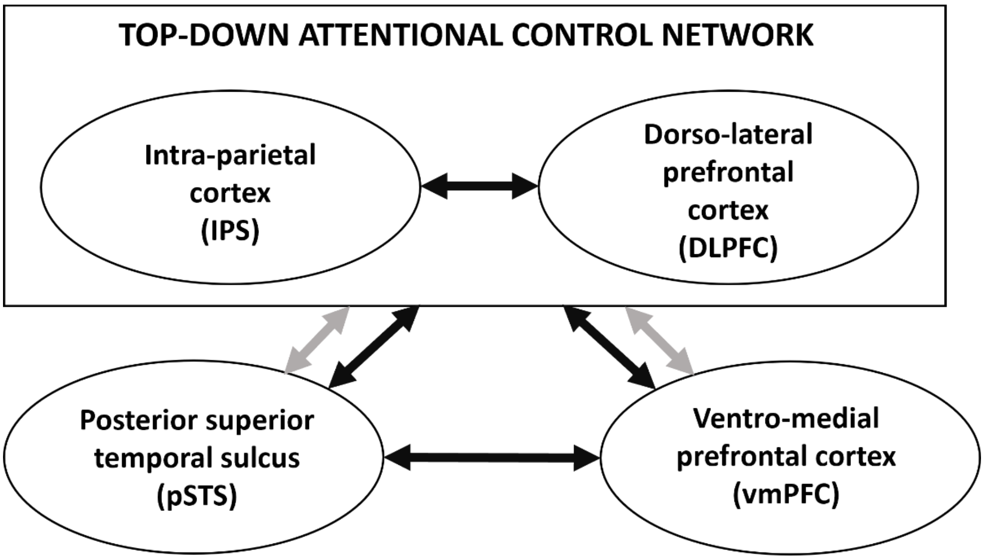
Another interpretation for the attentional advantage for the own face is that the own face processing relies on multisensory information which may lead to a processing advantage compared to other faces. Sugiura (2013) postulated that the recognition of one's own face or body (i.e., self-recognition) relies on the ‘sensorimotor schema’, that is, the combination of information from visual, proprioceptive, and motor information (see also Estudillo & Bindemann, 2017b). In addition, individuals would have years of detailed feedback experiences from the ‘sensorimotor schema’ as humans are ‘the subject of their own cognition’, which consequently results in a highly elaborated and extensive representation of their own image (Li & Tottenham, 2013). Following this notion, studies have suggested that the mental representation of one’s self-face may be enhanced by both the distinct visual experience people have for the self-face and the multisensory information (Tajadura-Jiminez et al., 2012; Tsakiris, 2008).

1.3.2 The Self-Attentional Network

To account for the relationship between self and attention, Humphreys and Sui (2016) proposed the Self-Attentional Network, a neural network consisting of three processing nodes that mediates attention to self-related stimuli. The authors identified three main processing nodes which interact to determine one’s responses to self-referential stimuli, namely (1) a top-down attentional control network consisting of dorsolateral prefrontal cortex (DLPFC) and the intra-parietal sulcus (IPS); (2) the ventro-medial prefrontal cortex (vmPFC) housing the self-representation; and lastly (3) the posterior superior temporal sulcus (pSTS) that is involved in bottom-up visual orienting. The Self-Attentional Network framework is illustrated in *Figure 1.1*.

Figure 1. 1

The Self-Attentional Network



Note. The Self-Attentional Network consist of a top-down attentional network that includes the DLPFC and IPS and a bottom-up network which includes the vmPFC and pSTS. Black arrows indicate an excitatory connection and grey arrows indicate an inhibitory connection. Adapted from Humphreys and Sui (2016).

According to this framework, the self-representations housed in the vmPFC is rapidly activated by any self-related sensory information which in turn activates the pSTS. The excitatory connectivity between vmPFC and pSTS is thought to prime a response bias to self-related items, altogether resulting in a self-bias effect in perception and attention. This bottom-up network (i.e., vmPFC and pSTS) is modulated by a frontoparietal network (i.e., DLPFC and IPS) that acts as an inhibitory control network by allocating attentional resources according to task constraints. This inhibitory control is important as not all events or incoming sensory information are high in self-relevance (Ocampo & Kahan, 2016). Altogether, the Self-Attentional Network model illustrates the interaction between top-down and bottom-up processes consisting of both an attentional control network and the areas involved in self-referential cognition.

Sui and Rotshtein (2019) later updated the Self-Attentional Network model by discussing and evaluating the relationships between self-processing and the three attentional systems put forth by Petersen and Posner (2012), namely the alerting system, orienting system, and executive control. Based on findings with several paradigms, the authors postulated that all components of the attentional system are modulated by self-referencing. Specifically, evidence suggest that self-related stimuli act as efficient endogenous and exogenous cues and increase alertness. Finally, the interaction between self-processing and executive control relies on the task demands involved, contributing to either allowing or supressing self-prioritization. In sum, individuals need to prioritize processing so that stimuli or information that are most relevant are selected for action and through the interaction with the three attentional networks, self-processing acts as a 'global' modulator of the attentional systems (Sui & Rotshtein, 2019).

1.3.3 Is the Own Face just another Familiar Face?

One may also argue that the observed SFA could be accounted for by a simple familiarity effect of the own face (e.g., Bortolon et al., 2017). However, the SFA is reported even when compared to famous (Miyakoshi et al., 2010, Tacikowski & Nowicka, 2010) or friend's faces (Keyes & Brady, 2010; Sui et al., 2009; Sugiura et al., 2008) across face identification tasks. Crucially, the contribution of familiarity effects to the reported SFA seems to be challenged by findings of studies using other highly familiar faces (i.e., close others: spouses, partners, or very close friends) as a control condition. Generally, these studies have also reported an SFA (Cygan et al., 2014; Kotlewska & Nowicka, 2015; Kotlewska et al., 2017).

Furthermore, the reported differences between the self and close others' faces were also observed on a neural level as reflected by ERP components (e.g., Cygan et al., 2014; Kotlewska & Nowicka, 2015) which provides an additional body of evidence that the processing of the own face differs from the processing of highly familiar faces. In a recent study, Alzueta et al (2019) investigated whether the advantages reported for own face processing can be accounted by a mere familiarity effect (i.e., as indexed by the N250 component) and found that recognizing the own face elicited a higher N250 amplitude, followed by a friend's face, then an unfamiliar face, indicating that these three types of faces were processed distinctively as a function of familiarity. Hence, these findings lead the authors to suggest that self-face recognition relies on distinct neural processes compared to other-face recognition and these differences could not be explained by a mere visual familiarity effect (see also Estudillo et al., 2018).

Finally, another line of evidence ruling out the role of familiarity in the SFA comes from studies using newly acquired self-related information (Sui et al., 2012, 2014). In particular, when asked to associate three different identities, namely self, friend, and unfamiliar with three arbitrary stimuli (i.e., geometrical shapes), individuals were still faster in identifying matching pairs of shapes that were associated with the self-label as compared to a friend- or unfamiliar-labelled pairings in a perceptual matching task. Crucially, this finding cannot be attributed to a mere familiarity effect as all shapes were similarly unfamiliar to the participants at the start of the experiment.

1.3.4 Moderators of SFA

On a theoretical basis, whether the self-face should be considered as a unique stimulus with specific characteristics is still a matter of debate (for review, see Estudillo & Bindemann, 2017b; Gillihan & Farah, 2005). Previous lines of studies seem to suggest an advantage in the processing for the self-face stimuli (i.e., processed faster and more accurately) compared to other face stimuli. More specifically, evidence from behavioural (e.g., Geng et al., 2012; Keyes & Brady, 2010; Tong & Nakayama, 1999; Wójcik et al., 2018; 2019) and neural studies (e.g., Alzueta et al., 2019; Devue & Brédart, 2011; Estudillo, 2017; Estudillo et al., 2018; Platek et al., 2006; Sugiura et al., 2012, 2015) postulated that the processing of the self-face seems to differ from the processing of other faces. However, there are studies which showed contradictory results. For instance, Gillihan and Farah (2005) reported inconsistent evidence supporting an SFA, such that there is mixed evidence on the anatomical localization for self-face processing. In a meta-analysis by Bortolon and Raffard (2018), the authors put forward several moderators that could explain the contradictory findings on the self-face advantage.

1.3.4.1 Type of Task Demands

It is suggested that the tasks used for testing SFA, specifically the cognitive functions that the task reflects, may have an influence on self-face processing (Bortolon & Raffard, 2018). Memory and perceptual processes are involved in tasks that require participants to recognize or identify stimulus properties (e.g., tasks which require individuals to determine identity or head orientation), whereas attentional processes are involved in task requiring participants to search for a specific stimulus property (e.g., visual search tasks). These tasks could also be categorized based on whether participants are asked to extract perceptual information (e.g., head angle) or semantic information (e.g., face identity).

In their meta-analysis, Bortolon and Raffard (2018) reported SFA effects for memory and perceptual based identification tasks. In line with previous findings which have suggested a faster reaction time for identifying familiar faces due to a robust mental representation (see Tong & Nakayama, 1999), the self-face may benefit from a more robust mental representation than other familiar faces. Interestingly, no SFA effects were reported for visual search (e.g., Lee et al., 2007) and face detection tasks (e.g., Cygan et al., 2014), suggesting that self-face and other faces are detected at a similar speed when the task relies on attentional processes. Taken together, it seems reasonable to infer that task demands may modulate self-face processing.

1.3.4.2 Cultural Differences in One's Self-Concept

Another factor that seems to play an important role in the SFA is culture. There is consistent evidence demonstrating a varying importance of the self-face across cultures. For instance, using a head orientation judgement task, Sui et al. (2009) showed that British participants responded faster and more accurately to their own face relative to a friend's face. In contrast, such an advantage was not found in Chinese participants. With a similar task paradigm, Liew and colleagues (2011) showed that Chinese participants responded faster to their supervisor's face relative to their own face (i.e., "boss effect"), demonstrating a lost or weakened SFA in the presence of their supervisor. Interestingly, this "boss effect" was, however, not observed in British participants. The "boss effect" suggests how one's self-processing is strongly modulated by the presence of an influential or superior individual (Liew et al., 2011).

In line with these studies, it has been suggested that culture plays a key role in determining one's self-concept, with different self-concept styles for East Asian and Western cultures (Liew et al., 2011). Self-concept or self-construal is generally understood as the way in which people perceive and evaluate themselves (Markus & Kitayama, 1991). Individuals from Western cultures (e.g., White Americans) demonstrate an independent self-concept. In these cases, they tend to be more individualistic, and the self is generally perceived as an autonomous entity (Markus & Kitayama, 1991). East Asians (e.g., Chinese), on the other hand, tend to demonstrate an interdependent self-concept, in which they value the interconnectedness with others and the self is generally conceptualized in terms of its relationships with others and social contexts (Markus & Kitayama, 1991).

It is therefore postulated that individuals with independent self-concepts assign a greater social salience or positive associations to self-relevant stimuli (i.e., self-face) than those with interdependent self-concepts (e.g., Ma & Han, 2009). Thus, independent self-concepts should lead to a stronger attentional bias to self-related stimuli, such as the self-face, and, consequently to a stronger advantage in the processing of self-faces (i.e., SFA). Conversely, as interdependent self-concepts value the interconnectedness with others, self-face might be as relevant as friend's faces, which should diminish the SFA (Sui et al., 2009).

1.3.4.3 A Negative Self-Concept

Finally, in healthy individuals, self-face recognition is generally associated with positive and rewarding self-perceptions (Blackwood et al., 2003) wherein these positive self-biases promote faster behavioural responses to the own face (Ma & Han, 2010). Ma and Han (2010) put forward the implicit positive association theory to explain the SFA from a social cognitive perspective. This theory stems from studies showing that individuals generally respond faster to positive stimuli compared to negative stimuli (Feyereisen et al., 1986; Kirita & Endo, 1995; Ma & Han, 2010). The implicit positive association theory postulates that when viewing the own face, positive self-attributes are activated, which in turn results in faster behavioural responses to the own face (Ma & Han, 2010).

On the other hand, studies have showed that depressed individuals tend to show greater endorsement and recall of negative self-traits and faster reaction times for negative self-related stimuli (e.g., Burke et al., 2015; Fritzsche et al., 2010; Quevedo et al., 2016). Beck’s (1976) widely used cognitive model of depression theorizes that depressed individuals may have a negative self-concept and this negative self-concept influences the perception and interpretation of self-related information (e.g., adjectives describing the self or autobiographical memories) as negatively biased (Beck, 1976; as cited in Gotlib et al., 2004). Consistent with this hypothesis, it is reasonable to infer that one’s self-view would modulate the SFA. Indeed, individuals with low levels of positive self-evaluations were reported to show lesser preferential bias for the own face (i.e., a weakened SFA; Ma & Han, 2010).

In addition, studies have also suggested that depressive individuals are prone to selectively process information related to sadness, showing an attentional bias towards negative emotional stimuli, such as facial expressions (Gotlib et al., 2004). This attentional bias can be interpreted as a mood-congruent bias – “an enhanced coding or retrieval of positive or negative” stimuli corresponding with the individuals’ mood (Dalgleish & Watts, 1990). In fact, there is strong evidence for a mood-congruency effect, wherein depressed individuals show higher recognition of negative materials compared to controls (e.g., Clark & Teasdale, 1982; Lloyd & Lishman, 1975). Depressed individuals also tend to show greater attentional avoidance of positive facial expressions (Hankin et al., 2010) and a negative cognitive thinking style led to faster reaction times to one's sad face compared to one's happy or neutral face (Caudek & Monni, 2013).

In sum, the emerging picture from the aforementioned literature seems to suggest that the attentional advantage for the own face might be modulated one's self-concept. Chapter 4 will specifically explore the modulation effects of cultural effects and depressive personality traits affect a SFA using a visual search paradigm.

1.4 The Qualitative Differences: A Featural Perceptual Strategy for the Self-Face

As aforementioned, the reported processing advantage for the self-face might also be contributed by the extensive amount of visual experience with the own face (e.g., Brédart, 2003; Tong & Nakayama, 1999). Arguably, one may see their friend's faces more often than they see themselves, however, the familiarity with one's own face extends over a long period of time. Besides the global amount of exposure to an own face, it is also important to acknowledge that the way individuals view themselves differs from the way they view others. Specifically, individuals generally perceive other's faces for identification purposes (i.e., identity and expression), whereas individuals perceive the own face for grooming purposes, and one might naturally pay attention to more subtle details (e.g., specific features) when viewing themselves in the mirror.

Although it may be argued that one may also see themselves on photographs and video images, the visual experience of the own face is, however, is mostly acquired from self-inspection in mirrors (Brédart, 2003; Gregory, 2001). The distribution of views for one’s own face is thus generally highly restrictive relative to the views seen for other faces as individuals are only able to view their faces from a frontal view and slight deviations from it through mirrors (Brédart, 2003). The effect of such exposure can be seen through participants’ preference for mirror-reversed images of themselves relative to a non-reversed image. This preference was, however, not found for familiar faces (e.g., Brady et al., 2005; Laeng & Rouw, 2001; Troje & Kersten, 1999). Taken together, these studies suggest that due to the ecological constraints of one’s visual experience for the own face, there is a preference for mirrored views for self-face recognition (Brady et al., 2005).

The distinct visual experience an individual has with their own face may contribute to the own face being processed qualitatively differently to other familiar and unfamiliar faces. In fact, a few studies have pointed toward this direction. For instance, although it has been widely suggested that a face is perceived as a “whole” (i.e., holistically) and not as a collection of individual parts (i.e., featurally), this holistic advantage is not always found for the own face, but rather a featural processing seems to be adopted (see Greenberg & Goshen-Gottstein, 2009). For example, participants are faster creating a mental image of a facial feature of their own face compared to a mental image of facial feature of a familiar face, but slower in creating a mental imagery of the whole own face compared to a whole familiar face (Greenberg & Goshen-Gottstein, 2009). Nevertheless, this evidence is mainly based on subjective measures (i.e., participants’ reports of mental imaging of faces).

In a similar vein, Keyes and Brady (2010) presented evidence that the processing of the own face relies on featural information from a more objective measure: the face inversion task. Inverting a face is known to severely disrupt holistic processing for faces (Rossion, 2008, 2009; Yin, 1969), causing poor recognition. In their study, individuals were faster and more accurate at recognizing their own face over both stranger and friend faces, and these advantages were observed for both upright and inverted orientations (see also Alzueta et al., 2021; Qian et al., 2017). Keyes (2012) later also showed that participants were better in recognizing a self-face morphed with a friend's face compared to an unfamiliar face morphed with another unfamiliar face, regardless of whether the faces were upright or inverted.

Correspondingly, existing sources of evidence from event-related potential (ERP) studies that reported an increased N170 amplitude for the own face are also largely consistent with the position that the own face is processed more featurally (e.g., Caharel et al., 2002; Geng et al., 2012; Keyes et al., 2010). The N170 component is a face-sensitive ERP component which indexes the structural encoding of faces. For instance, a larger N170 is reported when viewing inverted faces, thereby reflecting a more featural processing (e.g., Eimer et al., 2010). In addition, a few studies have shown that when isolated facial features are presented rather than the whole face, a higher amplitude was observed for the N170 component (e.g., Itier et al., 2007; Kloth et al., 2013). Hence, a heightened amplitude of the N170 component for the self-face might reflect that featural processing of facial features is crucial for self-face recognition.

One might ask why the own face is processed qualitatively differently compared to other faces. As aforementioned, these differences in the perceptual analysis might be accounted by the fact that individuals might extract different kind of facial information when viewing the own face and other faces as the processing goals are different. In particular, individuals tend to process another person's face to make judgements of their identity or emotional expressions whereas individuals typically process their face to inspect their facial features (i.e., grooming; see Estudillo &

Bindemann, 2017a, 2017b; Greenberg & Goshen-Gottstein, 2009). In line with this notion, Brédart (2003) postulated that although individuals mainly rely on configurational information when recognizing others, featural (or local) information also plays a role in recognizing themselves and this additional use of featural information may help account for why the SFA persists for inverted faces.

In sum, given the distinct visual experience and different processing goals individuals have with the own face, the own face may be processed in a qualitatively different manner compared to other faces. Chapter 2 will explore the role of holistic and featural processing in own-face processing with eye-tracking measures whereas Chapter 3 will delve into exploring the role of holistic and featural processing in the identification of the own face and other faces, using three standard tests of face holistic processing: a face inversion, a part-whole, and a composite face task.

1.5 Thesis Structure

The aim of this thesis is to further explore the cognitive mechanisms (perceptual and attentional) involved in the processing of the own face. Chapter 2 and Chapter 3 will delve into exploring the perceptual mechanisms involved in own-face processing whereas Chapter 4 will explore two possible moderators for an attentional advantage (i.e., an SFA) for the self-face (i.e., culture and depressive traits).

Firstly, Chapter 2 will explore the role of holistic and featural processing involved in processing the self, friend, and unfamiliar face using eye-tracking measures. The differences in gaze behaviour across faces with different familiarity will be explored in a passive viewing paradigm (Experiment 1) and a face identification task (Experiment 2). Across the two experiments, observers were asked to view a series of face images presented in different horizontal (*normal vs. mirrored*) and vertical (*upright vs. inverted*) orientations. In both experiments, face images were cropped based on the individual contours to include the face shape information.

Next, Chapter 3 explores the role of holistic and featural processing in own-face processing with three standard but largely independent measures of holistic processing (Rezlescu et al., 2017), namely the face inversion task, the composite face task, and the part-whole task. In Experiment 3, participants were asked to identify their own face, a friend's face, and unfamiliar face in three different experimental blocks: (1) inverted vs. upright; (2) top and bottom halves of the face aligned vs. misaligned; and (3) facial features presented in isolation vs. whole foil face context.

Finally, Chapter 4 will explore the role of cultural effects and depressive personality traits on the SFA with a visual search paradigm. A visual search paradigm is used as the paradigm allows one to explore early attentional orientation effects of a target stimuli among an array of interfering stimuli (Tong & Nakayama, 1999). With Experiment 4, the cultural modulation effects on an SFA are explored by asking British Caucasian (i.e., with independent self-concept or individualistic culture) and Chinese Malaysians (i.e., with interdependent self-concept or collectivist culture) participants to search for the own, a friend, and an unfamiliar face among an array of distractor faces. Experiment 5 explores the modulation effects of depressive personality traits on an SFA. Specifically, the SFA is explored across the lower and higher end of depressive personality traits (i.e., a negative self-concept) and participants were asked to search for their face and an unfamiliar face among an array of distractor faces. Lastly, Experiment 6 further explores the modulation effects of depressive traits on SFA while considering the role of emotional valence of stimuli by asking participants to search for the own and unfamiliar face presented in a neutral, happy, and sad expression among other distractor faces.

Chapter 2

A Featural Account for Own-Face Processing: Evidence from Eye-Tracking Study

2.1 Introduction

The own face is strongly tied to one's identity (e.g., Estudillo & Bindemann, 2017a), and the ability to recognize it helps in maintaining a sense of self (Estudillo & Bindemann, 2016, 2017b; Estudillo et al., 2018; Tsakiris, 2008). Being a significant stimulus critical to one's identity and the most relevant face to each individual (e.g., McNeill, 1998), there has been an increased interest in self-face processing in recent years. However, there is little understanding of the cognitive processes involved in self-face processing and, more specifically, whether these processes differ from those for other familiar and unfamiliar faces. Using eye-tracking, this chapter addresses this question by exploring the quantitative and qualitative differences in the visual scanning between the own, familiar, and unfamiliar faces.

2.1.1 Self-Face Processing

Although it is widely accepted that faces are processed at a global or holistic level (Estudillo, 2012; Maurer et al., 2002; Rossion, 2013; Wong et al., 2021), it has been suggested that, compared to other faces, the own face is processed in a more featural manner. For instance, participants are faster at creating a mental image of a facial feature of their own face compared to a mental image of a facial feature of a familiar face, but they are slower in creating a mental image of the whole own face compared to a mental image of the whole familiar face (Greenberg & Goshen-

Gottstein, 2009). The authors hence concluded that the own face is processed in a more featural based manner. In a different study, Keyes and Brady (2010) showed that participants were faster and more accurate at recognizing their own face than friends' and strangers' faces, and interestingly, this processing advantage was observed for both upright and inverted orientations. As inverting a face disrupts the holistic processing of faces (e.g., Rossion, 2009; Yin, 1969), this finding suggests that the processing of own face relies on a more featural processing approach.

It is possible that the distinct visual experiences an individual has with their own and other faces might contribute to these processing differences. For instance, most of the visual experience gathered with the own face is acquired through self-inspection in mirrors (Brédart, 2003; Gregory, 2001) and thus the distribution of views for one's own face is generally restricted to mirror-reversed frontal views (Brédart, 2003). The effect of such exposure can be observed through an individual's preference for mirror-reversed images of the own face compared to non-reversed images. Importantly, this preference was not found for familiar faces (e.g., Brady et al., 2005; Laeng & Rouw, 2001; Troje & Kersten, 1999). Additionally, when people perceive their own and other people's faces, they might have different processing goals. Specifically, whereas individuals tend to perceive the face of other people for identification purposes, they tend to perceive the own face for the detailed inspection of facial features (e.g., grooming purposes; see Estudillo & Bindemann, 2017a, 2017b). Hence, the different demands associated with the perception of the own and other faces might partially explain the processing differences between the own and other faces.

2.1.2 Eye-Tracking Measures in Self-Face Recognition

Eye movements are thought to provide a sensitive measure of visual processing (Henderson, 2003) and an index of the cognitive processes involved in the task at hand (Just & Carpenter, 1980). Fixations are generally referred to as “pauses over informative regions” (Salvucci & Goldberg, 2000), such that these “pauses” are indicative of extracting or encoding information (Poole & Ball, 2006). Amongst the face recognition literature, a specific facial region receiving a higher number of fixations is generally conceived as an indicator of its saliency or its informativeness compared to other fixated regions (Holmqvist et al., 2011). Additionally, the duration of fixation is generally indicative of the amount of time used to process a fixated region (Salvucci & Goldberg, 2000) and a longer fixation duration suggests a greater cognitive exertion when extracting information (i.e., information complexity; Rayner, 1998).

Eye movements are also postulated to indicate the processing style (e.g., Hills, 2018; Rossion, 2008). For example, holistic processing is generally associated with longer central eye fixations to the nose region and between the eyes (e.g., Blais et al., 2008), as this strategy allows for the perception of the facial region as a whole (Van Belle, Ramon, et al., 2010). Featural processing, on the other hand, is implied through a higher number of fixations to individual facial features (e.g., Rossion, 2008). Furthermore, several notable face-scanning strategies have been revealed through eye-tracking studies on face perception. For instance, when viewing faces, most eye fixations land in between the eyes (Hsiao & Cottrell, 2008; Tyler & Chen, 2006), followed by fewer fixations on the mouth and other facial features (Bindemann et al., 2009; Stacey et al., 2005). Conversely, studies have shown that prosopagnosic patients who rely on featural processing directed more eye fixations to the mouth instead of to the eyes (e.g., Bukach et al., 2006; Orban de Xivry et al., 2008; Ramon et al., 2010).

In recent years, a growing literature has explored the differences in gaze behaviour when looking at the own face compared to other faces. For instance, using eye-movement measures, Chakraborty and Chakrabarti (2018) asked participants to identify their own face from a series of self-other face morph images. Participants made longer fixations to the lower part of the self-face compared to other faces, whereas no differences were reported for the upper part of the face. Although these results may indicate a peculiar visual scanning strategy for the own face, this study compared the gaze behaviour between the self-face and an unfamiliar face, so the reported effects could be confounded with simple familiarity effects (see Estudillo, 2012). Furthermore, the face stimuli were presented at the centre of the screen which could lead to the initial fixation to coincide with the centre of the face (Bindemann et al., 2009).

In another study, Hills (2018) recorded the eye movements of children aged between 6 to 11 years when asked to perform a familiarity judgement task with the own, a familiar, and an unfamiliar face. The findings showed that the own face received significantly more fixations which were directed to the diagnostic facial features (i.e., eyes, mouth, and nose), altogether suggesting an overall enhanced use of featural processing for the self-face compared to other faces. Contrary to holistic processing, featural processing is generally associated with a higher number of short fixations to each feature (Bombari et al., 2009) and such a fixation pattern has also been observed when participants viewed inverted images (e.g., Hills et al., 2013). Interestingly, the self-face and the familiar face also received longer central fixations than the unfamiliar face, suggesting an enhanced use of holistic processing for familiar faces (see Blais et al., 2008; Van Belle, Ramon, et al., 2010). These findings indicate that the processing of the own face employs both holistic and featural processing and this dual strategy ensures that the self-face is processed efficiently (Hills, 2018). However, as this study was only conducted with children, it is unknown whether the observed effects reflect adult-like face processing strategies or, in contrast, are a consequence of immature face processing strategies (Hills & Lewis, 2018). In fact, some research has found that fixation duration to natural scenes decreases with age and salient features have a stronger influence on children compared to adults (Helo et al., 2014).

Other studies have not found different visual-scanning strategies for the self and other faces. For example, Kita et al. (2010) asked participants to watch a morphing movie (e.g., self-face gradually changing into a familiar face) and to respond when they thought that the initial face image had morphed into a target face image. Although self-face evoked increased oxyhaemoglobin levels in frontal areas of the brain, they found no difference in the fixation count and fixation duration across face image conditions. The authors suggested that irrespective of face identity, individuals employ similar strategies when sampling facial information. However, this information is later processed differently wherein the oxyhaemoglobin activity around the right inferior frontal gyrus changes across face identities, with increased activity in the self-face condition compared to the familiar face condition (Kita et al., 2010).

Two reasons might help explain the lack of consistency across the findings of the aforementioned studies. First, several studies above (e.g., Chakraborty & Chakrabarti, 2018; Hills, 2018) did not mention if the self-images were presented in a mirror-reversed or normal orientation. Experience with the own face is mostly gathered through mirrors (i.e., in a mirror-reversed orientation). Thus, when someone is presented with a photograph of their own face, the face image is always flipped (i.e., normally oriented) compared to the usual mirror-reversed version of themselves that they see in the mirror. Consequently, photographs of one's own face misplace facial asymmetries (Frautschi et al., 2021) which affects self-perception (see Lu & Bartlett, 2014). In fact, individuals prefer mirror-reversed images compared to normally oriented images of the own face and this effect is not found in familiar faces (Brady et al., 2005; Brédart, 2003). Therefore, to ensure ecological validity, it is important to record eye movements when viewing a mirror-reversed image of the own face as this view more closely corresponds to the visual experience people have with the own face (i.e., when looking in the mirror).

Second, the lack of consistency across studies could also be explained by the different task demands employed across these studies (Kita et al., 2010). In line with this notion, Stacey et al. (2005) reported that the effects of familiarity on face processing were influenced by the type of task demands imposed. More specifically, for tasks requiring the involvement of higher cognitive load (i.e., memory), such as recognition or familiarity judgement tasks, an individual's attention window narrows, allowing only limited information to be processed, whereas, under low demand tasks, attention can be widely dispersed throughout a scene.

The sensitivity of eye-movement behaviour to task constraints has been well-established in previous face-recognition and face perception studies. For instance, Cook (1978) observed different visual sampling behaviours depending on whether participants were asked to memorize a series of faces or to recognize them. Additionally, Walker-Smith et al. (1977) observed differences in eye-movement behaviour of participants when asked to match either simultaneously or successively presented face images. Taken together, different patterns of gaze behaviour would be expected under different task demands, as eye movements are thought to be goal-directed and vary according to task constraints (Henderson, 2003). Consequently, one might expect that the processing of the own face is modulated by the type of task employed. Indeed, Bortolon and Raffard (2018) took the view that self-face processing may be influenced by the type of task used for testing a self-face advantage (SFA). In their meta-analysis, the authors reported SFA effects for memory and perceptual based identification tasks (i.e., determine face identity or head orientation), whereas no SFA effects were reported for tasks which involve attentional processes (i.e., visual search or face detection tasks). Based on these discussed studies, it seems reasonable to hypothesize that task demands may modulate one's self-face processing.

2.1.2 The Current Study

With two different experiments, Chapter 2 aims to explore the role of holistic and featural processing in the processing and the recognition of own, familiar, and unfamiliar faces using the eye-tracking technique. Rather than restricting eye movements to a specific task demand, Experiment 1 used instead a free-viewing task to observe spontaneous eye-movement behaviour while exploring the own face and other faces. A free-viewing task was used as passive viewing of faces might imply a more direct index for face processing compared to task-oriented viewing of faces (Scott et al., 2005). In particular, recognizing a face in our daily lives is more often accompanied by a 'passive' recognition, wherein a facial representation is activated briefly after unintended perception of a face rather than by an 'active' recognition, wherein sustained attention is required to focus on a representation of a face (Sugiura et al., 2000) which typically occurs in task-oriented viewing of faces.

Therefore, to explore this aim, participants were presented with one face (self, friend, or unfamiliar) at a time and were asked to freely explore the images. Finally, to complement the free-viewing data, visual scanning behaviour for faces under the confinement of tasks was considered in Experiment 2; that is, participants were asked to make overt responses by judging the identity of faces with differing levels of familiarity.

2.2 Experiment 1

With eye-tracking measures, Experiment 1 was conducted to explore the role of holistic and featural processing of the own face and other faces in a free-viewing paradigm. This paradigm also allowed us to examine the relevance of each facial feature for each of the three different identities by quantifying the facial features fixated through the number of fixations and average fixation duration without the restriction of task demands. Based on the literature on eye-tracking measurements and evidence suggesting that featural processing supports self-face recognition (e.g., Greenberg & Goshen-Gottstein, 2009), it is expected compared to other faces, the self-face would receive a higher number of fixations and longer fixations. Additionally, it is possible that most of these fixations are directed to mouth areas, as some studies with prosopagnosic patients have shown that featural processing is associated with more fixations to mouth compared to eyes (e.g., Bukach et al., 2006; Ramon et al., 2010). For both friend and unfamiliar faces, a fixation pattern indicative of holistic processing and longer fixations to the nose area was expected (see Van Belle, de Graef, et al., 2010).

Experiment 1 also manipulated the vertical orientation of face images. Previous studies had consistently shown that inverted faces receive more fixations than upright faces due to a more featural based processing for inverted faces (e.g., Hills et al. 2013; Van Belle, Ramon, et al., 2010). Hence, it is also expected that there would be a higher number of fixations for the inverted friend face and unfamiliar face compared to when these faces would be being presented in an upright manner. However, if the own face is processed in a more featural manner than other faces, it is expected that the self-face would receive similar number of fixations across its upright and inverted versions.

Finally, as the experience that one has with their face is mostly through mirrors, Experiment 1 also manipulated the horizontal orientation (i.e., normal orientated or mirror-reversed) of the face images. Studies have shown that compared to an unfamiliar face, participants preferred mirror-reversed images of their own face compared to normally oriented images (e.g., Brady et al., 2005; Laeng & Rouw, 2001).

Overall, for Experiment 1, the own face is expected to be sampled in a more featural manner with an overall higher number of fixations and longer fixation durations, and to show no inversion effect. Conversely, the friend and unfamiliar faces are expected to be sampled in a more holistic manner with an overall lesser number of fixations and shorter fixation durations compared to the own face, and to show an inversion effect.

2.2.1 Method

2.2.1.1 Participants

Thirty Malaysian[1] participants (4 males; M_{age} = 20.53, *SD* = 2.03) were recruited from the University of Nottingham Malaysia. All participants were recruited in pairs matched by age, gender, and ethnicity, so each of them served as the friend for the other. The pairs had to have known each other for at least 6 months and have met at least once a week. All participants had normal or corrected-to-normal vision. All participation was completely voluntary, and all gave informed consent after experimental procedure had been fully understood. Participants either received course credit or RM5 for their contribution. Ethics approval for the study was obtained from the Science and Engineering Research Ethics Committee of the University of Nottingham Malaysia.

2.2.1.2 Apparatus

A desktop mounted EyeLink 1000+ eye-tracking system with a sampling rate of 1000 Hz was used. The eye tracker was positioned under the display screen at a distance of 75 cm from the participant. Participants were asked to position their head on a chin rest to minimize head movements.

2.2.1.3 Stimuli.

Photograph stimuli (self and friend faces) were individually tailored for each participant. Each participant was photographed under similar conditions (i.e., constant lighting conditions and a uniform grey background). Different images were used for

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[1] Based on the effect size from previous research (i.e., η_p^2 = .11, Hills, 2018) and an alpha of .05, a power analysis performed in G*Power 3.1 (Faul et al., 2007) gives a required sample size of 28 participants to achieve 80% power.

each identity to reduce image-specific learning. Participants were photographed in a frontal position while assuming neutral and happy expressions and articulating three different speech sounds (i.e., A, O, and E; see *Figure 2.1a*). All five different images were used as "self-face" for the participants themselves and as "friend's face" for their friend, respectively. Six separate individuals (three males and three females) matched in age and race were photographed under similar conditions to be used as "unfamiliar faces". These unfamiliar faces were counterbalanced across each participant. Each participant's stimulus set consisted of three sets of identities: one self-face (5 different images × 2 *inversion* × 2 *orientation*), one friend's face (5 different images × 2 *inversion* × 2 *orientation*), and one unfamiliar face (5 different images × 2 *inversion* × 2 *orientation*).

Using Adobe Photoshop CS6, all photographs were resized to 401 x 562 pixels, corresponding to an approximate visual angle of 8.09° horizontally and 11.32° vertically at a viewing distance of 75 cm. All photographs were rotated to ensure eyes were horizontal .All face stimuli were being cropped based on their individual contours to ensure that face shape information was available to participants. Each face image was saved in an upright, normal; upright, mirror-reversed; inverted, normal; and inverted and mirror-reversed version (see *Figure 2.1b*).

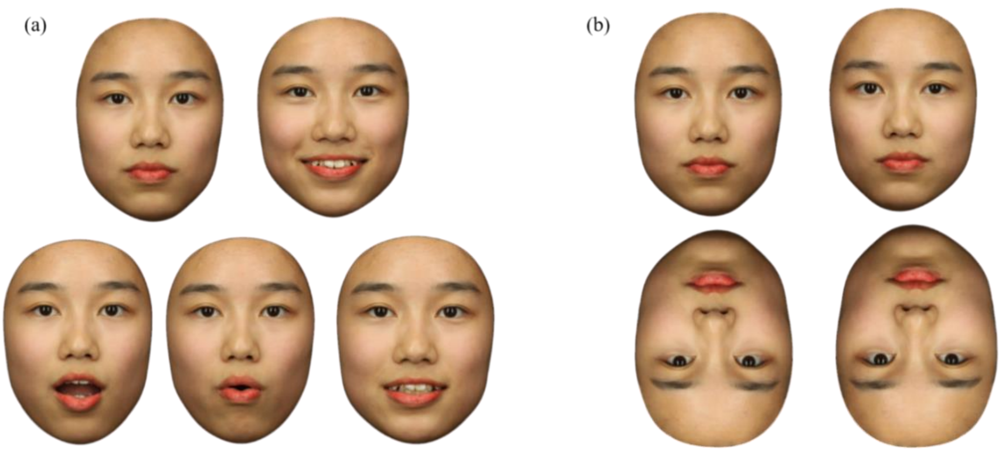
Images were flipped vertically downwards to create an inverted image and flipped horizontally across to create a mirror-reversed version. *Figure 2.2* and *Figure 2.3* are illustrated to clarify why the inverted images were flipped vertically downwards instead of rotated a 180°. Some might argue that flipping the image vertically will provide with us a mirror-reversed image, however, when images are flipped vertically (i.e., using the 'flipped vertically' function in Adobe Photoshop), the horizontal orientation of the image, would in fact, be maintained. As depicted in

Figure 2.2, after flipping the *Upright & Normal* image vertically, the blue box on the left remains on the left in the *Inverted & Normal* image, and the horizontal orientation of the face image is maintained. Likewise, the horizontal orientation of a face stimuli is reversed when the *Upright & Normal* image is flipped horizontally (i.e., creating a mirror-reversed image of the original image). However, as shown in *Figure 2.3*, if we were to rotate the *Upright & Normal* in 180°**,** the blue box would end up on the right side of *the Inverted & Normal* image. In other words, the horizontal orientation of the face stimuli would have been reversed. Hence, images are flipped vertically (instead of rotating it with a 180°**)** to create the inverted images in order to maintain the horizontal orientation of the face stimuli.

Finally, all images were collected and processed at least one week before the experimental session.

Figure 2. 1

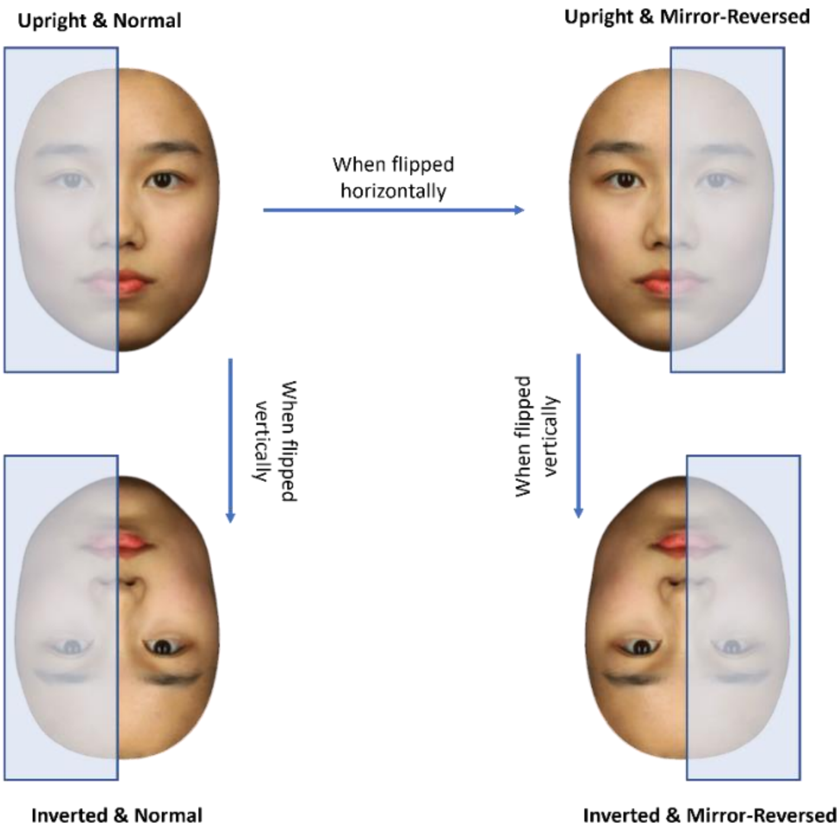
Example of Face Stimuli used in Experiment 1.



Note. (a) The five different images of each identity: from top left: “neutral” and “happy”; from bottom left: “A”, “O”, and “E” expression; (b) an example of a face image presented in two different inversion conditions and two different orientation conditions. From top left: upright and normal; mirror-reversed and normal; from bottom left: inverted and normal, and inverted and mirror-reversed.

Figure 2. 2

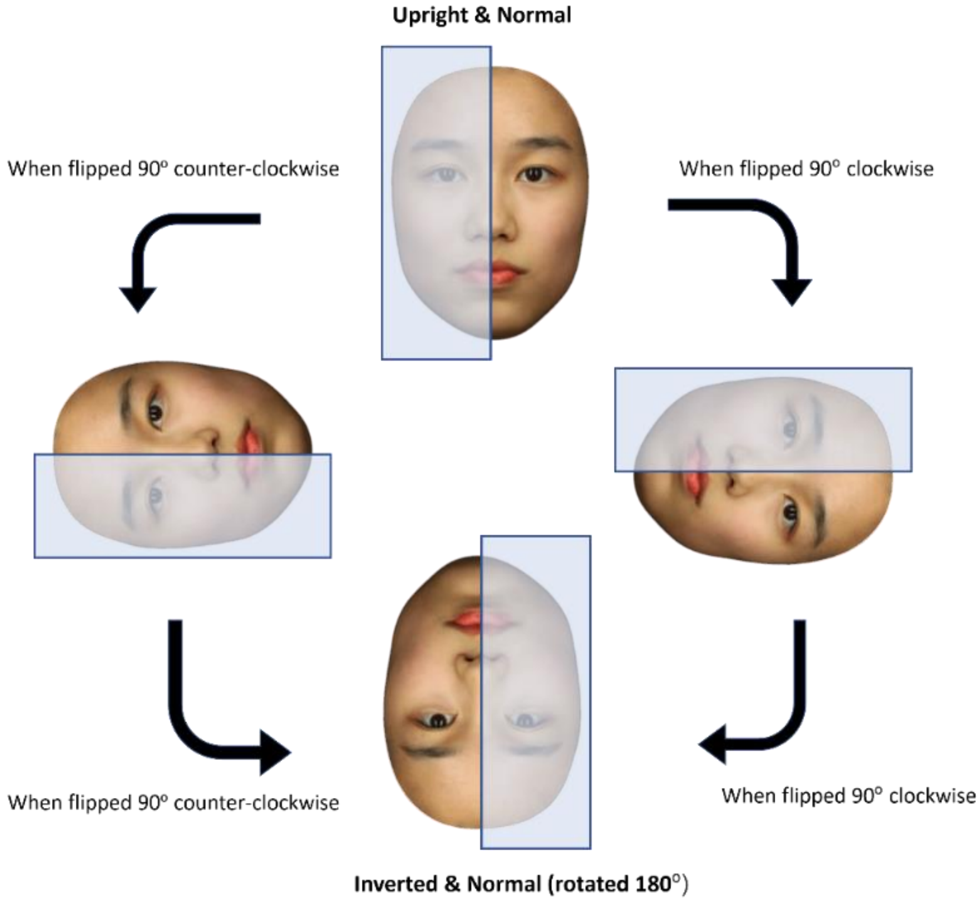
Upright and Normal Images Flipped Vertically and Horizontally



Note. The Upright & Normal image being flipped vertically downwards to create an Inverted and Normal image with the horizontal orientation of the face maintained (i.e., blue box on the left of Upright & Normal remains on the left of Inverted & Normal).

Figure 2. 3

Upright and Normal Image Rotated at a 180°



Note. The Upright & Normal image being rotated 180° to create an Inverted and Normal image but the horizontal orientation of the face stimuli have been reversed (i.e., blue box on the left of Upright & Normal end up on the right of Inverted & Normal).

2.2.1.4 Procedure

After giving their informed consent, participants were individually tested in a dimly lit room. At the beginning of the experiment, the standard nine-dots EyeLink calibration procedure was performed. This calibration was later validated with a second sequence of nine fixations. Calibration was repeated if the latter showed low measurement accuracy.

Each trial began by asking participants to fixate on a single centred dot with an automatic drift correction. The experimenter pressed a button to initiate a trial when participants were seen to be fixating on the dot. Participants would first see an average face mask (i.e., a mask created by morphing few faces together to create an 'average' face) being presented to a similar location as the target face. The average face mask was only removed when participants fixated on its location and the target face would then be made visible to the participants to ensure that participants are fixating at the face stimulus and is engaging with the task Target face stimulus was randomly presented to either the top or bottom location of the screen. This method ensures that the critical face regions did not coincide with the centrally presented fixation cross at the beginning of each trial. Each target face stimulus was displayed for 3000 ms. Participants were asked to freely explore the presented face images and feedback was provided when participants' gazes would leave the screen.

Each participant completed a total of 120 trials (60 trials per block) with the four combinations of orientation and inversion of the five expressions of the three face identities being displayed twice. The presentation of trials was also counterbalanced across face identity, inversion, and orientation, respectively. The experiment lasted for approximately 15 minutes, and participants were given a short break between the two blocks, followed by a recalibration phase.

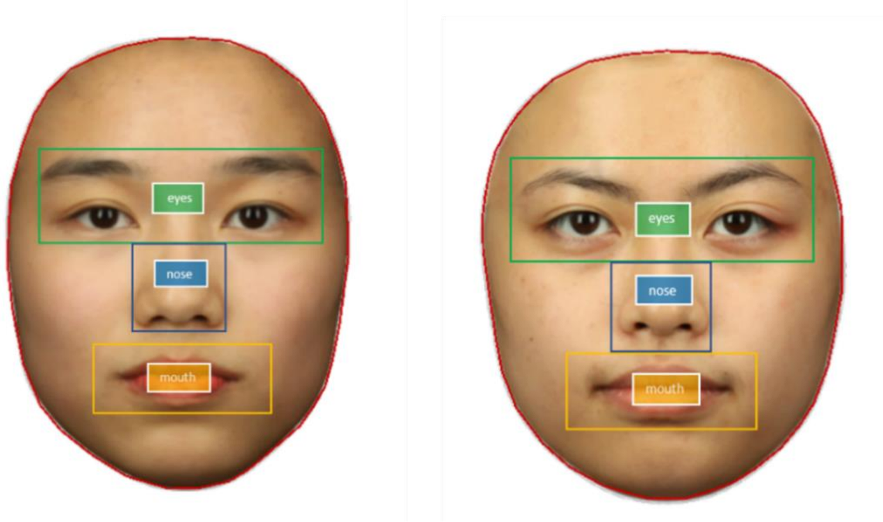
2.2.1.5 Data Analyses

Eye-movement data were processed from the target face onset to aggregate the total number of fixations, their locations, and their durations. Short continuous fixations (i.e., shorter than 80 ms) were combined with the following fixations if they would fall within half a degree of the visual angle; otherwise, the fixation was excluded. Such short fixations were excluded due to the possibility of incorrect saccade planning and less likely to reflect meaningful processing of information (Pollatsek et al., 1984). For cases where an eye blink took place, its duration was integrated with the immediately preceding fixation, as information processing is unlikely to pause during a blink (Pollatsek et al., 1984).

Predefined Area of Interest (AOI) was generated individually for each face image, such that they outlined a region for the eyes, nose, mouth, and rest of the face (see *Figure 2.4*). The location of all AOIs were identical across all presented face stimuli. As each face consists of a different face shape and different speech configurations, the AOI for the facial features differed across each individual (see *Figure 2.4*). Due to differences in size among facial features, the dimension of each AOI differs within and between faces. Hence, any fixation data could simply reflect the relative size of the AOIs rather than the interest region held by an observer (see Bindemann et al., 2009). To address this issue, area-normalization for the fixation data was performed by dividing the proportion of fixations to an AOI by the size of the AOI (i.e., the total area of the screen occupied by a particular AOI). This procedure normalizes the size of each AOI so that a score larger than one indicates that the AOI is specifically targeted (see Fletcher-Watson et al., 2008). This normalization adjustment was only conducted for analysis of the raw data involving “facial features.”

Figure 2. 4

Predefined Area of Interests (AOIs) for Face Stimulus.



Note. An example of two different face stimuli used in Experiment 2 with its predefined AOIs: a) eyes; b) nose; c) mouth; and d) rest of the face.

All raw eye-tracking data (number of fixations and fixation duration) over the predefined AOIs within each face were collected for each trial. For each face presentation, the number and duration of fixations for each AOI were aggregated and summed, and later averaged across faces to provide indices of an average total number of fixations and fixation duration for each AOI.

A general analysis of the average total number of fixations and average total fixation duration was conducted using a 3 (identity: self (*SF*), friend (*FF*), and unfamiliar (*UF*)) × 2 (inversion: inverted vs. upright) × 2 (orientation: mirror-reversed vs. normal) repeated-measures ANOVA. Next, to assess the extent to which specific features were looked at when viewing different identities, the normalized scores for the number of fixations and fixation duration were analysed with a 3 (identity: SF, FF, and UF) × 2 (inversion: inverted vs. upright) × 2 (orientation: mirror-reversed vs. normal) × 4 (features: eyes, nose, mouth, and others). All post-hoc analyses were

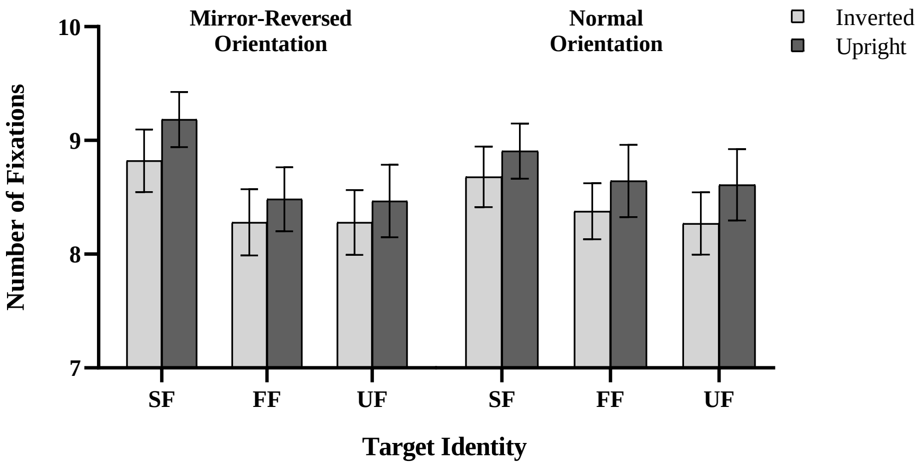
Holm-Bonferroni corrected. Additionally, for all analyses with the variable 'features', the Mauchly's test of sphericity showed significance, thus Huynh-Feldt corrections were applied to correct the degrees of freedom.

2.2.2 Results

2.2.2.1 Average Total Number of Fixations. *Figure 2.5* presents the average total number of fixations across conditions. A 3 × 2 × 2 repeated-measures ANOVA, with the variables: identity, inversion, and orientation, was conducted on the average total number of fixations received by each face. The left side of Table 1 reports the detailed ANOVA results. The analysis revealed a significant main effect for identity, with Holm-Bonferroni corrected pairwise comparisons indicating the SF (M = 8.90, SD = 1.40) being fixated upon significantly more than FF (M = 8.45, SD = 1.55; p = .006, d = 0.62) and UF (M = 8.41, SD = 1.62; p = .008, d = 0.60) but no significant difference between FF and UF (p = 1.00, d = 0.05). The main effect of inversion was also significant, with the upright faces (M = 8.72, SD = 1.57) receiving more fixations than inverted faces (M = 8.45, SD = 1.54). There was no significant main effect of orientation and no significant interactions.

Figure 2. 5

The Average Total Number of Fixations for Different Identities (Exp. 1).



Note. The average total number of fixations received by faces for each identity (SF, FF, and UF) across different inversion and orientation conditions. Error bars represent standard error of the mean.

Table 2. 1

Statistical Analysis of Average Total Number of Fixations and Average Total Fixation Duration corresponding to Identity, Inversion, and Orientation (Exp. 1).

Variables	Average Total Number of Fixations			Average Total Fixation Duration		
	df	*F*	η_p^2	*df*	*F*	η_p^2
Identity	2, 58	7.73***	.21	2, 58	2.99	.09
Inversion	1, 29	16.81***	.37	1, 29	3.80	.12
Orientation	1, 29	0.004	.00	1, 29	0.27	.01
Identity x Inversion	2, 58	0.004	.001	2, 58	0.73	.03
Identity x Orientation	2, 58	1.79	.06	2, 58	0.38	.01
Inversion x Orientation	1, 29	0.04	.001	1, 29	0.01	.00
Identity x Inversion x Orientation	2, 58	0.30	.01	2, 58	0.58	.02

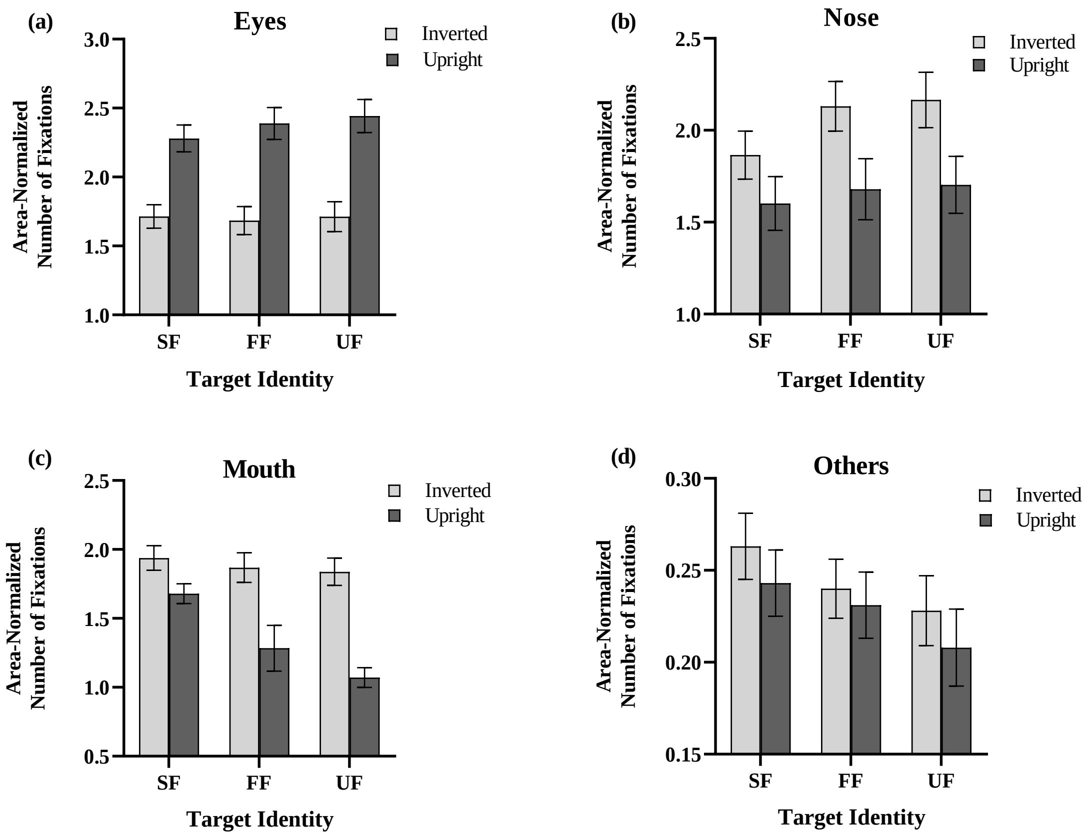
***$p < .001$, ** $p < .01$, *$p < .05$

For the following analysis, the main effects of identity, inversion, and orientation and the interactions between them will not be described, as they have already been described in the previous analysis. Instead, only significant main effects of the factor AOI or interactions between the AOI and previously described factors will be reported.

Figure 2.6 presents the normalized average total number of fixations for each feature AOI across different factors. A 3 × 2 × 2 × 4 repeated-measures ANOVA, with the variables: identity, inversion, orientation, and features, was conducted on the normalized scores for the number of fixations. The detailed ANOVA results are summarized on the left side of *Table 2.2*. A main effect of features was found, which was qualified by a significant interaction with the identity factor. Simple main effects analyses followed by Holm-Bonferroni corrected pairwise comparisons revealed that the nose was fixated more often in FF (M = 1.90, SD = 0.88) and UF (M = 1.93, SD = 0.90) compared to SF (M = 1.73, SD = 0.81). In contrast, the mouth was fixated more often in SF (M = 1.61, SD = 0.51) compared to FF (M = 1.48, SD = 0.52) and UF (M = 1.45, SD = 0.52). The rest of the face was fixated significantly more on SF (M = 0.25, SD = 0.11) than UF (M = 0.22, SD = 0.12). Finally, there were no significant differences in the number of fixations for the eyes across all three identities (see *Table 2.3*).

Figure 2. 6

Area-normalized Average Total Number of Fixations across Each Facial Feature (Exp. 1).



Note. Area-normalized average total number of fixations received by (a) eyes, (b) nose, (c) mouth, and (d) other facial regions for each identity across different inversion conditions. The orientation factor is collapsed across each AOI. Error bars represent the standard error of mean.

Table 2. 2

Statistical Analysis of Average Total Number of Fixations and Average Fixation Duration corresponding to Features, Identity, Inversion, and Orientation (Exp. 1).

Variables	Average Total Number of Fixations			Average Total Fixation Duration		
	df	*F*	η_p^2	*df*	*F*	η_p^2
Identity	-	-	-	2, 58	9.80***	.25
Inversion	-	-	-	1, 29	43.55***	.60
Orientation	-	-	-	1, 29	43.121***	.60
Features	1.42, 41.20	90.75***	.76	1.57, 45.56	67.44***	.74
Features x Identity	4.47, 129.69	3.81**	.12	3.57, 103.62	7.99***	.22
Features x Inversion	1.35, 39.02	26.63***	.48	1.78, 51.53	11.87***	.29
Features x Orientation	1.95, 56.44	0.28	.01	1.43, 41.32	22.16***	.43
Features x Identity x Inversion	4.41, 127.73	1.49	.05	4.30, 124.59	23.26***	.45
Features x Identity x Orientation	4.42, 122.33	0.37	.01	3.66, 106.19	19.21***	.40
Features x Inversion x Orientation	1.63, 47.17	2.32	.07	2.04, 59.06	24.00***	.45
Features x Identity x Inversion x Orientation	4.66, 135.22	1.70	.06	4.41, 127.90	23.16***	.44

Note. Huynh-Feldt corrections were applied to the *d.f.* for all analyses with the ‘features’ variable; ***$p < .001$ ** $p < .01$ *$p < .05$

Table 2. 3

Simple Main Effect Analysis of Identity Considered at Each Level of Features on the Average Total Number of Fixations (Exp. 1).

Simple Main Effects of *Identity* at each level of:				
Features	*df*	*F*	η_p^2	Pairwise Comparisons
Eyes	2, 58	1.39	.05	-
Nose	2, 58	4.07*	.12	SF < FF (*p* = .04, *d* = -0.49) SF < UF (*p* = .05, *d* = -0.46) FF = UF (*p* = 1.00, *d* = -0.06)
Mouth	2, 58	4.68*	.14	SF > FF (*p* = .03, *d* = 0.43) SF > UF (*p* = .04, *d* = 0.51) FF = UF (*p* = 1.00, *d* = 0.09)
Others	2, 58	4.12*	.12	SF = FF (*p* = .52, *d* = 0.26) SF > UF (*p* = .04, *d* = 0.47) FF = UF (*p* = .30, *d* = 0.31)

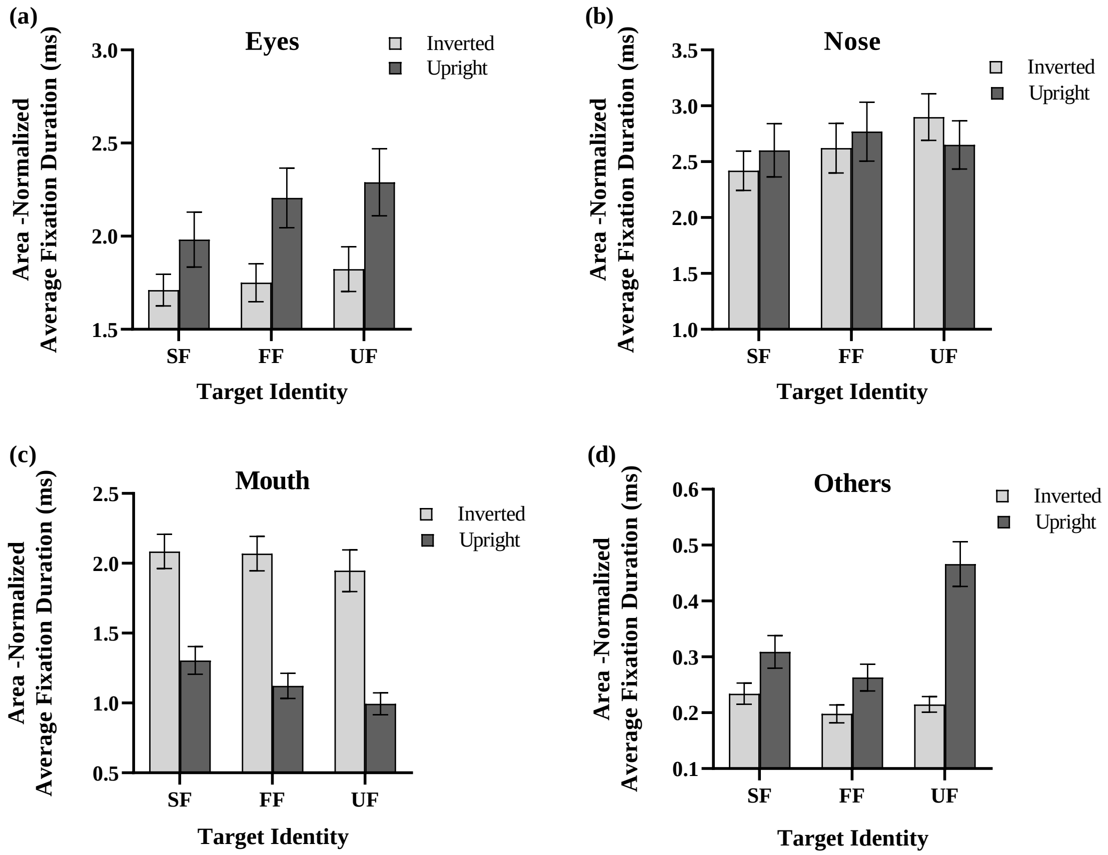
***$p < .001$ ** $p < .01$ *$p < .05$

2.2.2.2 Average Total Fixation Duration. A 3 × 2 × 2 repeated-measures ANOVA, with the variables: identity, inversion, and orientation, was conducted on the average total fixation duration. This analysis revealed no significant main effects and interactions. The summary of the ANOVA results is presented on the right side of *Table 2.1*.

Figure 2.7 presents the area-normalized average total fixation duration to each feature AOI across all factors. A 3 × 2 × 2 × 4 repeated-measures ANOVA, with the variables: identity, inversion, orientation, and features, was conducted on the normalized scores for the average total fixation duration. The summary of the ANOVA results is presented on the right side of *Table 2.2.* The analysis revealed a significant main effect of features, which was qualified by a significant interaction with the factors: identity, inversion, and orientation respectively, and was further qualified by a four-way interaction between these factors. A simple main effect analysis followed by Holm-Bonferroni corrected comparisons revealed that the eyes were fixated longer on both FF (*M* = 1.98, *SD* = 0.77) and UF (*M* = 2.06, *SD* = 0.86) compared to SF (*M* = 1.85, *SD* = 0.68) and were also fixated longer across upright faces (*M* = 2.16, *SD* = 0.93) than inverted faces (*M* = 1.76, *SD* = 0.60). Next, the nose was fixated longer for a mirror reversed UF in inverted condition (*M* = 2.90, *SD* = 1.27) compared to in an upright condition (*M* = 0.01, *SD* = 0.001). The mouth was fixated longer on SF (*M* = 1.70, *SD* = 0.70) compared to FF (*M* = 1.60, *SD* = 0.62) and UF (*M* = 1.47, *SD* = 0.67) and was also fixated longer on inverted faces (*M* = 2.03, *SD* = 0.78) compared to upright faces (*M* = 1.14, *SD* = 0.55). Finally, the rest of the face was fixated longer for both an upright SF (*M* = 0.31, *SD* = 0.17) and an upright UF (*M* = 0.46, *SD* = 0.25) compared to in an inverted SF (*M* = 0.23, *SD* = 0.12) and an inverted UF (*M* = 0.22, *SD* = 0.10), whereas for normal oriented faces, the rest of the face was fixated for a longer duration on SF (*M* = 0.27, *SD* = 0.15) compared to FF (*M* = 0.22, *SD* = 0.11; see *Table 2.4).*

Figure 2. 7

Area-normalized Average Total Fixation Duration for Each Facial Feature (Exp. 1).



Note. Area-normalized average total fixation duration received by (a) eyes, (b) nose, (c) mouth, and (d) other facial regions for each identity across different inversion and orientation conditions. The orientation factor is collapsed across each AOI. Error bars represent the standard error of mean.

Table 2. 4

Significant Simple Main Effects of Identity, Inversion, and Orientation Considered at Each Level of Features on the Average Total Fixation Duration (Exp. 1).

Simple main effects of *Identity*, *Inversion*, and *Orientation* at each level of

Features	Sig. factors /interactions	*df*	*F*	η_p^2	Pairwise Comparisons
Eyes	Identity	2, 58	6.20**	.18	SF < FF (*p* = .04, *d* = -0.46) SF < UF (*p* = .02, *d* = -0.55) FF = UF (*p* = .18, *d* = -0.25)
	Inversion	1, 29	5.27*	.15	upright faces > inverted faces
Nose	Identity x Inversion x Orientation	2, 58	39.07***	.57	inverted, mirror-reversed, UF > upright, mirror-reversed, UF
Mouth	Identity	1.97, 57.07	7.02**	.20	SF > FF (*p* = .02, *d* = 0.32) SF > UF (*p* = .01, *d* = 0.60) FF = UF (*p* = .08, *d* = 0.42)
	Inversion	1, 29	39.69**	.58	inverted faces > upright faces (*p* < .001)
Others	Identity x Inversion x Orientation	2, 58	18.82**	.39	upright SF > inverted SF (*p* < .05, *d* = 0.43) upright UF > inverted UF (*p* < .001, *d* = 1.12) normal oriented SF > normal oriented FF (*p* = .01, *d* = 0.58)

***p < .001 ** p < .01 *p < .05

2.2.3 Discussion

Findings from Experiment 1 can be summarized as follows: when asked to explore the faces, (1) the own face received a greater number of fixations compared to a friend’s face or an unfamiliar face; however, both the own face and friend’s face were fixated on for a longer duration than the unfamiliar face. Next, (2) there is no evidence supporting an inversion effect (i.e., higher number of fixations to inverted faces compared to upright faces) across all faces, such that upright faces were fixated more and longer compared to inverted faces. Lastly, (3) the mouth feature received more fixations and is fixated longer in one's own face than in other faces.

The self-face was sampled more compared to a friend and unfamiliar face, and it was also fixated for a longer duration compared to an unfamiliar face. Whereas a higher number of fixations may indicate that individual features of the own face are sampled more (Hills, 2018), longer fixation durations may suggest a difficulty in disengaging attention from the own face (Devue et al., 2009). Notably, there were no differences between the fixation duration for the own face and the friend's face. Next, contradicting previous studies that had shown an increased number of fixations for inverted faces due to the disruption of holistic processing for faces (i.e., an inversion effect; Rossion, 2008, 2009; Yin, 1969), Experiment 1 did not observe such gaze pattern for inverted faces across all three identities, such that upright faces were fixated with a higher number of fixations and a longer fixation duration compared to inverted faces. To compensate for the disruption in the extraction of holistic facial information in an inverted face, a more featural "scan path" is employed to extract the necessary structural facial information slowly and partially for recognition purposes (see Barton et al., 2006). Following this line of reasoning, it is postulated that, as free-viewing tasks do not require any extraction of facial information, such a viewing pattern was not observed for the inverted faces.

Additionally, compared to the friend and unfamiliar face, the nose was fixated with a lesser number of fixations whereas the mouth was fixated with a higher number of fixations and a longer fixation duration on the own face. Long central fixations to the nose denote holistic processing of faces (e.g., Hills, 2018; Van Belle, de Graef, et al., 2010), but a higher number of fixations to the mouth might indicate a more featural based processing of faces (e.g., Bukach et al., 2006; Ramon et al., 2010). These findings may suggest that when exploring faces, observers employ a more featural based processing with their own faces than with a friend's or an unfamiliar face. Conversely, Experiment 1 showed a similar viewing pattern for both friend and unfamiliar faces, such that there were no significant differences in the overall number of fixations when exploring both faces. Furthermore, compared to the own face, the nose feature was sampled with a higher number of fixations whereas the mouth feature was sampled with a lesser number of fixations across both the friend and unfamiliar face. Such findings may suggest that when asked to explore faces, the own face is processed distinctly compared to other familiar or unfamiliar faces.

2.3 Experiment 2

Experiment 1 used a free-viewing task without the restrictions of task demands, allowing the capture of spontaneous eye movements when exploring faces. However, as participants were only required to passively explore the face images without any specific task, it is possible that the different face types facilitate or even elicit different types of tasks. For instance, in an event-related potential (ERP) study, Sui et al. (2006) presented evidence that even when participants were not asked to perform an explicit face-recognition task, the own face was automatically recognized compared to a familiar face, suggesting that the self-face recognition was not modulated by task demands. Consequently, one may ask whether the visual scanning behaviour for faces in a free-viewing task differs from when being restricted by task demands. More specifically, one might ask in Experiment 2 if participants would show a different viewing pattern for the faces when asked to make explicit responses regarding the identity of a certain face.

Experiment 2 was conducted to complement the free-viewing findings, exploring the visual scanning behaviour for faces under the restriction of tasks. Participants were asked to identify faces of differing levels of familiarity, and the eye movements before participants reach their decision were recorded and analysed. Having an identity task demand, for instance, would then require participants to extract facial information to facilitate their judgements in identity (Scott et al., 2005). Based on previous evidence (e.g., Kita et al., 2010; Stacey et al., 2005), it is hypothesized that when task demands were introduced, observers would adopt a similar scanning strategy across the self-face, the friend’s face, and the unfamiliar face. More specifically, to facilitate the extraction of facial information, the gaze would be directed more and longer towards the centre of a face which allows for the simultaneous extraction of facial information.

2.3.1 Method

2.3.1.1 Participants

Thirty Malaysian participants (4 males; M_{age} = 23.57, *SD* = 1.90) were recruited from the University of Nottingham Malaysia. As was the case in Experiment 1, all participants were recruited in pairs matched by age, gender, and race, so each of them served as the friend for the other participant. They had to have known each other for at least 6 months and have met at least once a week. All participants were right-handed and had normal or corrected-to-normal vision. All participation was completely voluntary, and all gave informed consent after experimental procedure had been fully understood. Participants received either course credit or RM5 for their contribution. Ethics approval for this present study was obtained from the Science and Engineering Research Ethics Committee of the University of Nottingham Malaysia.

2.3.1.2 Apparatus and Stimuli

The apparatus set up and preparation of stimuli are similar to Experiment 1, such that the face stimuli were cropped based on their individual contours. See *Figure 2.1* for examples of experimental stimuli.

2.3.1.3 Procedure

The procedure was similar to the preceding experiments, except for the following changes. Participants were required to indicate whether the face presented was their own face, their friend's face, or the stranger's face by pressing a button on the keyboard ("J", "K", and "L", respectively). Face stimuli remained on the screen until the participants made a keyboard response. Twelve practice trials were presented prior to the experiment to familiarize participants with the task.

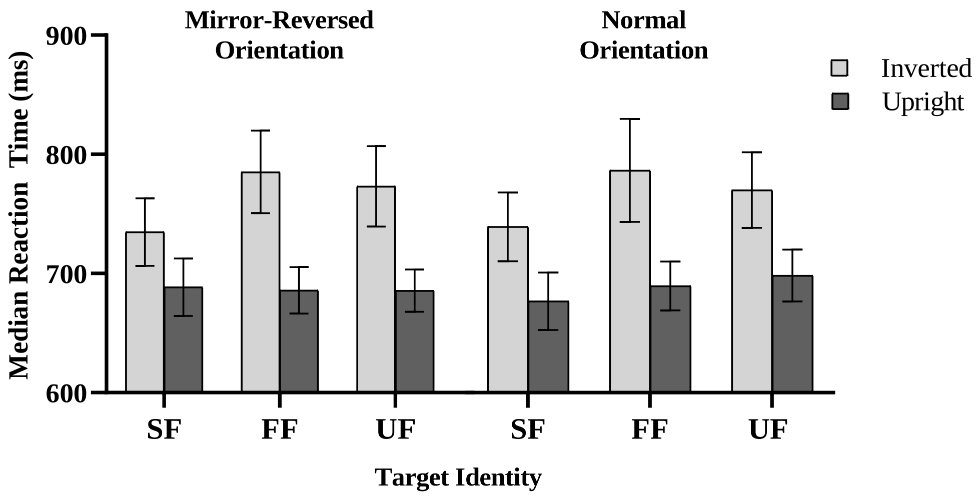
Each participant completed two blocks (120 trials per block) of testing. In each block, fifteen images (3 *target identity* × 5 *different expressions*) were presented twice in each of the four different inversion and orientation conditions. The experiment lasted for approximately 20 minutes, and participants were given a short break between the two blocks, followed by a recalibration phase.

2.3.2 Results

2.3.2.1 Behavioural Performance. Recognition accuracy was high for all three faces in the face identity judgement task (self-face: 99.21%; friend's face: 98.75%; unfamiliar face: 98.88%). *Figure 2.8* illustrates the median reaction time for each identity. The median reaction time (RT) was used instead of the mean RT to remove the influence of extreme values. Median RTs were subjected to a repeated-measures ANOVA with the factors: identity, inversion, and orientation. The analysis revealed a significant main effect of inversion, $F(1, 29) = 48.04$, $p < .001$, $\eta_p^2 = .62$, with a shorter median reaction time to upright faces compared to inverted faces. The analysis revealed no other significant main or interaction effects.

Figure 2. 8

The Median Reaction Time to Identify Faces.

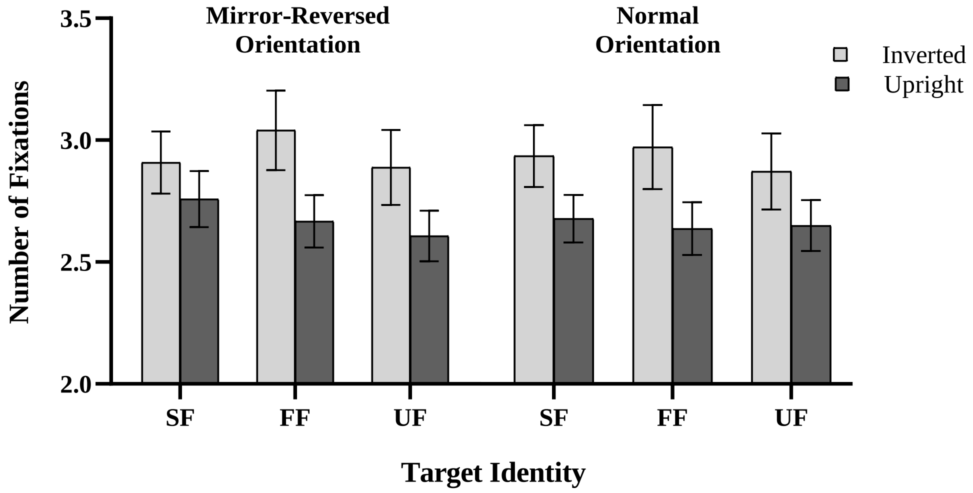


Note. The average median reaction time (ms) per participant for each identity (SF, FF, and UF) across different conditions. Error bars represent the standard error of the mean.

2.3.2.2 Average Total Number of Fixations. *Figure 2.9* shows the average total number of fixations for each face identity across inversion and orientation conditions. A 3 × 2 × 2 repeated-measures ANOVA, with the variables: identity, inversion, and orientation, was conducted on the total number of fixations. The left side of *Table 2.5* reports the summary of the ANOVA results. A significant main effect of inversion was reported, with the inverted faces (M = 2.94, SD = 0.82) receiving significantly more fixations than upright faces (M = 2.67, SD = 0.58). The analysis revealed no other significant main or interaction effects.

Figure 2. 9

The Average Total Number of Fixations for Different Identities (Exp. 2).



Note. The average total number of fixations per participant received by faces for each identity (SF, FF, and UF) across different inversion and orientation. Error bars represent the standard error of the mean.

Table 2. 5

Statistical Analysis of Average Total Number of Fixations and Average Total Fixation Duration corresponding to Identity, Inversion, and Orientation (Exp. 2).

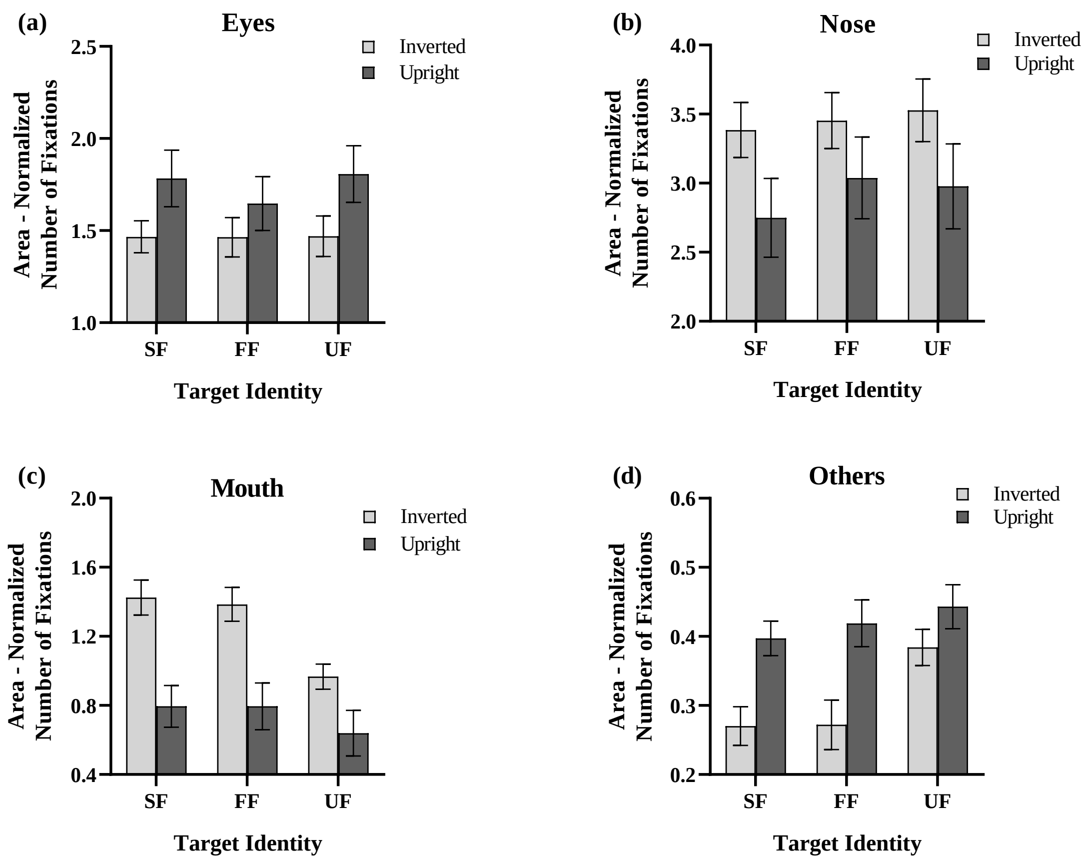
Variables	Average Total Number of Fixations			Average Total Fixation Duration		
	df	*F*	η_p^2	*df*	*F*	η_p^2
Identity	2, 58	0.73	.02	2, 58	13.01***	.31
Inversion	1, 29	19.71***	.41	1, 29	0.06	.002
Orientation	1, 29	2.00	.07	1, 29	0.84	.03
Identity x Inversion	2, 58	1.31	.04	2, 58	0.11	.004
Identity x Orientation	2, 58	1.00	.03	2, 58	2.42	.08
Inversion x Orientation	1, 29	0.01	.00	1, 29	0.86	.03
Identity x Inversion x Orientation	2, 58	3.04	.10	2, 58	0.62	.02

***p < .001 ** p < .01 *p < .05

Figure 2.10 presents the normalized total number of fixations for each feature across different factors. A 3 × 2 × 2 × 4 repeated-measures ANOVA with the variables: identity, inversion, orientation, and features, was conducted on the normalized scores for the average total number of fixations. The left side of *Table 2.6* shows the detailed ANOVA results. A main effect of features was found, which was quantified by a significant interaction with identity. A simple main effects analysis followed by Holm-Bonferroni corrected pairwise comparisons revealed that the mouth was fixated upon lesser for UF (M = 0.80, SD = 0.60) than SF (M = 1.11, SD = 0.69) or FF (M = 1.01, SD = 0.68), but there were no significant differences between SF and FF. Conversely, the rest of the face was fixated more for UF (M = 0.41, SD = 0.18) than SF (M = 0.33, SD = 0.16) and FF (M = 0.35, SD = 0.19), but there were no significant differences between SF and FF. Finally, there were no significant differences in the number of fixations between the eyes and nose across all identities (see *Table 2.7*).

Figure 2. 10

Area-Normalized Average Total Number of Fixations for Each Facial Feature (Exp. 2).



Note. Area-normalized total number of fixations received by (a) eyes, (b) nose, (c) mouth, and (d) other facial regions for each identity across different inversion conditions. The orientation factor is collapsed across each AOI. Error bars represent the standard error of mean.

Table 2. 6

Statistical Analysis of Average Total Number of Fixations and Average Total Fixation Duration corresponding to Identity, Inversion, Orientation, and Features (Exp. 2).

Variables	Average Total Number of Fixations			Average Total Fixation Duration		
	df	*F*	η_p^2	*df*	*F*	η_p^2
Features	1.62, 46.84	106.53***	.79	1.54, 44.68	95.97***	.77
Identity x Orientation	2, 58	4.39*	.13	2, 58	3.36*	.10
Features x Identity	3.66, 106.18	6.35***	.18	3.21, 90.45	4.74***	.14
Features x Inversion	1.56, 45.14	3.71*	.11	1.54, 44.51	4.24	.13
Features x Orientation	1.90, 55.15	0.73	.02	1.64, 47.40	1.72	.06
Features x Identity x Inversion	3.63, 105.14	1.27	.04	3.33, 96.42	1.08	.04
Features x Identity x Orientation	3.92, 113.74	1.58	.05	3.40, 98.47	2.33	.07
Features x Inversion x Orientation	1.59, 46.21	2.37	.08	1.38, 39.96	2.37	.08
Features x Identity x Inversion x Orientation	3.07, 89.15	0.39	.01	2.72, 78.79	0.81	.03

Note. Huynh-Feldt corrections were applied to the *d.f.* for all analyses with the 'features' variable; ***$p < .001$ ** $p < .01$ *$p < .05$

Table 2. 7

Simple Main Effects of Identity Considered at each level of Features on the Average Total Number of Fixations (Exp. 2).

Simple main effects of *Identity* at each level of:				
Features	*df*	*F*	η_p^2	Pairwise Comparisons
Eyes	2, 58	1.95	.15	-
Nose	2, 58	2.08	.07	-
Mouth	2, 58	21.03***	.42	SF > UF (*p* < .001, *d* = 1.00) FF > UF (*p* < .001, *d* = 1.11) SF = FF (*p* = 1.00, *d* = 0.07)
Others	2, 58	11.21***	.28	SF < UF (*p* < .001, *d* = -0.87) FF < UF (*p* = .002, *d* = -0.68) SF = FF (*p* = 1.00, *d* = -0.11)

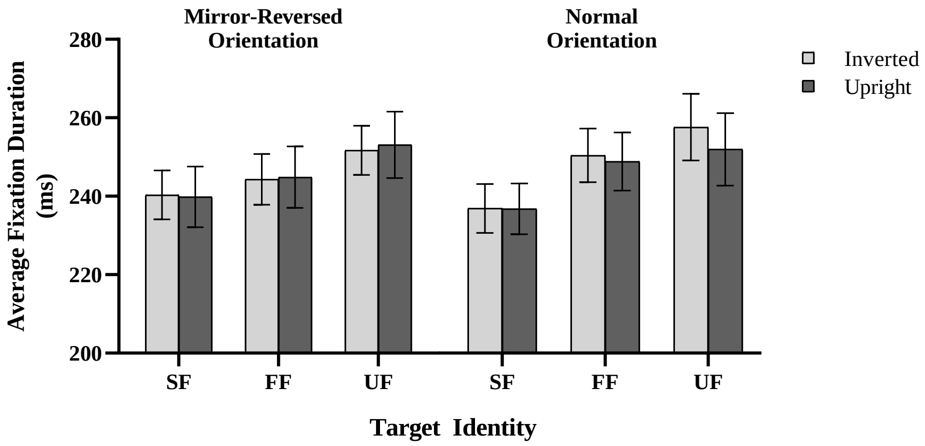
***p < .001 ** p < .01 *p < .05

This analysis further revealed a significant interaction between identity and orientation (see *Table 2.6*). A Holm-Bonferroni post-hoc analysis revealed that FF was fixated upon more in the normal oriented version (M = 1.59, SD = 0.79) than in a mirror-reversed orientation (M = 1.53, SD = 0.73; p = .02, d = 0.45), whereas the number of fixations on both SF (normal: M = 1.54, SD = 0.77; mirrored: M = 1.53, SD = 0.73; p = .91, d = 0.02) and UF (normal: M = 1.50, SD = 0.78; mirrored: M = 1.55, SD = 0.77; p = .07, d = 0.34) did not differ significantly across the orientation conditions.

2.3.2.3 Average Total Fixation Duration. *Figure 2.11* shows the average total fixation duration for each identity across inversion and orientation conditions. A 3 × 2 × 2 repeated-measures ANOVA, with the variables: identity, inversion, and orientation, was conducted on the average fixation duration. The right side of *Table 2.5* reports the summary of the ANOVA results. A main effect of identity was reported with Holm-Bonferroni corrected pairwise comparisons revealing that participants fixated shorter on SF (M = 238.44, SD = 36.50) than FF (M = 247.10, SD = 39.01; p = .003, d = -0.67) and UF (M = 253.59, SD = 44.44; p < .001, d = -0.78). Contrariwise, the fixation durations for FF and UF (p = .10, d = -0.41) did not differ significantly. The analysis further revealed no other significant main or interaction effects.

Figure 2. 11

Average Total Fixation Duration for Different Identities (Exp. 2).

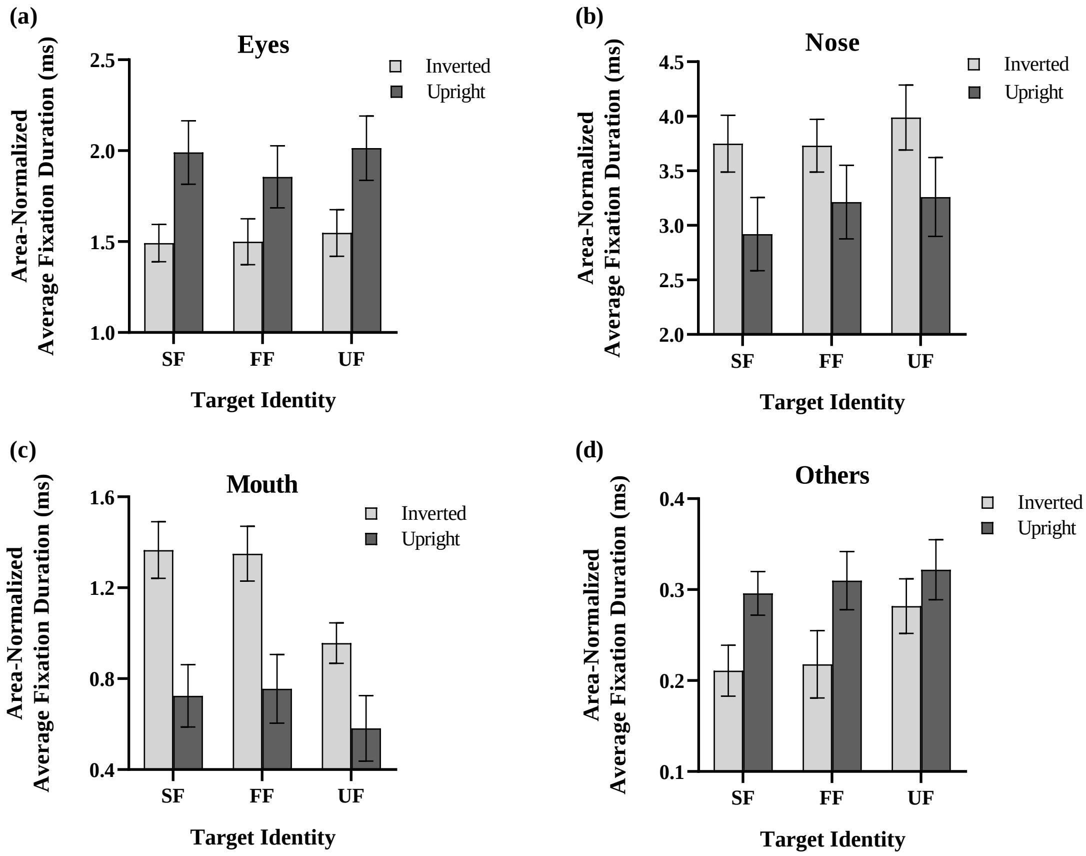


Note. The average total fixation duration received by faces for each identity (SF, FF, and UF) across different inversion and orientation. Error bars represent the standard error of the mean.

Figure 2.12 presents the normalized average total fixation duration for each feature across different factors. A 3 × 2 × 2 × 4 repeated-measures ANOVA, with the variables: identity, inversion, orientation, and features, was conducted on the normalized scores for the average total fixation duration. The right side of *Table 2.6* reports the summary of the ANOVA results. The analysis revealed a significant main effect for features, which was quantified by a significant interaction with the identity factor. Simple main effects analysis followed by Holm-Bonferroni corrected pairwise comparisons revealed that the mouth was fixated shorter on UF (*M* = 0.77, *SD* = 0.67) than SF (*M* = 1.04, *SD* = 0.78) or FF (*M* = 1.05, *SD* = 0.79), but there was no significant difference between SF and FF. Conversely, the rest of the face was fixated upon longer for UF (*M* = 0.30, *SD* = 0.19) than SF (*M* = 0.25, *SD* = 0.16) or FF (*M* = 0.26, *SD* = 0.20), and there were no significant differences between SF and FF. Finally, there were no significant differences in the fixation duration for the eyes and nose across all identities (see *Table 2.8*).

Figure 2. 12

Area-Normalized Average Total Fixation Duration for Each Facial Feature (Exp. 2).



Note. Area-normalized average total fixation duration received by (a) eyes, (b) nose, (c) mouth, and (d) other facial regions for each identity across different inversion conditions. The orientation factor is collapsed across each AOI. Error bars represent the standard error of the mean.

Table 2. 8

Simple Main Effects of Identity Considered at each level of Features on the Average Total Fixation Duration (Exp. 2).

Simple main effects of *Identity* at each level of:				
Features	*df*	*F*	η_p^2	Pairwise Comparisons
Eyes	2, 58	2.58	.08	-
Nose	2, 58	2.31	.10	-
Mouth	2, 58	14.71***	.34	SF > UF (*p* < .001, *d* = 0.79) FF > UF (*p* < .001, *d* = 1.15) SF = FF (*p* = 1.00, *d* = 0.02)
Others	2, 58	4.42*	.13	SF < UF (*p* = .04, *d* = 0.49) FF < UF (*p* = .04, *d* = 0.47) SF = FF (*p* = 1.00, *d* = 0.11)

****p* < .001 ** *p* < .01 **p* < .05

The analysis also revealed a significant interaction between identity and orientation (see *Table 2.6*). Holm-Bonferroni post-hoc analysis revealed that FF was fixated upon longer in the normal oriented version (*M* = 1.65, *SD* = 0.90) than in a mirror-reversed orientation (*M* = 1.59, *SD* = 0.86; *p* = .04, *d* = 0.40), whereas the number of fixations on both SF (normal: *M* = 1.48, *SD* = 0.89; mirrored: *M* = 1.71, *SD* = 0.86; *p* = .85, *d* = 0.04) and UF (normal: *M* = 1.54, *SD* = 0.90; mirrored: *M* = 1.69, *SD* = 0.93; *p* = .15, *d* = 0.27) did not differ significantly across the orientation conditions.

2.3.3 Discussion

Experiment 2 explored the effects of task demands, specifically a face identification task, on the viewing pattern for self, friend, and unfamiliar faces. When participants were asked to recognize faces, (1) there were no significant differences in the number of fixations across all faces, but the own face was fixated for a shorter duration compared to the friend and the unfamiliar face. Next, (2) there were no significant differences in the number of fixations and fixation duration for the eyes and the nose across all face identities, whereas the mouth and the rest of the face were fixated with a lesser number of fixations and a shorter amount of fixation duration on unfamiliar faces compared to both the friend face and self-face, and finally, (3) there is an evident inversion effect on the viewing patterns for all faces.

When asked to identify the faces, there were no significant differences in the number of fixations across all face identity conditions with the nose being sampled with a higher number of fixations and the longest fixation duration compared to all facial features. To identify a face, individuals first scan several facial features to extract facial information, followed by structural analysis and semantic encoding (Kita et al., 2010). When completing tasks which require higher cognitive demands, such as memory, the attention space of an individual narrows, allowing only limited information to be processed, therefore leading to a similar scanning strategy to extract facial information from all faces (see Stacey et al., 2005). To further facilitate this strategy, by directing attention to the centre of a face (i.e., the nose area), individuals are able to extract facial information simultaneously, as a “whole” face representation (Van Belle, Ramon, et al., 2010), altogether further facilitating the face identification task.

Next, the own face received shorter individual fixations compared to a friend and unfamiliar faces when asked to make identity judgements suggest that compared to other faces, individuals spent less time acquiring sufficient facial information to identify their own face (e.g., Hsiao & Cottrell, 2008). As people are more familiar with their own faces and also have a more robust mental representation of their own face (Tong & Nakayama, 1999), less cognitive effort is needed when extracting facial information from their own faces (see Rayner, 1998; Salvucci & Goldberg, 2000).

Overall, findings from Experiment 2 showed that task demands modulated the viewing patterns for the own face. Specifically, when asked to freely view their own face in Experiment 1, individuals adopted a more featural processing strategy, whereas when prompted to extract facial information, individuals adopted a more holistic approach instead. However, such a viewing pattern was not observed for both familiar and unfamiliar faces, wherein individuals adopted a more holistic approach when asked to passively view and when asked to identify faces.

2.4 General Discussion

With two experiments, Chapter 2 explored the role of holistic and featural processing when viewing the own face and other faces in a free-viewing task (Experiment 1) and a face-identification task (Experiment 2). Overall, in Experiment 1, the own face received a higher number of fixations than both the friend and unfamiliar face, with a higher proportion of fixations and longer fixation durations to the lower regions of the own face as compared to the lower regions of the other faces. Interestingly, in Experiment 2, the number of fixations did not differ significantly for all three faces, with the nose receiving a higher proportion of fixations and being fixated for a longer duration than the other facial features.

2.4.1 A More Featural Based Processing for the Own Face

First, when asked to freely explore the faces, a greater proportion of fixations were allocated to the own face compared to both familiar and unfamiliar faces. These results are in line with Hills (2018) who also showed a higher number of fixations to the own face. Featural processing is generally associated with a higher number of fixations to individual facial features (e.g., Bombari et al., 2009) than holistic processing (Hills, 2018). In line with this notion, studies have reported that such a viewing pattern was also observed when individuals were asked to look at inverted faces (e.g., Hills et al., 2013; Van Belle, de Graef, et al., 2010). As facial features for the own face might be overall sampled more often, each facial feature (i.e., eyes and mouth) may be focused and processed individually, therefore resulting in an overall higher number of fixations for the own face compared to other faces. Additionally, such findings may also imply a feature verification dependent process for the own face (Van Belle, Ramon et al., 2010). This process ensures a match between a perceived stimulus and its stored representation in memory, through the comparison of feature by feature, resulting in an overall more individual fixations to the facial features.

Experiment 1 also revealed that in comparison to the friend and unfamiliar face, the nose on the self-face received a fewer number of fixations. Fixations to the nose have been associated with holistic processing as such fixations would allow for a perception of the whole face (Van Belle, Ramon, et al., 2010). Under this assumption, findings from Chapter 2 suggest that when asked to explore faces, the self-face is processed less holistically compared to familiar and unfamiliar faces. Additionally, the mouth was fixated more often and longer on the own face compared to other faces. Chakraborty and Chakrabarti (2018) also observed a similar gaze allocation strategy to the lower region of the own face. The authors suggested that the own face holds attention more compared to other faces as the own face triggers more exploration of the facial features of the own face (see also Devue et al., 2009). More specifically, despite the eyes providing ample facial information, due to the “rewarding nature” of the own face to sustain attention, increased sampling of facial features could take place (Chakraborty & Chakrabarti, 2018). Likewise, studies have also shown that individuals with prosopagnosia who rely on the featural processing of faces, fixated less on the eyes but directed a greater proportion of gaze towards the mouth (e.g., Bukach et al., 2006; Ramon et al., 2010).

Experiment 1 also showed no differences in the proportion of fixations across the friend’s face and the unfamiliar face, suggesting no differences in the sampling manner between both faces. This finding is also in line with the study by Van Belle and colleagues (2010), which showed no differences in the number of fixations when viewing a friend and an unfamiliar face. More specifically, there was a higher number of fixations positioned on the nose for both a friend and an unfamiliar face compared to the self-face. The observed differences in the gaze pattern between the own face and other faces suggest the own face is processed in a distinctive manner compared to a personally familiar face and an unfamiliar face, at least in a free-viewing paradigm.

However, when asked to identify faces, Experiment 2 observed no differences in the viewing pattern for the own face, a friend’s face, and an unfamiliar face, with a higher number of fixations and a longer total fixation time on the nose across all faces. Generally, familiarity judgements are based on an appreciation of the face as a whole instead of focusing on detailed feature information (e.g., Van Belle, Ramon, et al., 2010). Directing fixations towards the centre of a face allows for extracting all facial information simultaneously to facilitate the face identification task. Indeed, Hsiao and Cottrell (2008) demonstrated that face recognition can be achieved within two fixations, and these fixations are generally allocated around the top of the nose. These findings were consistent with the findings by Stacey et al. (2005) who reported that the effects of familiarity on face processing were influenced by the task demands imposed.

More specifically, the differences reported in the eye-movement patterns for the own face across a passive-viewing and recognition task might also reflect the different goals for the processing and the recognition of the own face. In particular, individuals generally perceive others' faces for identification purposes, whereas one does not aim to identify their own faces when looking in the mirror. However, when the task demands were introduced and kept consistent for all faces, there were no differences in the eye-movement patterns when recognizing the own, the personally familiar, and the unfamiliar face. Therefore, the findings across the two experiments seem to suggest an influence of task demands on the viewing pattern for the own face, such that when asked to passively view or explore their own face, individuals adopted a more featural processing strategy, whereas when asked to make identity judgement or to recognize the own face, a more holistic approach is adopted. In particular, due to the personal significance and relevance of the own face, the processing and recognition of the own face may be supported by both featural and holistic processing (see Hills, 2018) and these processes are employed depending on the task at hand.

Previous research found that two fixations are enough for face recognition (e.g., Hsiao & Cottrell, 2008). Interestingly, when the results of Experiment 1 were reanalysed including only the first two fixations (see *Appendix A)*, there were no differences in the viewing patterns across all three faces. This finding replicated the results of Experiment 2 and confirmed that the differences in the viewing patterns between the self-face and other faces reported in Experiment 1 are not related to identification processes. Instead, the differences found in Experiment 1 could reflect a stronger attention holding property of the own face (e.g., Devue et al., 2009), which might cause individuals to spend more time exploring and looking at their own face.

2.4.2 The Nose as a Diagnostic Facial Feature

Contradicting the feature-saliency hypothesis which denotes the eyes as the most diagnostic feature when perceiving faces (e.g., Hsiao & Cottrell, 2008; Shepherd et al., 1981; Walker-Smith et al., 1977), our findings suggest otherwise. There was a preference for the nose to be fixated when perceiving faces. For instance, in a free-viewing task (Exp. 1), a similar number of fixations and fixation duration was allocated to both the nose and the eyes; whereas the nose received a greater proportion of fixation and longer fixations compared to the eyes when the task demands were introduced (Exp. 2).

Studies have consistently reported a hierarchy of features for upright faces, with the eyes identified as the most diagnostic feature for face recognition, followed by the mouth, and the nose (e.g., Ellis et al., 1979; Shepherd et al., 1981). Specifically, the eyes are focused upon more often when perceiving faces, at least for Western individuals (Blais et al., 2008). In fact, when asked to describe faces, Western participants tend to describe the eyes more often compared to other facial features (Ellis et al., 1979). The upper face, specifically the eyes, automatically attracts attention due to its role in expressing social cues, such as emotions or direction of gaze (Barton et al., 2006; Shepherd et al., 1981).

Despite the well-established role of eyes in the face processing literature, Kita et al. (2010) observed that when asked to view faces, East Asian participants made more fixations toward the nose instead of the eyes or mouth. Furthermore, Blais et al. (2008) showed that, in comparison to Western Caucasian individuals, East Asian individuals showed a preference to “integrate information holistically”, hence resulting in attention being directed to the centre of a face (i.e., the nose area), which allows the perception of the “whole” face. Consistent with these studies, there was a similar proportion of fixations and fixation duration between the eyes and nose in Experiment 1. Nevertheless, beyond the race of faces or participants, it is also worth taking note that the different diagnostic features in Western and Asian populations may be attributed to the type of picture employed across each study. Specifically, whereas Kita et al. (2010) employed cropped faces in Asian populations (similar to our study), Blais et al. (2008) used headshots in Western populations. These two studies found that people fixate on the eyes and the nose, respectively. These features happen to be located at the centre of the image in both types of pictures (i.e., eyes on the headshots and bridge of the nose on cropped images), and this location could thus be the most optimal point of fixation to gather the most visual information, regardless of whether the face appears at the centre of the screen or not).

Nevertheless, the role of the nose in the perception of faces became more evident when participants were asked to make identity judgements (Exp. 2). In this case, participants may adopt an efficient strategy by fixating at the centre of a face (nose area) for facial information to be extracted simultaneously (Hsiao & Cottrell, 2008; Van Belle, Ramon, et al., 2010), therefore resulting in the nose being sampled more often and fixated longer across all faces, regardless of their identity, in Experiment 2. Importantly, this fixation pattern cannot be explained by the observer’s tendency to fixate in the centre of the screen, as the face stimuli were presented either to the top or bottom of the screen in a pseudorandom order.

2.4.3 Modulation of Task Demands on an Inversion Effect for Faces

Contradicting previous studies which showed a higher number of fixations for inverted faces (e.g., Barton et al., 2006; Hills, 2018), findings from the free-viewing task reported no such observation for inverted faces whereas findings from the identity judgement task showed a higher proportion of gaze for inverted than upright faces. Inverting a face is known to disrupt the holistic processing of a face, which affects the extraction of facial information (Rossion, 2008, 2009). To compensate for this disruption, featural processing is employed, such that inverted faces receive a higher proportion of fixations compared to upright faces (i.e., an inversion effect). It is important to acknowledge that most studies which reported a higher proportion of fixations for inverted faces included task demands, requiring participants to make familiarity judgements and to extract facial information from these face stimuli (e.g., Hills, 2018). Following this line of argument, an inversion effect was reported for Experiment 2 where participants had to make identity judgements, whereas no such observation was reported in the free-viewing task wherein observers might make a 'general sweeping scan' of faces instead of attending to critical facial features that facilitate face recognition tasks (Sammaknejad et al., 2017). Overall, such findings suggest that the inversion effect for faces may also be modulated by the presence of task demands.

2.4.4 Strengths and Limitations

The free-viewing task was employed as Experiment 1 aimed to explore how facial features are sampled under natural conditions. Also, this paradigm allows for one to record spontaneous eye-movements when viewing faces, rather than confining viewing behaviour through specific task demands. Considering that gaze behaviour varies according to task constraints, a subsequent study with task demands was conducted to complement the free-viewing data. Furthermore, findings of this chapter revealed a preference to process the center of a face (i.e., nose and eyes sampled more often), which cannot be explained by having a fixation cross in the center of the display screen, which may indirectly cue the eyes or the bridge of the nose (e.g., Henderson et al., 2005). To prevent such anticipatory eye-movement strategies, face stimuli were presented in a pseudorandom manner at either the top or bottom of the screen.

One limitation of this chapter that should be noted is the use of static faces rather than dynamic faces. Static faces are important to shed light on cognitive mechanisms underlying face perception, as static stimuli are more controlled in their presentation. Nevertheless, these stimuli may not be an accurate depiction of real-life scenarios and it remains as an artificial method employed in laboratory settings. The everyday-life interaction between individuals is a dynamic process, thus using dynamic stimuli in face research would be more ecologically valid.

Additionally, it is important to note that the diagnostic facial feature information might not be necessarily reflected by the location of fixations. For instance, predefining the area of interest might mask important information about the potential differential scanning behaviour for faces with different levels of familiarity through the reduction of fixation points to a facial feature which is nearest to the actual fixation position (see Van Belle, Ramon, et al., 2010). Furthermore, the subtle differences defining the AOI borders may cause an artificial difference between the visual scanning patterns across different studies as well.

2.4.5 Implications

More globally, work in Chapter 2 has highlighted how individuals process faces with different levels of familiarity across different experimental conditions: without and with task demands. As most face recognition models do not shed light on the differential development for the processing of different type of faces, findings from this chapter may have important implications to further understand the development of face recognition. Also, findings from this chapter also highlight the importance of considering the role of task constraints in varying gaze behaviour.

More specifically, in a free-viewing condition, it was observed that the self-face is processed in a distinct manner (i.e., more featural based processing) compared to a personally familiar face or an unfamiliar face and the mouth is seemingly an important feature for the own face. Nevertheless, when task demands were introduced, there was no difference in the viewing behaviour across all faces, regardless of their identity.

These findings may imply that self-face recognition is coupled with more self-familiarity or self-specificity effects rather than with general face recognition abilities (Malaspina et al., 2016). This is interesting as both the self-face and friend's face are highly familiar faces. Nevertheless, it is important to acknowledge familiarity may be modulated by the level of experience with a person (e.g., Bortolon & Raffard, 2018), such that a highly encountered face may be more robustly represented (e.g., Tong & Nakayama., 1999). Following this line of thought, as individuals are in constant contact with their own face, the own face may be more robustly represented compared to other faces. Additionally, such specific face processing strategies for the own face might also be due to the distinct visual experience individuals have with their own face through the mirror. This mirrored image of the own face differs considerably from the visual experience with the true image of other faces. Altogether, these findings imply a self-face advantage, specifically, the self-face is being processed qualitatively differently from other faces.

2.5 Conclusions

In conclusion, due to the personal significance and relevance of the own face, the processing and recognition of self-face may be supported by both a featural and holistic processing and these processes are employed depending on the nature of the experiment: either the exploration or the recognition of faces. Specifically, the own face may hold attention more than other faces, allowing individuals to further explore their face (i.e., featural processing) compared to other faces, whereas when asked to identify faces, holistic processing is employed across the self-face and other faces.

Although work from this chapter speaks specifically to self-face processing, Experiments 1 and 2 have also replicated and extended findings on general face processing. More specifically, work from this chapter replicated previous studies which showed differences in the viewing patterns for upright and inverted faces: an increased sampling of the mouth and decreased sampling of the eyes for inverted faces. Notably, previously reported inversion effect for faces (i.e., more fixations to inverted faces than to upright faces) were only evident when task demands were introduced. Lastly, across all features, there was also a preference for scanning of the nose compared to scanning of the eyes, the mouth, and the rest of the face.

Chapter 3

A Featural Account for Own-Face Processing: Evidence from Inversion, Composite Face, Part-Whole Tasks

3.1 Introduction

In Chapter 2, with eye-tracking measures, it was observed that in a free viewing task, the own face is processed in a more featural manner compared to a personally familiar face and an unfamiliar face. Nevertheless, when task demands were introduced, there were no differences in the viewing behaviour across all faces, regardless of their identity. It is, however, important to acknowledge that eye-tracking measure is only a passive indication of holistic processing. In other words, holistic processing is inferred only from eye fixation patterns. Furthermore, eye-movements are thought to be goal-directed and may vary according to task constraints (e.g., Henderson, 2003). Hence, to complement the findings in Chapter 2, Chapter 3 aims to further explore the role of holistic and featural processing in one's self-face processing using the three experimental paradigms that have been widely considered as the standard measures of holistic face processing. Namely, the face inversion task (Yin, 1969), the composite face task (Young et al., 1987), and the part-whole task (Tanaka & Farah, 1993; for a review, see Piepers & Robbins, 2012; Tanaka & Gordon, 2011).

Inverting a face impairs face identification, such that longer response times and lower accuracy are observed when identifying inverted faces compared to upright faces (i.e., face inversion effect; Yin, 1969). As upright faces are generally processed holistically, face-specific processes are claimed to be disrupted or suppressed when a face is turned upside down (Rossion, 2008). To compensate for this disruption, inverted faces are processed in a more featural manner instead (Barton et al., 2006).

Notably, this face inversion effect is significantly larger and evident for face stimuli compared to other visual object stimuli (Yin, 1969). Furthermore, the finding that inverting face stimuli is particularly disruptive for familiar faces seems to suggest the importance of holistic processing for familiar faces. For example, with a familiarity judgement task, Caharel and colleagues (2006) found that participants were slower to respond to inverted familiar faces but not to inverted unfamiliar faces. Mirroring these findings, Keyes and Brady (2010) also showed that individuals tended to recognize friends' faces faster than unfamiliar faces in upright but not in inverted conditions, postulating that holistic processing of faces underlies such a finding.

The composite face effect shows that two identical top parts of a face are identified as different if they are aligned with different bottom parts (Rossion, 2013; Young et al., 1987). The composite effect was interpreted to demonstrate that individuals automatically perceive two halves as a "whole" (i.e., integrating two face halves) when they are aligned to form an upright face template (Susilo et al., 2013). Critically, by misaligning the top and bottom halves, the information for the "whole" face is disrupted, eliminating the effect (Young et al., 1987). Whereas the composite effect is generally not observed for inverted faces and object stimuli (e.g., Macchi Cassia et al., 2009; Rossion, 2008), composite effects are reported to be present for objects of expertise (Wong et al., 2009). Nevertheless, the observed effects for objects of expertise are typically smaller compared to those reported for faces (Degutis et al., 2012).

Holistic face processing has also been demonstrated with the part-whole task. This task shows that facial features are identified better when presented in the context of the whole face than when presented alone (Tanaka & Farah, 1993). The part-whole effect seems to show that facial features are not encoded as isolated units but that they are encoded and integrated as one “whole” perceptual unit (an upright face; Tanaka & Farah, 1993). Despite empirical evidence showing a part-whole effect for recognizing objects (i.e., “object superiority effect”; Davidoff & Donnelly, 1990), the effect is, however, not reported for all objects (e.g., houses), and the part-whole effect is substantially larger and consistently reported for faces (Tanaka & Farah, 1993).

Although these tasks are considered to measure the same processes, recent evidence seems to suggest that the face inversion, composite face, and part-whole effects tap into different notions of holistic processing (Rezlescu et al., 2017; Richler et al., 2012). Specifically, Rezlescu and colleagues (2017) tested the relations between the performances on these three tasks. Their findings showed that these measures correlated poorly with each other, indicating that these tasks might tap distinct perceptual mechanisms. In other words, the mechanisms behind the face inversion, composite face, and part-whole tasks seem to reflect different forms of holistic processing.

3.1.1 Own-Face Processing

Even though holistic face perception supports the processing of both familiar and unfamiliar faces, it is possible that the own face, given its distinct visual experience, might be processed in a qualitatively different manner. For example, although it may be argued that one may also see themselves in photographs and video images, the visual experience of the own face is mostly acquired from self-inspection in mirrors (Brédart, 2003; Gregory, 2001). The distribution of views for one’s own face is thus generally mirror-reversed frontal views (Brédart, 2003). The effect of such exposure can be seen through participants’ preference for mirror-reversed images of the own face compared to non-reversed images. This preference is, however, not found in familiar faces (e.g., Brady et al., 2005; Laeng & Rouw, 2001; Troje & Kersten, 1999). Similarly, Brédart (2003) showed that individuals use different types of information to determine the orientation of their own faces and other familiar faces. Specifically, when determining the orientation of their own face, individuals relied preferentially on the location of asymmetric features (e.g., moles, scars, or blemishes). In contrast, observers relied preferentially on facial configural information when determining the orientation of a familiar face. According to Brédart (2003), these differences are explained by the different visual experiences gathered with the self-face and familiar faces.

Furthermore, it is also important to acknowledge that the goal of processing other people's and own faces is different. Specifically, individuals generally perceive the face of other people for identification purposes, whereas the own face is generally viewed for the inspection of facial features through the mirror (e.g., for grooming purposes; see Estudillo & Bindemann, 2017a, 2017b). In other words, although holistic information might be important to make identity or emotion judgements when viewing others' faces, individuals may naturally pay attention to more subtle facial details when they view themselves in the mirror.

In agreement with this idea, a few studies have questioned the holistic processing of the own face and have proposed a more featural approach. For instance, in a mental imagining study, Greenberg and Goshen-Gottstein (2009) measured the time participants took to generate a mental image of one's own face or a mental image of other people's faces. The authors showed that participants were faster to create a mental image of a facial feature of their own face than a mental image of a facial feature of a familiar face. However, participants were slower to create a mental imagery of the whole own face than a mental image of the whole familiar face. These findings suggest that the processing of the own face relies on featural information.

Nevertheless, this evidence is mainly based on a subjective measure (i.e., participants' reports of mental imagining of faces). Keyes and Brady (2010) presented evidence from a more objective measure (i.e., the face inversion task). As aforementioned, inverting a face is known to disrupt holistic processing for faces (Rossion, 2008, 2009), resulting in poor recognition of faces. In Keyes and Brady (2010), individuals were faster and more accurate at recognizing their own faces over both friend's and stranger's faces, and, interestingly, these processing advantages were observed for both upright and inverted orientations. This advantage for the own face suggests that the own face is recognized at a more featural level.

Nonetheless, although Keyes and Brady's (2010) results suggest that the own face is processed in a more featural manner, these findings do not deny the holistic nature of face processing. In fact, their study also showed a smaller but significant face inversion effect for the own face. This finding is in agreement with a recent eye-tracking study that showed that the own face is processed in both a featural and holistic manner (Hills, 2018). Given the importance of the own face, this dual-processing strategy for the own face ensures that the own face is efficiently processed (Hills, 2018).

3.1.2 Experiment 3

Although both Greenberg and Goshen-Gottstein (2009) and Keyes and Brady (2010) have presented evidence that the own face may be processed in a more featural manner, the former study presented evidence that is mainly based on a subjective measure (i.e., a mental imagining task), whereas Keyes and Brady (2010) presented evidence from a more objective measure with the face inversion task. However, a limitation of the face inversion task is that the interference of holistic processing is inferred by the face inversion effect, but holistic processing is not directly manipulated in the face inversion paradigm (Tanaka & Simonyi, 2016). Furthermore, it has been suggested that inversion disrupts both holistic and featural processing (see McKone & Yovel, 2009). Finally, the face inversion task is only one of the three measures of holistic face processing and, as previously noted, it is not always associated with other holistic processing tasks, such as the part-whole and composite face tasks (Rezlescu et al., 2017).

Experiment 3 thus aimed to extend the findings that the own face may be processed in a more featural manner compared to familiar and unfamiliar faces. Experiment 3 used the three standard tests of holistic face processing: a face inversion, a composite face, and a part-whole task to further examine the role of holistic and featural processing when perceiving faces with different levels of familiarity. It is hypothesized that the own face is processed in a more featural manner, whereas both familiar and unfamiliar faces are processed in a more holistic manner.

To test for these hypotheses, participants were asked to identify their face, a friend’s face, and an unfamiliar face in three different tasks. In the face inversion task, participants were asked to identify the three faces presented in either upright or inverted conditions. In the composite face task, participants were required to identify the top halves of the faces presented either in aligned or misaligned conditions with a distractor bottom part. Lastly, in the part-whole task, participants viewed facial features presented in either isolation or a whole foil face context, and they were asked to decide the identity to whom the facial features belong.

If the own face is processed in a more featural manner compared to the familiar and the unfamiliar faces, smaller face inversion, composite face, and part-whole effects would be expected for the own face compared to those of the familiar and unfamiliar faces. More specifically, for the face inversion task, the difference between the identification of upright and inverted faces should be smaller for the own face compared to these differences for familiar and unfamiliar faces. For the composite face task, the self-face would be less affected by the "holistic interference" from the to-be-ignored bottom half (see Rossion, 2013) compared to the familiar and unfamiliar faces. Lastly, for the part-whole task, a weaker "whole-face interference" during part recognition for the own face features would be expected (see Tanaka & Simonyi, 2016). That is, compared to familiar and unfamiliar faces, the recognition of a specific face part of the own face embedded in the context of a foil face will be less affected by the presence of the foil face's facial features.

3.2 Methods

3.2.1 Participants

Fifty Chinese Malaysians (13 males) participants whose ages ranged between 18 and 20 years old (*M* = 20.9, *SD* = 1.78) were recruited from the University of Nottingham Malaysia. A power analysis performed in G*Power 3.1 (Faul et al., 2007) with an effect size of 0.15 and an alpha of .05 gives a required sample size of 50 participants to achieve 80% power. This experiment utilized a 3 (target identity*: self, friend, or unfamiliar*) × 2 (orientation*: inverted or upright*; alignment*: aligned or misaligned; or* whole part*: whole or part*) within-subjects design.

Participants were recruited in pairs of friends matched by age, gender, and race so that each of them served as a friend of the other participant. The age range allowed for matching is up to three years. Participants were either awarded with course credits or compensated financially for their participation. Ethics approval for this study was obtained from the Science and Engineering Research Ethics Committee of the University of Nottingham Malaysia (JLKW220520).

3.2.2 Stimuli

3.2.2.1 Image collection. Across all three tasks, photograph stimuli (self-face and friend face) were individually tailored to each participant. Each participant was photographed under similar conditions (i.e., constant lighting and uniform background), in a frontal position while assuming a neutral expression and articulating four different speech sounds (e.g., A, O, E, and M; see *Figure 3.1*). Different images were used for each identity to reduce image-specific effects (Bruce, 1982; Estudillo, 2012; Estudillo & Bindemann, 2014). All different images were used as “self-face” for the participant themselves and as “friend’s face” for their friend, respectively.

Six separate individuals (three males and three females) matched in age were photographed under the same conditions to be used as unfamiliar targets. Different unfamiliar faces were used for each task (counterbalanced across each participant) to reduce the learning of the unfamiliar face. Specifically, in the learning stage, participants were asked to learn only one out of the three unfamiliar faces across each task and the learned faces were presented in a neutral expression. The face images with different expressions (e.g., neutral, A, O, E, and M) were used across all three tasks. All images were collected and processed at least one week prior to the experimental session.

Figure 3. 1

Example of Face Images

Note. Example of five different images for each identity. From top left: "neutral", "A", "O", "E", and "M" expression. All images were cropped based on its individual contours and converted to grayscale.

3.2.2.2 Image Processing. To prepare the images for this experiment, all face stimuli were edited using Adobe Photoshop CS6. All original photographs were resized to 397 x 567 pixels (16-bit depth), corresponding to an approximate visual angle of 9.53° horizontally and 13.58° vertically at a viewing distance of 63 cm. Also, in an effort to eliminate any low-level variations between different types of stimuli, Gaussian (radius = 3 pixels) and Pixelate Filters (cell size = 2 square) in Photoshop™ were applied to all face images to normalize the image resolution. Across all the three tasks, all photographs were aligned on the eyes' position and were cropped based on their individual contours and external features (i.e., hairs and ears were removed). Finally, all face images were also converted to greyscale. In Chapter 2, we wanted to explore the gaze behaviour of individuals when looking at faces, hence, to ensure ecological validity, coloured face stimuli were used to ensure that participants were viewing faces that resembled as closely to when they see faces in real life. However, face stimuli in this chapter were converted to greyscale as an attempt to minimize the differences in non-facial cues (i.e., color of the skin). In addition to minimizing the differences in non-facial cues, these transformations are important in providing the most optimal stimuli for holistic face processing (see Retter & Rossion, 2015). “Self-face” images were presented in a mirror-reversed orientation (i.e., the view in which people generally view their own face), whereas the “friend” and “unfamiliar” images were presented in a normal orientation.

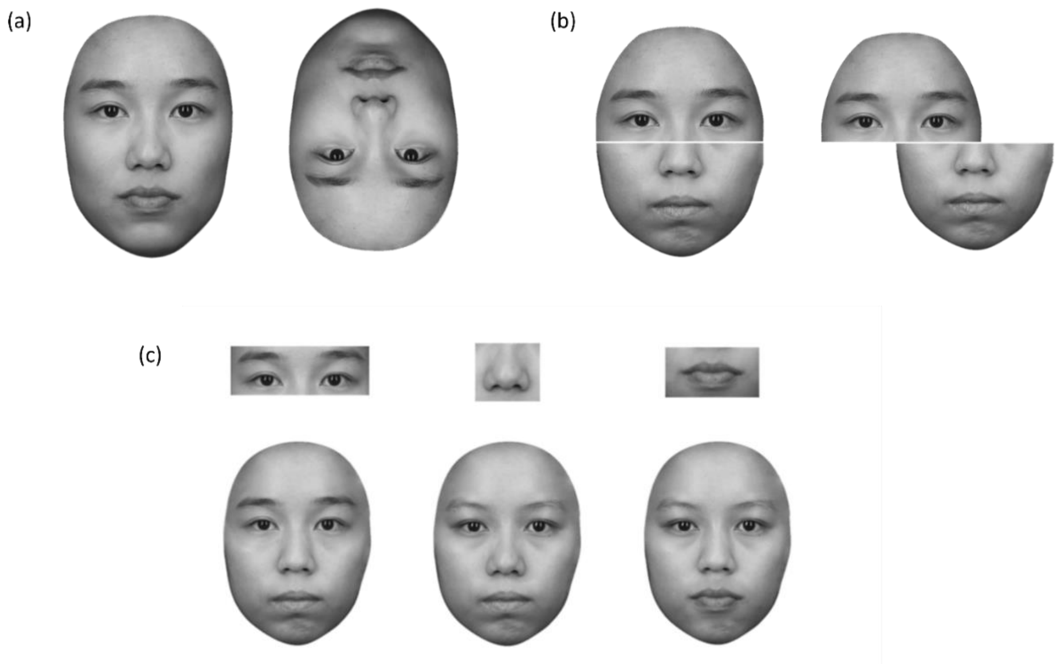
3.2.3 Procedure

Participants were asked to complete three experimental tasks in a counterbalanced order. Participants were seated approximately 63 cm from the screen. The screen measured horizontally 51 cm and vertically 28.5 cm. Participants were instructed to respond as quickly and accurately as possible.

3.2.3.1 Face Inversion Task. Each face image had an upright and inverted version (see *Figure 3.2a*). Inverted face images were created by flipping the upright face images vertically downwards.

Figure 3. 2

Examples of Stimuli Used in Each Task



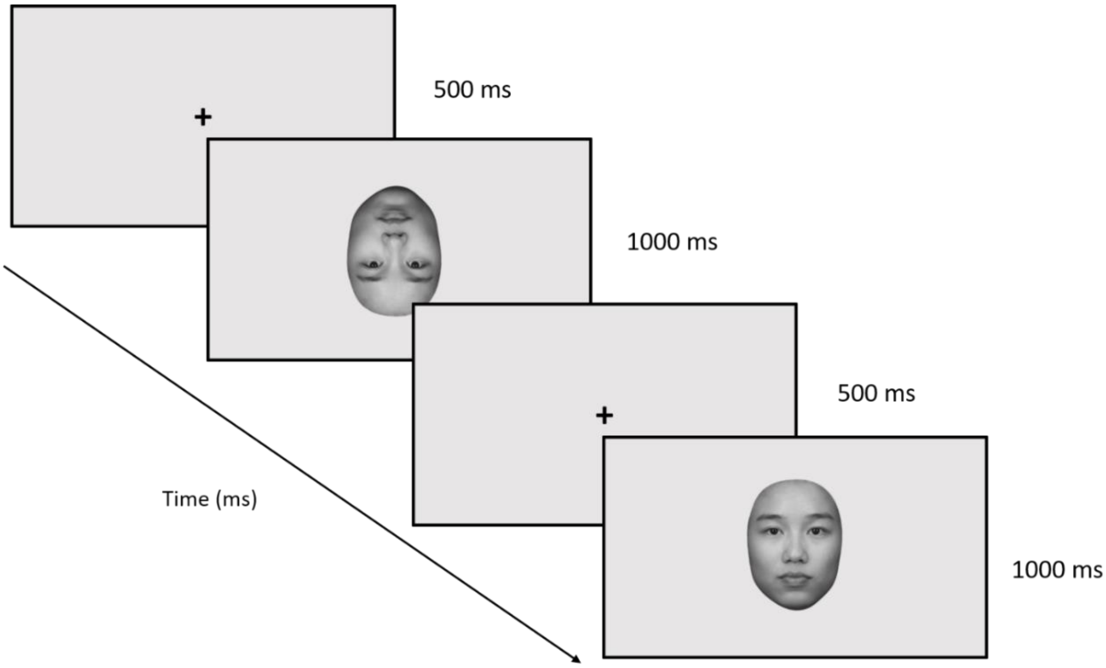
Note. (a) In the inversion task, face images are presented in an upright manner (left) and an inverted manner (right) by flipping them vertically downwards; (b) in the composite face task, the top half (e.g., of self-face) and the bottom half (e.g., of a novel face) combined to form a face composite in an aligned (left) and misaligned (right) manner with a 3-pixel gap; (c) in the part-whole task, facial features in "part" condition (top) and face foils created by substituting one critical feature across a face template, while keeping the original configuration of the face template (bottom).

This task had two within-subject variables: target identity (self, friend, and unfamiliar) and face orientation (upright and inverted). Each participant was asked to complete 12 practice trials and two blocks of 120 experimental trials. The 240 trials included 80 trials for each identity (self, friend, and unfamiliar), with 40 upright trials (5 different images x 8 repetitions) and 40 inverted trials (5 different images x 8 repetitions). All 240 experimental trials were randomized.

This task consisted of an initial learning stage for the unfamiliar face and a subsequent identification stage with all three faces. Observers were asked to memorize an unfamiliar face with the given name (e.g., “Wong”). This learning stage was self-paced. Observers pressed a key to move on to the identification stage once they indicated that they were ready (for a similar procedure, see Estudillo et al., 2018; Tanaka et al., 2006). The learned unfamiliar face was the same as the one shown in the identification task. In the identification task, participants were asked to indicate the identity of the presented face, with the following instructions: “If it is your own face, press the ‘J’ key; if it is your friend’s face, press the ‘K’ key; and if it is Wong’s face, press the ‘L’ key”. Each trial was then initiated with a central fixation cross appearing for 500 ms. The fixation cross was replaced by an image of an upright or inverted self-face, friend’s face, or unfamiliar face, which remained on screen for 1000 ms or until participants made a response. The response time and whether the response was correct were recorded. See *Figure 3.3* for a depiction of the experimental paradigm.

Figure 3. 3

Experimental Paradigm of the Face Inversion Task



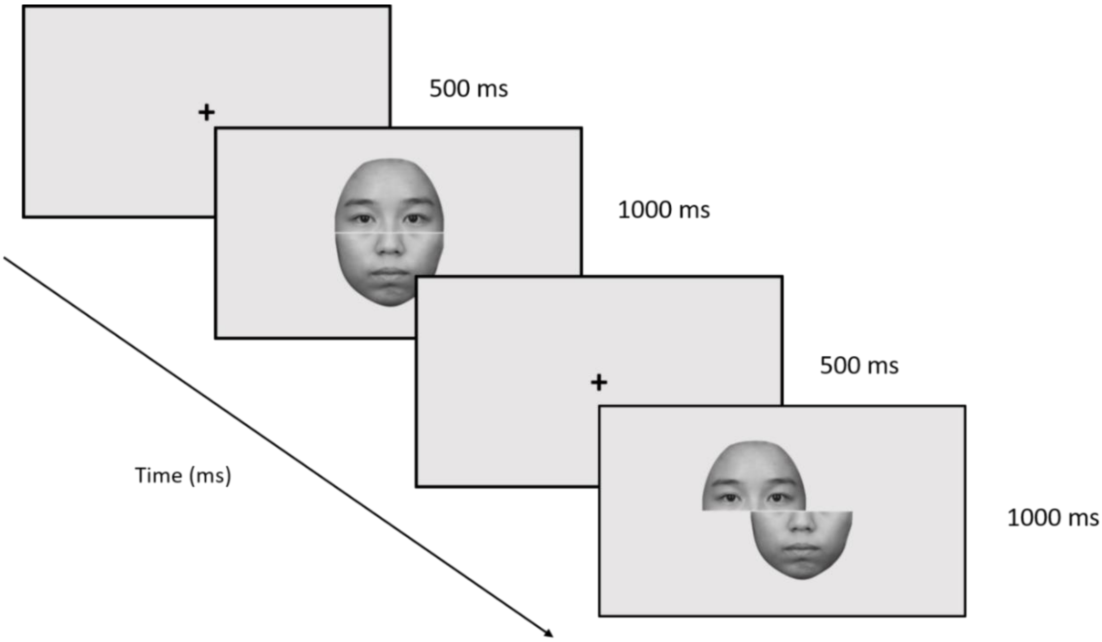
Note. Experimental paradigm: face inversion task started with the learning stage for an unfamiliar face. On each trial, a central fixation was replaced by either an upright or inverted face stimulus (self-face, friend's face, or unfamiliar face) after 500 ms.

3.2.3.2 Composite Face Task. In this task, participants were asked to identify the top half of the composite face presented in either an aligned or misaligned condition with an unfamiliar face. Face composites were first created by halving face images horizontally across the middle of the nose. Next, the top half of a face (from self, friend, or unfamiliar face) was combined with the bottom half of another face from a set of novel faces (either 12 females or 12 males), either in an aligned manner or misaligned manner, with a gap of 0.5 % of the image height separating the top and bottom face halves (see *Figure 3.2b*). This gap aimed to provide an objective definition of the to-be-matched face half and to remove an enhanced border contrast (see Rossion & Retter, 2015). Specifically, aligned conditions were when the top and bottom halves of a face were combined to form a standard face template, whereas, in misaligned conditions, the bottom half of a face was moved to the left/right by half of the face width. The bottom halves of the face composites were always different. Specifically, each identity (self, friend, or unfamiliar) was combined with bottom halves from four different novel faces, with 5 different images of a novel face (i.e., the different expressions: A, O, E, M, and neutral). The bottom and top halves were also matched in terms of the speech sound (e.g., the self-face with “A” expression was matched with a novel-face with “A” expression). The novel faces used for each identity were randomized across participants.

This task had two within-subject variables: target identity (self, friend, and unfamiliar) and face alignment (aligned and misaligned). Each participant was asked to complete 12 practice trials and two blocks of 120 experimental trials. For each block, there was a total of 60 aligned trials (3 identities x 20 repetitions) and 60 misaligned trials (3 identities x 20 repetitions). All 240 trials were randomized. The procedure was identical to the procedure of the face inversion task: with a learning stage for unfamiliar faces followed by the identification stage for all faces, but in this task, participants were asked to identify the top halves of face stimuli and to ignore the bottom halves. See *Figure 3.4* for a depiction of the experimental paradigm.

Figure 3. 4

Experimental Paradigm of the Composite Face Task



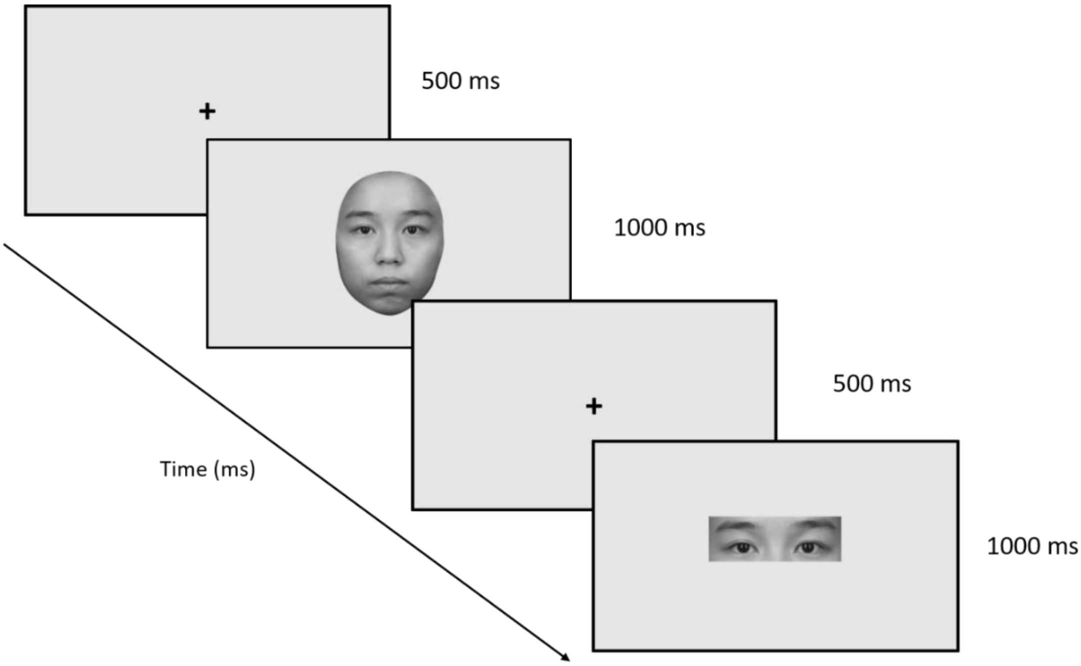
Note. Experimental paradigm: composite face task started with the learning stage for an unfamiliar face. On each trial, a central fixation was replaced by an aligned or misaligned face stimulus (self-face, friend's face, or unfamiliar face) after 500 ms.

3.2.3.3 Part-Whole Task. In this task, participants were asked to identify facial features presented in either isolation or the context of a whole foil face, and they were asked to decide which identity the facial feature belongs to (e.g., "whose eyes are these?" or "whose nose is this?"). For the whole face condition, face foil stimuli were created by swapping only one critical facial feature (eyes, nose, or mouth) of a target face (self, friend, or learned unfamiliar face) across six novel faces (3 females) of the same gender, while keeping the original configuration of the novel face template. In other words, the target face and whole foil faces were similar with the exception of the critical facial feature under examination (see *Figure 3.2c*). For instance, for the recognition of eyes in the whole face condition, the non-target features (nose and mouth of the novel face) were kept unchanged. Altogether, there was a total of nine whole foil faces and nine face parts stimuli for each participant: for each identity, three whole face foils were formed by swapping one of the critical facial features (eyes, nose, or mouth) with a novel face whereas three face parts were created with only one critical facial feature (eyes, nose, or mouth).

This task had two within-subject variables: target identity (self, friend, and unfamiliar) and part-whole condition (whole or part). Each participant was asked to complete 12 practice trials and a total of 180 trials. There were three feature blocks (eyes, nose, or mouth), each with 30 upright “whole” trials and 30 upright “part” trials respectively. Similar to the face inversion and composite face tasks, observers first went through a familiarization stage for the unfamiliar face followed by the identification stage, except that participant was asked to indicate the identity of the facial features presented either in isolation or in a whole foil face context. See *Figure 3.5* for a depiction of the experimental paradigm.

Figure 3. 5

Experimental Paradigm of the Part-Whole Task



Note. Experimental paradigm: part-whole task started with the learning stage for an unfamiliar face (top); on each trial, a central fixation was replaced by either "part" or "whole" stimuli after 500 ms.

3.2.4 Data Analyses

As holistic processing is measured by the face inversion, composite face, and part-whole effects, each of these effects was computed by comparing the accuracy score and median reaction time (RT) from the baseline conditions (i.e., upright, aligned, or whole) and the conditions of interest (i.e., inverted, misaligned, or part). The median RT was used instead of the mean RT to remove the influence of extreme values.

If the own face is processed more in a more featural manner compared to a familiar and an unfamiliar face, a smaller face inversion, composite face, and part-whole effects would be expected for the own face than for those of the familiar and unfamiliar faces. Specifically, for the face inversion task, it was expected that the differences between the identification of upright and inverted faces would be smaller for the own face compared to the differences for familiar and unfamiliar faces. In this case, the face inversion effect (FIE) was calculated by considering both the accuracy and median RT for correct responses on the upright and inverted trials, with the formula: (accuracy: upright – inverted; median RT: inverted – upright).

In addition, for the composite face task, it is expected that the self-face would be less affected by the 'holistic interference' from the to-be-ignored bottom half compared to the familiar and unfamiliar faces. In this instance, the composite face effect (CFE) was computed by considering the accuracy scores and median RT for correct responses on the aligned and misaligned trials, with the formula: (accuracy: misaligned – aligned; median RT: aligned – misaligned).

Lastly, for the part-whole task, it is expected that the recognition of a face part of the own face would be less affected by the presence of other facial features in a whole foil face context (i.e., less whole-face interference) compared to the recognition of a face part of familiar and unfamiliar faces. In this case, the part-whole effect (PWE) was calculated by considering the accuracy scores and median RT of correct responses in the "whole" and "part" conditions, with the formula: (accuracy: part – whole; median RT: whole – part) (see Rezlescu et al., 2017; Rossion, 2013).

Next, for each task, 3 (target identity*: self, friend, or unfamiliar*) × 2 (orientation*: inverted or upright;* alignment*: aligned or misaligned;* part-whole*: whole or part*) repeated-measures analyses of variance (ANOVAs) and follow-up comparisons were performed on the accuracy scores and median reaction times. In addition, to further explore the interaction effects of identity and FIE, CFE, and PWE, a one-way ANOVA was conducted on the accuracies and median RT for each identity. Overall, it is expected that: (1) for the face inversion task, participants would show a weaker face inversion effect for the own face as compared to the friend and unfamiliar faces; (2) for the composite face task, participants would show a weaker composite face effect for the own face than for the friend and unfamiliar faces; and (3) for the part-whole task, participants would show a weaker part-whole effect for the own face as compared to the friend and unfamiliar faces.

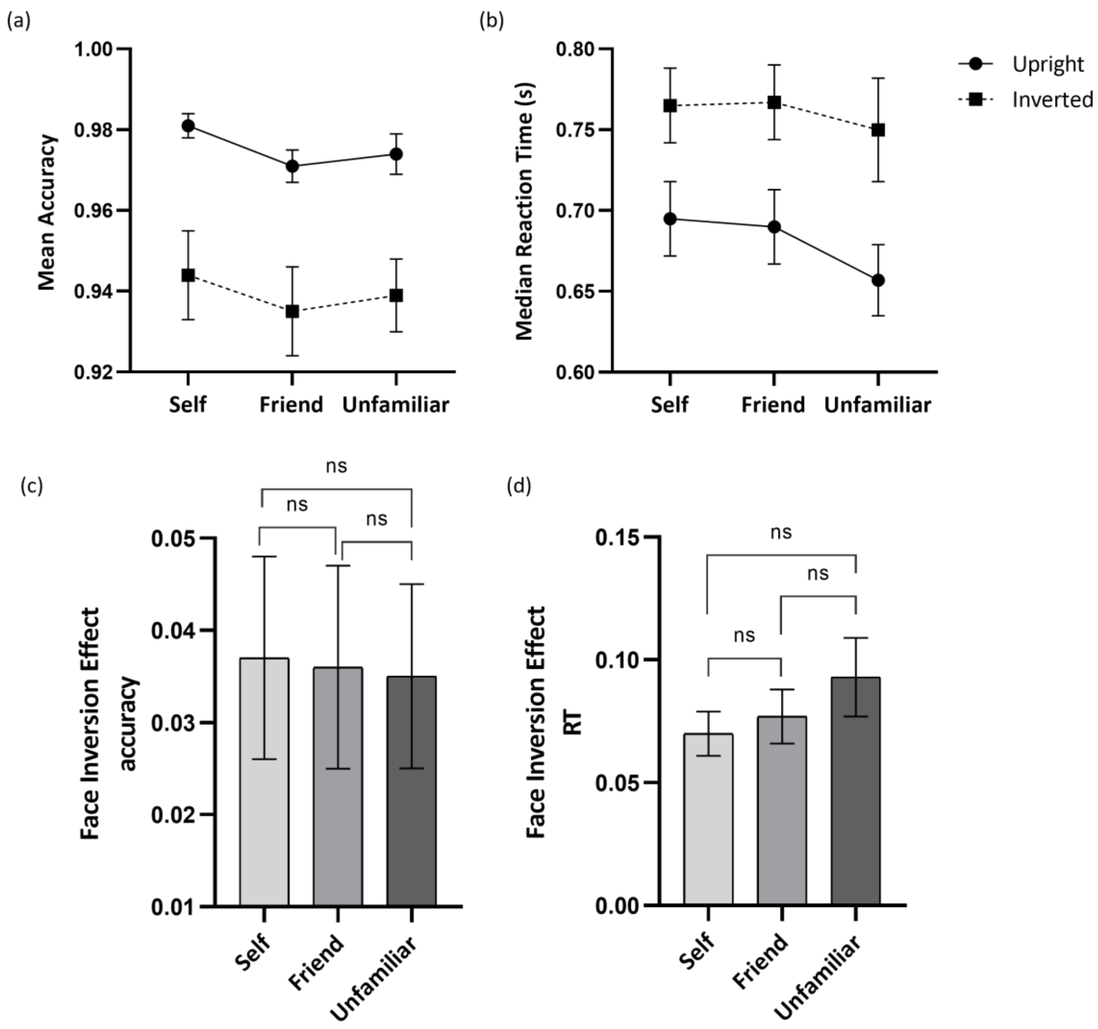
3.3 Results

3.3.1 Face Inversion Task

3.3.1.1 Accuracy. *Figure 3.6a* shows the accuracy for each face identity across upright and inverted conditions. The analysis revealed a significant main effect of Orientation, $F(1, 49) = 30.14$, $p < .001$, $\eta_p^2 = .381$, with a higher accuracy reported for face images presented in upright condition ($M = .975$, $SD = .003$) compared to inverted condition ($M = .939$, $SD = .007$). The analysis revealed no other significant main or interaction effects.

Figure 3. 6

(a) Mean accuracies and (b) median RT in response to identifying self, friend, and unfamiliar faces in upright (circles) and inverted (squares) conditions; (c) the FIE on mean accuracies and (d) median RT for self, friend, and unfamiliar faces.



Note. Error bars represents the standard error of the mean.

3.3.1.2 Median RT. *Figure 3.6b* shows the median RT for each face identity across upright and inverted conditions. The analysis revealed a significant main effect of Identity, $F(2, 98) = 4.84$, $p = .010$, $\eta_p^2 = .090$. Holm-Bonferroni post-hoc comparisons indicated that participants performed significantly faster for an unfamiliar face compared to the friend's face ($p = .008$, $d = -0.45$) whereas there were no significant differences in the RT between the self-face and friend face ($p = 1$, $d = -0.02$) and the self-face and unfamiliar face ($p = .051$, $d = -0.35$). Next, a significant main effect of Orientation was reported as well, $F(1, 49) = 85.61$, $p < .001$, $\eta_p^2 = .636$, with participants performing faster on the upright trials ($M = .680$, $SD = .022$) compared to the inverted trials ($M = .761$, $SD = .027$). The analysis further revealed no significant interaction effect.

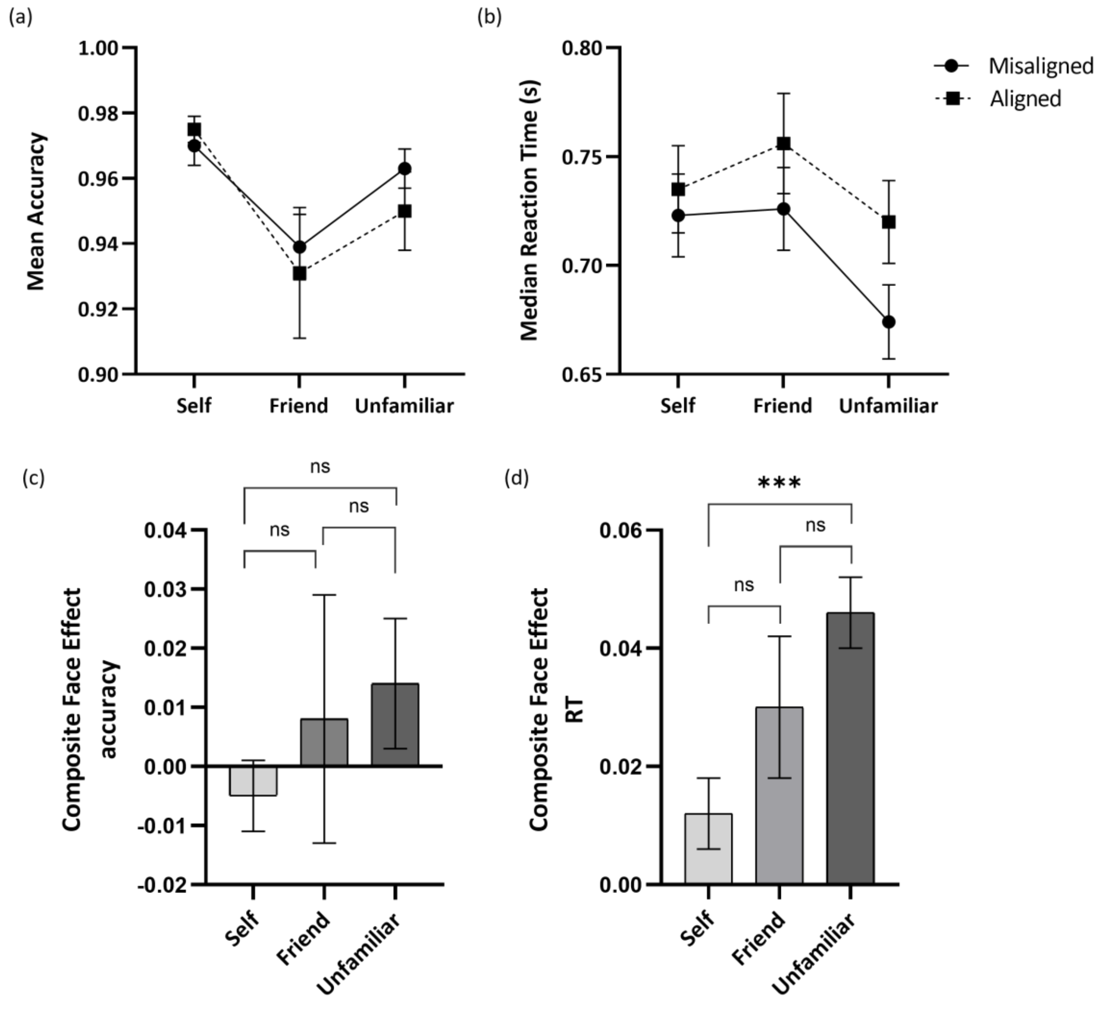
3.3.1.3 Face Inversion Effect (FIE). *Figure 3.6c* and *Figure 3.6d* shows the FIE for both accuracy and median RT across each face identity. For accuracy, the analysis revealed no significant main effect of Identity, $F(2, 98) = 0.01$, $p = .990$, $\eta_p^2 = .000$. Similarly, for median RT, the analysis indicated no significant main effect of Identity, $F(2, 98) = 1.28$, $p = .282$, $\eta_p^2 = .025$.

3.3.2 Composite Face Task

3.3.2.1 Accuracy. *Figure 3.7a* shows the accuracy for each identity across misaligned and aligned conditions. The analysis revealed a significant main effect of Identity, $F(2, 98) = 8.77$, $p < .001$, $\eta_p^2 = .152$. Holm-Bonferroni post hoc comparisons indicated that participants performed better for the self-face compared to a friend's face ($p = .006$, $d = 0.46$) and for an unfamiliar face compared to a friend's face ($p = .016$, $d = -0.41$), but there were no significant differences in the accuracy for self-face and unfamiliar face ($p = .115$, $d = 0.30$). The analysis further revealed no other significant main or interaction effects.

Figure 3. 7

(a) Mean accuracies (b) and median RT in response to identifying self, friend, and unfamiliar faces in misaligned (circles) and aligned (squares) conditions; (c) the CFE on mean accuracies and (d) median RT for self, friend, and unfamiliar faces.



Note. Error bars represents the standard error of the mean.

3.3.2.2 Median RT. *Figure 3.7b* shows the median RT for each face identity across misaligned and aligned conditions. The analysis revealed a significant main effect of Identity, $F(2, 98) = 12.32$, $p < .001$, $\eta_p^2 = .201$. Holm-Bonferroni post-hoc comparisons revealed that participants responded faster for unfamiliar faces compared to self-face ($p = .012$, $d = 0.43$) and friend's face ($p < .001$, $d = 0.74$) whereas there were no significant differences in the RT for self-face and friend's face ($p = .467$, $d = -0.20$). In addition, a significant main effect of Alignment was reported, $F(1, 49) = 31.98$, $p < .001$, $\eta_p^2 = .395$, with participants performing faster on misaligned trials ($M = .708$, $SD = .018$) compared to aligned trials ($M = .737$, $SD = .019$). Lastly, the analysis revealed a significant interaction effect between Identity and Alignment, $F(1.48, 72.64) = 3.91$, $p = .036$, $\eta_p^2 = .074$ (Huynh-Feldt corrected). Holm-Bonferroni post-hoc comparisons revealed that for the self-face, there were no significant differences in the RT for misaligned and aligned trials ($p = .066$, $d = -0.27$) whereas participants performed faster for misaligned trials compared to aligned trials for both friend's face ($p = .019$, $d = -0.34$) and unfamiliar face ($p < .001$, $d = -1.01$).

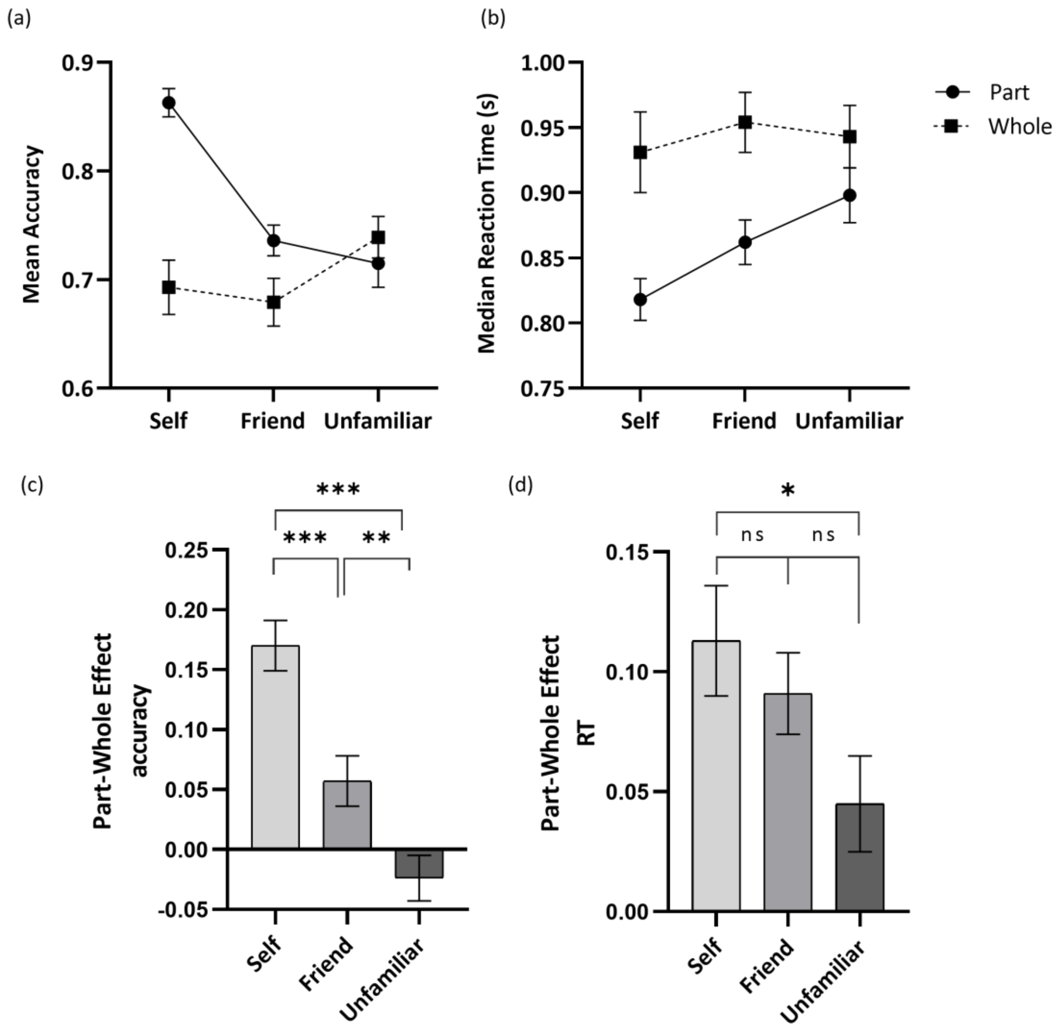
3.3.2.3 Composite Face Effect (CFE). *Figure 3.7c* and *Figure 3.7d* show the CFE for both accuracy and median RT across each face identity. For accuracy, the analysis revealed no significant main effect of Identity, $F(2, 98) = 0.59$, $p = .554$, $\eta_p^2 = .012$. On the other hand, for the median RT, the analysis revealed a significant main effect of Identity, $F(2, 98) = 4.42$, $p = .023$, $\eta_p^2 = .074$. Holm-Bonferroni post hoc comparisons revealed that the FCE was significantly smaller for the self-face compared to an unfamiliar face ($p < .001$, $d = -0.58$), whereas there were no significant differences in the CFE for self-face and friend's face ($p = .726$, $d = -0.17$) and for friend and unfamiliar face ($p = .573$, $d = -0.19$).

3.3.3 Part-Whole Task

3.3.3.1 Accuracy. *Figure 3.8a* shows the accuracy for each face identity across part and whole conditions. The analysis revealed a significant main effect of Identity, $F(2, 98) = 8.29$, $p < .001$, $\eta_p^2 = .145$. Holm-Bonferroni post-hoc comparisons revealed that participants performed better for self-face compared to friend's face ($p < .001$, $d = 0.64$) and unfamiliar face ($p = .052$, $d = 0.34$), whereas there were no significant differences in the accuracy for friend's face and unfamiliar face ($p = .735$, $d = -0.17$). A significant main effect of Part-Whole was also reported, $F(1, 49) = 28.77$, $p < .001$, $\eta_p^2 = .370$, with a higher accuracy for part trials ($M = .771$, $SD = .012$) compared to whole trials ($M = .704$, $SD = .017$). The analysis further revealed a significant interaction effect for Identity and Part-Whole, $F(2, 98) = 24.75$, $p < .001$, $\eta_p^2 = .336$. Holm-Bonferroni post-hoc comparisons revealed that for both self-face ($p < .001$, $d = 1.17$) and friend's face ($p = .009$, $d = 0.38$), participants performed better on part trials compared to whole trials whereas for unfamiliar face, there was no significant difference between part and whole trials ($p = .229$, $d = -0.17$).

Figure 3. 8

(a) Mean accuracies (b) and median RT in response to identifying self, friend, and unfamiliar faces in part (circles) and whole (squares) conditions; (c) the PWE on mean accuracies and (d) median RT for self, friend, and unfamiliar faces.



Note. Error bars represent the standard error of mean.

3.3.3.2 Median RT. *Figure 3.8b* shows the median RT for each face identity across part and whole conditions. The analysis revealed a significant main effect of Identity, $F(2, 98) = 7.05$, $p < .001$, $\eta_p^2 = .126$. Holm-Bonferroni post-hoc comparisons indicated that participants performed faster for self-face compared to friend's face ($p = .045$, $d = -0.36$) and unfamiliar face ($p = .003$, $d = -0.50$), whereas there were no significant differences in the RT for friend's face and unfamiliar face ($p = .843$, $d = -0.15$). In addition, a significant main effect of Part-Whole was reported, $F(1, 49) = 33.04$, $p < .001$, $\eta_p^2 = .403$, with participants performing faster in the parts condition ($M = .860$, $SD = .016$) compared to the whole condition ($M = .943$, $SD = .024$). Finally, the analysis revealed a significant interaction effect for Identity and Part-Whole, $F(2, 98) = 4.02$, $p = .021$, $\eta_p^2 = .076$. Holm-Bonferroni post-hoc comparisons revealed that for all faces, participants performed faster in the part condition compared to the whole condition (all ps < .001).

3.3.3.3 Part-Whole Effect (PWE). *Figure 3.8c* and *Figure 3.8d* show the PWE for both accuracy and median RT across each face identity. For accuracy, the analysis revealed a significant main effect of Identity, $F(2, 98) = 24.75$, $p <.001$, $\eta_p^2 = .336$. Holm-Bonferroni post-hoc comparisons revealed a larger PWE for the self-face compared to a friend's face ($p < .001$, $d = 0.63$) and an unfamiliar face ($p < .001$, $d = 0.86$) whereas the friend's face also showed a larger PWE compared to an unfamiliar face ($p = .007$, $d = 0.45$). Finally, for the median RT, the analysis revealed a significant main effect of Identity, $F(2, 98) = 4.02$, $p = .021$, $\eta_p^2 = .076$. Holm-Bonferroni post-hoc comparisons revealed a trend of a larger PWE for self-faces compared to unfamiliar faces ($p = .051$, $d = 0.35$) whereas there were no significant differences in the PWE for self and friend's face ($p = 1$, $d = 0.14$) and for friend and unfamiliar face ($p = .136$, $d = 0.29$).

3.4 Discussion

With three standard but relatively independent measures of holistic face processing, the role of holistic and featural processing was explored when perceiving the own, a personally familiar, and an unfamiliar face. Due to the distinct visual experience with the own face, it was hypothesized that the own face is processed in a more featural manner whereas both familiar and unfamiliar faces are processed in a more holistic manner. More specifically, if the own-face is processed more featurally, a smaller inversion, composite, and part-whole effects would be expected for the own face compared to those of the familiar and unfamiliar faces.

Findings in this study could be summarized in the following points: (1) all faces, regardless of their identity, were affected by inversion, such that, there were no significant differences in the inversion effect between the self-face, friend's face, and unfamiliar face; (2) compared to a friend and an unfamiliar face, the self-face was not affected by the alignment effect and a significantly smaller composite face effect was observed for the self-face compared to the unfamiliar face; and finally (3) a feature advantage for the self-face compared to other faces was reported, wherein self-face features were better identified when presented in isolation compared to when presented in a whole-face context, but there were no differences in the recognition performance between the two conditions for other faces.

3.4.1 Self-Face Recognition in a Face Inversion Task

With the inversion task, findings from Experiment 3 indicated an evident inversion effect for all faces, regardless of their identity, wherein participants overall were poorer and slower in identifying inverted faces compared to upright faces. Specifically, there were no significant differences in the inversion effect across the self, friend, and unfamiliar faces. This finding is consistent with the mounting existing evidence showing that inversion impairs face identification (e.g., Rossion, 2008; Rossion & Gauthier, 2002). As inverting a face disrupts the ability to perceive the face as an integrated whole (Van Belle, de Graef, Verfaillie, Busigny, et al., 2010; but see McKone & Yovel, 2009), observers would extract facial information from an inverted face in a more featural manner to compensate for this disruption (Barton et al., 2006), and hence amounting to an overall longer response time and lower accuracy when identifying inverted faces compared to upright faces.

More importantly, contradicting to the hypothesis, findings from Experiment 3 showed that the self-face is not more resistant to the inversion effects compared to other faces. Notably, even after controlling for familiarity effects, Experiment 3 did not observe a smaller inversion effect for one’s own face compared to a friend and unfamiliar face. Although these findings contradicted studies which showed that self-face is less vulnerable to inversion effects (e.g., Keyes, 2012; Keyes & Brady, 2010), these findings mirrored findings from a recent study (Alzueta et al., 2021), which presented behavioural and neural evidence that the self-face and friend’s face are both affected by inversion effects. With such findings, Alzueta and colleagues (2021) argued that the processing advantage for the own face could be better accounted for by the prioritization of one’s attentional system rather than a different perceptual mechanism. It is also worth noting that although individuals pay more attention to the facial features of the own face, individuals, however, still have the most experience with upright faces; and an inverted face does not fit the face template as the first-order configuration is disrupted (e.g., Rossion & Boremanse, 2008), hence reducing the efficiency of extracting facial information from an inverted face (i.e., less effective eye fixation patterns; Hills et al., 2013; Xu & Tanaka, 2013).

On the other hand, it is also worth noting that the inversion task reflects a type of holistic processing that is qualitatively different to that observed in the part-whole and composite tasks. This is supported by recent research that showed that these three measures are, at best, only poorly associated with each other (Rezlescu et al., 2017). Alternatively, it is also possible that inversion might reduce overall processing efficiency and disrupt the ability to extract relevant identity information without affecting whether the faces are being processed in a holistic manner (e.g., Richler et al., 2011; Sekuler et al., 2004; Willenbockel et al., 2010).

Finally, extending on the findings from Alzueta et al.'s (2021) study, findings from Experiment 3 show that familiar faces (self and friend) are not more vulnerable to the inversion effect compared to unfamiliar faces. In other words, our findings seem to suggest that inversion affects the familiar and unfamiliar faces in a similar manner. This finding is rather surprising as studies have demonstrated that due to the importance and increased reliance of holistic processing for familiar faces (see Buttle & Raymond, 2003; Veres-Injac & Persike, 2009), inverting a face stimulus should be more disruptive for familiar faces compared to unfamiliar faces (e.g., Caharel et al., 2006; Keyes & Brady, 2010; but see Tong & Nakayama, 1999). Overall, in the context that the interference of holistic processing is inferred by the inversion effect, findings from Experiment 3 seem to suggest that the self-face is not processed in a more featural manner (or lesser use of holistic processing) compared to other faces.

3.4.2 Self-Face Recognition in a Composite Face Task

In the composite face task, participants were asked to identify whom the top part of the face stimulus belonged to with the face stimuli presented in either misaligned or aligned conditions. When identifying the top part of the face stimuli as one's own face, there were no differences in the reaction time across the aligned and misaligned conditions. However, participants were quicker to identify the friend and unfamiliar face when the top part is presented in a misaligned condition compared to an aligned condition. In other words, compared to the friend and unfamiliar face, the self-face is less affected by the "holistic interference" (Rossion, 2013) from the to-be-ignored bottom half.

In a composite face task (Young et al., 1987), the composite effect indexes a failure of selectively attending to just one half of the face as the faces are processed as undifferentiated wholes and observers cannot ignore the task-irrelevant face half (Richler & Gauthier, 2014; Richler et al., 2008). In other words, there is a "holistic interference" from the task-irrelevant face half as faces are processed as wholes (Rossion, 2013). Therefore, based on the expectation that composite effect measures holistic processing, it is appealing to infer from our findings that one's own face is processed in a more featural manner compared to other faces as the self-face is seemingly less affected by the "holistic interference" from the task-irrelevant face half.

Nevertheless, findings from Experiment 3 need to be treated with caution as further analyses showed that although there was a significantly smaller composite face effect for the self-face compared to an unfamiliar face, there were no significant differences in the composite face effect between the self-face and a friend's face. One could argue that mere familiarity effects can explain for this pattern of finding, but it should be highlighted that there were no significant differences reported for the composite face effect between a friend and an unfamiliar face.

3.4.3 Self-Face Recognition in a Part-Whole Task

In the part-whole task, participants were shown facial features (eyes, nose, and mouth) presented in isolation or in a whole-face context and were asked to identify to whom the facial feature belonged. Overall, participants showed better and faster recognition of one's own face facial features presented in isolation compared to when presented in a whole-face context. However, there were no differences in the behavioural performance for the identification of friend's and unfamiliar facial features presented in isolation or in a whole-face context. Thus, such results show a feature advantage for the self-face compared to friends and unfamiliar faces.

With the part-whole task, Experiment 3 aimed to explore whether the recognition of a specific face part of the own face (i.e., eyes) would be less affected by the presence of other facial features (i.e., nose, mouth) in a foil whole-face context. In other words, smaller differences were expected between part and whole trials for the own face compared to both the familiar and the unfamiliar faces. Interestingly, and in contrast to the hypothesis, the own face produced stronger part-whole effects compared to the other faces. It is worth mentioning that this part-whole effect only arises because participants performed significantly better in the parts condition compared to the whole condition for the own face. Conversely, part-whole effect was not observed for both friend and unfamiliar faces as there were no significant differences in the performance across part and whole conditions for both faces.

In other words, the fact that this part-whole effect occurs as a consequence of a larger feature advantage (i.e., better performance for isolated features) for the own face compared to both friend and the unfamiliar face (see *Figure 3.4*) can be better explained by a congruency effect instead (Leder & Carbon, 2005). This congruency effect would arise because people have a stronger representation of their individual facial features (Greenberg & Goshen-Gottstein, 2009). Thus, when one's facial features are presented in the context of a foil face, there is a contextual mismatch with the way that these features are normally processed. On the contrary, as the representation of other people's facial features is much weaker (Greenberg & Goshen-Gottstein, 2009), this congruency effect would be smaller, therefore showing no differences in the recognition of facial features in the part and whole conditions. Although this explanation is only tentative, it is supported by previous research showing that a facial feature learned in isolation is subsequently better recognized when presented in isolation than in the context of a whole face (Leder & Carbon, 2005).

3.4.4 Self-Face Recognition, Holistic Processing, and Featural Processing

Overall, findings from Experiment 3 showed that compared to a friend or an unfamiliar face, the self-face seemed to be processed in a more featural manner. This is reflected by a smaller 'holistic interference' by a task-irrelevant bottom half face for the own face compared to other faces in the composite face task and a stronger feature advantage for the own face compared to other faces in the part-whole task. Nevertheless, it was observed that like other faces, the self-face is also affected by inversion.

Firstly, these findings suggest that the own face uses both holistic and featural processing. Given the significance of the own face, this dual-processing strategy for the own face ensures that the self-face is processed efficiently (see Hills, 2018). For example, although Keyes and Brady (2010) suggested that the own face is processed in a more featural manner, findings from their study, however, did not disregard the holistic processing nature of face processing as they reported a smaller but significant face inversion effect for the own face. Similarly, findings from Experiment 3 showed that the recognition of the self-face is affected by inversion in a similar manner as other faces, suggesting that self-face recognition also relies on holistic processing.

Nonetheless, it should be pointed out that although the inversion task has been suggested to disrupt holistic processing in a more naturalistic way (Alzueta et al., 2021) and is deemed to be the best in predicting face recognition abilities (Rezlescu et al., 2017), these findings do not imply that holistic processing is directly manipulated in the face inversion task (Tanaka & Simonyi, 2016). In fact, some authors have argued that inversion disrupts both holistic and featural processing (see McKone & Yovel, 2009) and simply reduces the overall processing efficiency to extract relevant facial information rather than having a qualitative change in the processing of an inverted face (Sekuler et al., 2004; Willenbockel et al., 2010). Hence, findings from the face inversion task need to be interpreted with caution.

Findings from Experiment 3 also showed that different tasks reflect different results in terms of holistic processing of self-faces. Specifically, there was no interaction between inversion and face types but there was an interaction between alignment and face types and between part-whole and face types. When interpreting findings from this experiment, one should take into consideration that the inversion, composite, and part-whole effects are poorly associated with each other, and these three measures might be tapping into different perceptual mechanisms (see Rezlescu et al., 2017; Richler et al., 2012). For instance, with the composite task, holistic processing is indexed by a holistic interference: individuals fail to selectively attend to just the task-relevant top half of the face (Rossion, 2013; Richler & Gauthier, 2014); and with the part-whole task, holistic processing is generally demonstrated by showing that facial features are encoded and integrated as one “whole” perceptual unit (i.e., an upright face) rather than being encoded as isolated facial features (Tanaka & Farah, 1993). Hence, considering that the inversion, the composite, and the part-whole tasks might be measuring different forms of holistic processing and the measure of holistic processing may be affected by the different task manipulations, future studies could consider the use of a gaze-contingent window (Van Belle, de Graef, Verfaillie, Rossion et al., 2010) to explore the role of holistic and featural processing for the own face as this technique provides a clear and direct demonstration whether the observer's perceptual field comprises one facial feature at a time or the whole face.

3.5 Conclusions

Chapter 3 attempted to explore the role of holistic and featural processing in the identification of the own face using three standard, but largely independent measures of holistic face processing: the face inversion effect, the composite face effect, and part-whole interference or effect. Findings from this chapter showed that (1) the own face is not more resistant to inversion than other faces; (2) a smaller composite effect (or less holistic interference) was reported for the own face compared to an unfamiliar face; and lastly (3) a feature advantage (i.e., better recognition for isolated features compared to in a whole-face context) was found for the own face compared to other faces. In sum, findings from this study seem to suggest that not all faces are processed similarly. Specifically, the own face seems to be processed in a more featural manner but also relies on holistic processing compared to other familiar and unfamiliar faces. Findings from this chapter also suggest that caution is needed when designing and interpreting face perception studies involving the own face and other faces as these faces seem to be processed differently. Finally, this chapter also highlights the importance of taking into consideration how different experimental manipulations could affect the measure of holistic processing.

Chapter 4

Attentional Prioritization of the Own-Face: Evidence from Visual Search Study

4.1 Introduction

Self-processing involves the perceptions and memories of oneself (Liu et al., 2022) and it is modulated by one's self-concept (e.g., Morin, 2006). Self-concept is generally understood as the way in which people perceive and evaluate themselves (Markus & Kitayama, 1991). An individual's self-concept influences a range of cognitive processes, such that when a stimulus is perceived as self-relevant, self-concept would guide the perception and interpretation of the self-referent information, resulting in a systematic self-processing bias across domains of attention (Alzueta et al., 2020; Wójcik et al., 2019) and perception (Cunningham et al, 2008; Sui & Humphreys, 2015). Most importantly, it is theorized that an individual needs to have a self-concept to be able to recognize their face (Gallup, 1970) and likewise, the ability to recognize one's face in the mirror is often asserted to be fundamental in maintaining a coherent identity of the self (Rochat & Zahavi, 2011).

Nevertheless, it is suggested that one's self-concept can be modulated by culture, wherein those from individualistic culture tend to show an independent self-concept whilst those from a collectivist culture would show an interdependent self-concept (Markus & Kitayama, 1991). In addition, one's self-concept also influences the perception and interpretation of self-referent information (e.g., Alzueta et al., 2020; Sui & Humphreys, 2015). For instance, individuals with depression tend to have a negative self-concept causing the perception and interpretation of self-related information to be negatively biased (see Beck, 1967; 2008). In sum, considering how self-face recognition is linked to one's self-concept, Chapter 4 explores the modulation effects of culture and depressive personality traits (i.e., a negatively biased self-concept) on the attentional prioritization for the own face (i.e., SFA).

4.1.1 Cultural Effects and Self-Concept

There is consistent evidence demonstrating a varying importance of the self-face across cultures. For example, Broesch et al. (2011) observed that compared to Western children, fewer non-Western children demonstrated a self-orientated behaviour (i.e., to touch or to remove a mark placed on the child's face) during the classical "mirror mark test". This test is a benchmark index of an emerging self-concept in children from 18 to 24 months, wherein children display signs of mirror self-recognition (e.g., Amsterdam, 1972). The findings of Broesch et al. (2011) suggest that the self-face may carry different levels of importance across cultures.

It has been shown that culture plays a key role in determining one's self-concept, with distinct self-concept styles for East Asian and Western cultures (Liew et al., 2011). Individuals from Western cultures (e.g., White Americans and Europeans) demonstrate an independent self-concept. In these cases, they tend to be more individualistic, and the self is generally perceived as an autonomous entity. East Asians (e.g., Chinese, Koreans, and Japanese), on the other hand, tend to demonstrate an interdependent self-concept, in which they value the interconnectedness with others and the self is generally conceptualized in terms of its relationships with others and social contexts (Markus & Kitayama, 1991). It is suggested that individuals with independent self-concepts assign a greater social salience or positive associations to self-related stimuli than those with interdependent self-concepts (e.g., Sui et al., 2009).

For instance, using a self-referential task (Rogers et al., 1977) wherein participants were asked to make judgements on traits which best described the self or familiar others (i.e., mothers/best friends), it was reported that Western individuals showed a self-reference effect over other close others, recalling more adjectives for traits associated with the self (Heatherton et al., 2006). On the other hand, Chinese individuals recalled a similar number of trait adjectives describing the self and familiar others, demonstrating no self-reference effect (Qi & Zhu, 2002; Zhu & Zhang, 2002). Additionally, using a head orientation judgement task, Sui et al. (2009) showed that British participants responded faster and more accurately to their own face relative to a friend's face (i.e., self-face advantage, SFA). In contrast, such an advantage was not found in Chinese participants. Another study showed that Chinese participants displayed no or a weakened SFA in the presence of their supervisor, but this reduced SFA was not observed in British participants (Liew et al., 2011). Liew and colleagues (2011) coined this observation as the "boss effect" which shows that self-processing can be modulated in the presence of "influential social superiors".

Several studies also associated these cultural differences in self-concepts to differences in the cognitive processes related to self-processing. For instance, in a fMRI study, Zhu et al. (2007) asked Chinese and Western participants to make judgements on personal trait adjectives describing the self or the mother. The authors observed activation of neural regions associated with self-processing (i.e., the medial prefrontal cortex) when making judgements for the self and the mother in Chinese participants. Conversely, these self-processing regions were only activated when making self-judgements in Western participants. Similarly, in an EEG study, Sui et al.

(2009) showed that British participants displayed greater fronto-central activity (i.e., related to self-processing) for images of one's own face compared to a friend's face. However, a reverse pattern was observed for Chinese participants. This finding may suggest that, compared to Western individuals, East Asian individuals demonstrate an unclear distinction between the self and familiar others (Sui et al., 2009). Extending these findings, in an ERP study, Sui et al. (2012) observed an enlarged N2 to the self-face compared to the friend's face in British individuals, but Chinese individuals showed an enlarged N2 to the friend's face compared to the self-face. With the N2 component being specifically associated with deeper processing of faces to facilitate recognition of faces (Kubota & Ito, 2007), these results indicate that, compared to Chinese individuals, British individuals may deploy greater attention to self-related information, such as their own face, than to information related to others.

The emerging picture from the literature discussed above seems to suggest that the cultural differences might modulate the cognitive processes underlying self-face processing. More specifically, the modulation of cultural differences on self-concept may extend beyond the processing of the physical self (e.g., the own face), such that greater social salience is assigned to one's own face compared to a friend's face in Western individuals (i.e., independent self-concept) than in East Asian individuals (i.e., interdependent self-concept). Following this line of notion, independent self-concepts should lead to stronger attentional bias to self-related stimuli, such as the self-face, and, consequently, to an advantage in the processing of self-faces (i.e., SFA). Conversely, as interdependent self-concepts value the interconnectedness with others, self-face might be as relevant as friend's faces, which should diminish the SFA (Sui et al., 2009). Hence, Experiment 4 of this chapter would explore the cultural modulation effects on an SFA using a visual search paradigm.

4.1.2 Depressive Personality Traits and Self-Concept

Whereas it is generally observed that people tend to have a self-positivity bias (Greenwald, 1980; Watson et al., 2007), such that they view and evaluate themselves in a favourable and positive manner (e.g., Koole & DeHart, 2007), individuals with depression tend to have a negatively biased self-processing. In his seminal work, Beck (1967) proposed a cognitive model on depression which theorized that depressed individuals have a negative view of the self, the world, and the future and further proposed that this “negative triad” would result in a systematic and automatic negative bias on information processing (Beck, 2008). Based on this theory, depressed individuals possess a negative self-representation (or self-concept) built upon themes of inadequacy and failures. This negative self-representation would then influence the perception and the interpretation of self-related information as negatively biased.

Studies using a wide range of experimental paradigms had presented evidence that depression is associated with negative associations about the self (for a review, see Wisco, 2009). For instance, compared to non-depressed individuals, depressed individuals recall more negative self-traits (e.g., Burke et al., 2015), choose more negative words to describe themselves (e.g., Derry & Kuiper, 1981; Rude et al., 1988), report more negative views of themselves on self-report measures (e.g., Beckham et al., 1986) and respond faster to negative self-related stimuli (i.e., sad self-face; Fritzsche et al., 2010). There is also considerable evidence (e.g., Gotlib et al., 2004; Hankin et al., 2010) showing that the depressed (or depression prone) individuals show a greater avoidance to positive facial expressions stimuli and are less likely to correctly recall positive self-referential information compared to non-depressed individuals. Taken together, these studies put forth evidence that self-relevant information is associated with more negative thinking in depression.

Self-face processing is considered as a fundamental modality of self-processing such that individuals typically show a processing advantage (i.e., shorter response time and higher accuracy) for the own face compared to other faces (i.e., SFA). This SFA is suggested to be promoted by one's positive self-biases and self-evaluations (Greenwald, 1980; Watsons et al, 2007), as self-face recognition is generally associated with positive self-perceptions (Blackwood et al., 2003). For instance, Epley and Whitchurch (2008) showed that when they morphed photographs of participant's faces with attractive or unattractive faces, participants were more likely to identify the attractive morphs as the own face compared to their actual face or the unattractive morphs. DeBruine (2005) also observed that individuals rated morphs of their faces as more trustworthy compared to morphs of other faces, suggesting that people evaluate unfamiliar faces that resembled the self, more favourably. Correspondingly, Ma and Han (2010) had put forward the implicit positive associations theory to elucidate the SFA from a social cognitive perspective. The implicit positive associations theory stems from studies showing that individuals generally respond faster to positive stimuli compared to negative stimuli (e.g., Feyereisen et al., 1986; Kirita & Endo, 1995; Ma & Han, 2010). When postulating the implicit positive associations theory, Ma and Han (2010) argued that when viewing the own face, positive self-attributes are activated, which in turn facilitates the behavioural responses to the own face. In other words, positive emotion may be implicated as an underlying factor for an attentional prioritization of the self-face (i.e., SFA).

However, several studies had showed that the effects of having a negative self-concept can be extended to the processing for the own face. For instance, Ma and Han (2010) reported that participants who were primed with negative adjectives to describe the self (i.e., low levels of positive self-evaluation) showed a reduced preferential bias for the own face (i.e., a weaker SFA) compared to those with higher levels of positive self-evaluations. This finding implied that the observed SFA may be driven by the implicit positive associations to self-related stimuli. Furthermore, in a brain imaging study, Quevedo et al. (2016) observed that depressed youth with high suicidality showed lower activity in the midline cortical structures (i.e., medial prefrontal cortex, anterior cingular cortex, and posterior cingulate cortex) implicated for self-processing (Deeley et al., 2008; Sugiura et al., 2005). The authors also reported a significantly reduced neural activity in the limbic structures (i.e., hippocampus and amygdala) when viewing the own face with a happy expression compared to an unfamiliar face with a happy expression. In other words, suicidal depressed youth showed a reduced activity in the neural circuity for self-face processing when asked to recognize positive self-expression. These findings seem to be in parallel with the cognitive theories associating depression with negative biases in self-processing.

To date, less is also known about the modulation effects of depressive traits on self-face processing in a neurotypical sample. Assessing the relationship between depressive traits features and experimental manipulation by measuring depressive traits in the general population would provide a platform for follow-up investigations for clinically diagnosed depressed individuals (i.e., Robinson et al., 2011). Therefore, Experiment 5 would explore the modulation effects of depressive traits on the attentional prioritization of the own face in a general population.

On a different note, extending from Beck's (1967) negative self-concept theory, the specific preference for negative stimuli in depressive individuals could also be accounted for by a mood-congruency bias hypothesis (e.g., Bower, 1981; Dalgleish & Watts, 1990). Specifically, negatively valenced stimuli may correspond closely to a depressed individual's negative affective state (Cavanagh & Geisler, 2006; Ilardi et al., 2007), hence promoting an attentional bias to negative stimuli. Whilst existing sources of evidence are largely consistent with the mood-congruency bias hypothesis, some research has explored the combined effect of self-perception and emotion in depressive disorders. Caudek and Monni (2013) showed that after a negative mood-induction procedure to activate a distressed mood state, non-depressed individuals with a negative cognitive style showed a negative self-referential memory bias. Specifically, these individuals showed a better head-pose recognition for one's own sad face compared to one's own happy face. However, participants who are not distressed but have a negative cognitive style did not show a negative self-referential bias. This finding seems to suggest that negative self-concepts (or schemas) would only be activated in negative mood states (Ingram, 1984; Joorman, 2007).

In a recent study, McIvor et al. (2021) examined the influence of self-perception on the salience of emotional stimuli in depressive individuals using a perceptual matching task. In the study, participants had to associate geometric shapes with personal labels ("self" or "others") and each shape had a happy, neutral, or sad line drawing of a face. Participants had to decide whether the shape-label pairs matched whilst the facial emotion was deemed task irrelevant. The authors reported a self-face advantage regardless of facial emotion across both control and depressed participants. Interestingly, they observed that depressed individuals showed reduced happy and sad emotional biases regardless of the self-relevance of a stimulus and hence suggested that depressed individuals may instead show a general blunted response to emotion (see Rottenberg et al. 2005). These findings however, contradicted Becks' (1967) cognitive theory of depression which emphasized on a bias to negative stimuli due to a negative self-perception.

The emerging picture from the evidence discussed above seems to suggest that the mood-congruency bias hypothesis may be implicated as an underlying factor for the negative processing biases in depressed individuals. Therefore, Experiment 6 would further explore the modulation effects of depressive traits on SFA while considering the role of emotional valence of stimuli.

4.2 Experiment 4

Experiment 4 aims to examine cultural modulation effects on the SFA with a visual search paradigm. A visual search paradigm allows us to explore early attentional orientation effects of a target stimuli among an array of interfering stimuli (Tong & Nakayama, 1999). Although both Tong and Nakayama (1999) and Devue et al. (2009) used a similar visual search paradigm, they reported contradictory results as an SFA was reported in the former but not in the latter study. Discrepancies in the task might explain this difference. Tong and Nakayama (1999) did not control for possible familiarity effects, whereas face identity was task irrelevant in Devue et al. (2009). To control for familiarity effects but otherwise replicate the design of Tong and Nakayama (1999), as closely as possible, personally familiar faces (e.g., a friend's face) were included and face identity would be task relevant in Experiment 4.

For this study, it is hypothesized that the SFA might be modulated by the cultural differences in the self-concepts of participants, where people with independent selves (i.e., British Caucasians) are expected to show a robust SFA and people with interdependent selves (i.e., Chinese Malaysians) would show a weakened SFA. To test this hypothesis, Experiment 4 included British Caucasians and Chinese Malaysians and compared their search times and accuracy for frontal view images of self, friend, and unfamiliar faces among an array of unfamiliar distractor faces.

Specifically, it is hypothesized that, due to their independent selves, Caucasians would show faster reaction times and higher accuracy when searching for their own face compared to their friend's face. Conversely, as the interdependent selves place more emphasis on the interconnectedness between self and others, when searching for their own face and friend's face, Chinese participants would show a smaller difference in terms of reaction times and accuracy than Caucasian participants.

As both the self-face and the friend's face are –due to extensive exposure– highly overlearned faces, both faces should show a processing advantage compared to the unfamiliar face in both race groups. For example, di Oleggio Castello et al. (2017) observed that Caucasian individuals demonstrated a shorter searching time for a familiar target compared to an unfamiliar target in a visual search task. A similar pattern has also been reported for Asian participants (Zhang & Zhou, 2019). Therefore, it is expected that, regardless of the race of participants, the self-face and the friend's face would have a familiarity advantage compared to the unfamiliar face. Specifically, both Caucasians and Chinese would demonstrate shorter search times and higher accuracy for familiar faces compared to unfamiliar faces.

Additionally, Experiment 4 also explored whether an SFA can be explained by the differences in self-construal of the participants, regardless of their race. The Independent and Interdependent Self-Construal Scale (SCS; Singelis, 1994) was used to assess the independent and interdependent self-concepts among participants. For this explorative analysis, it was expected that, regardless of the race of the participants, individuals with a higher score on the independent self-construal subscale would show a stronger SFA whereas individuals with a higher score on the interdependent self-construal subscale would show a weaker SFA.

Although this questionnaire has been widely used in other face processing studies concerning cultural modulation effects (e.g., Ma & Han, 2010; Sui et al., 2012), it has low internal consistency scores that range from high .60's to middle .70's (Singelis, 1994). To address this reliability issue, another scale was included: the Horizontal and Vertical Individualism and Collectivism Scale (HVIC; Triandis & Gelfland, 1998) that measures multidimensional construct of individualistic and collectivism by characterizing it into horizontal (highlights equality) and vertical (highlights hierarchy) social relationship terms: namely Horizontal Collectivism (HC), Horizontal Individualism (HI), Vertical Collectivism (VC), and Vertical Individualism (VI). Horizontal patterns of social relationship assume oneself is similar to other selves (i.e., a preference for equality) whereas vertical patterns comprise of hierarchy and involvement of authority, wherein each self is distinct from other selves (i.e., a preference for hierarchy; see Triandis & Gelfland, 1998). Specifically, in cases of HI, individuals are more self-reliant and aspire to be unique from others, yet these individuals are less interested in acquiring a high social status. In cases of VI, individuals tend to care for acquiring status through individual competition with others. HC corresponds to individuals perceiving themselves similar to other and they give emphasis to interconnectedness and sharing common goals with groups. However, they do not yield easily to authority. Lastly, VC individuals are typically characterized with their willingness to sacrifice own ideals for the benefit of the in-group goals. For this analysis, regardless of the race of participants, individuals with a higher score on both HI and VI are hypothesized to show a stronger SFA whereas individuals with a higher score on both HC and VC are hypothesized to show a weaker SFA.

4.2.1 Methods

4.2.1.1 Participants

Fifty-six Chinese Malaysians and fifty-six British Caucasian students were recruited from the University of Nottingham, Malaysia (in Malaysia) and Bournemouth University (in the UK), respectively. A power analysis performed in G*Power 3.1 (Faul et al., 2007) with the smallest effect size of interest (SESOI; Lakens et al., 2018) of 0.10 and an alpha of .05 gives a required total sample size of 112 participants (56 participants for each group) to achieve 80% power in a mixed-design ANOVA analysis.

Participants were recruited in pairs matched by age, gender, and race, so that each served as the friend for the other participant. The age range allowed for matching is up to three years. Participants were either awarded with course credits or compensated financially for their participation. Ethics approval for this proposed study was obtained from the Science and Engineering Ethics Committee of the University of Nottingham Malaysia and the Ethics Committee of Bournemouth University.

4.2.1.2 Stimuli

Image collection. Photograph stimuli (self-face and friend face) were individually tailored to each participant. Each participant was photographed under similar conditions (i.e., constant lighting), in a frontal position while assuming a neutral and a happy expression and while articulating three different speech sounds (e.g., A, O, and E; see *Figure 4.1*). Different images were used for each identity to reduce image-specific learning. All five different images were used as “self-face” for the participant themselves and as “friend’s face” for their friend respectively. Twentyeight separate individuals: 14 Caucasians (7 males and 7 females) and 14 Chinese (7 males and 7 females) matched in age were photographed under same conditions to be used as unfamiliar targets and distractor faces. All images were collected and processed at least one week prior to the experimental session.

Figure 4. 1

Example of Face Stimuli

Note. The five different images for each identity that were presented throughout the study. From left to right, top row: neutral, happy. From left to right, bottom row: "A", "O", and "E".

Image Processing. Using Photoshop™, all photographs were rotated to ensure eyes are horizontal horizontaland were cropped to 113 x 126 pixels, corresponding to an approximate visual angle of 2.9˚ x 3.4˚at a viewing distance of 70 cm. All photographs were cropped based on their individual contours and external features (i.e., hairs and ears were removed). All face images were also converted to greyscale. These transformations would minimize differences in non-facial cues.

“Self-face” images were presented in a mirror-reversed orientation (i.e., the view in which people generally view their own face), whereas the “friend” and “unfamiliar” images were presented in normal orientation. Each participant’s stimuli set consisted of four sets of images: one target self-face set (with five different images), one target friend face set (with five different images), one target unfamiliar face set (with five different images), and six distractor faces sets (each with five different images). *Figure 4.1* shows example of face stimuli that were presented in the study.

After the main experiment, a subsequent study was conducted to assess the similarity of the face stimuli across target conditions and race groups. This assessment could only be conducted afterwards, because the self-face and friend face stimuli were not available before the visual search task has been completed. Ten independent raters from each race group (who did not participate in the main experiment) were asked to rate how much each of the own-race faces used in the different conditions of the visual search task (self, friend, unfamiliar, and distractor) stands out. Specifically, they were asked to rate “how likely will this face stand out in a crowd?” on a five-point Likert scale, with 1 = ‘not at all likely’ and 5 = ‘extremely likely’. Faces were presented individually in the center of the screen until participants respond.

With these scores, a “stand-out” score for each face condition compared to the mean stand out score for the distractor faces was calculated. Specifically, how much the familiar faces (i.e., self-face or friend face) stand out compared to distractor faces (SF or FF – DF), and how much the unfamiliar face stands out compared to the distractor faces (UF – DF) was calculated for each participant. Because participants were recruited in pairs, there would only be one set of familiar faces, as the face of each participant would have two roles (self-face and friend face). Lastly, two independent-samples t-tests were conducted with the two stand-out scores as the dependent variables and race group as the independent variable. If any of these t-tests show differences across race groups, these stand-out scores would be included as covariates in the analyses of the visual search task.

The stand-out scores between familiar faces (SF or FF) and distractor faces did not differ significantly across Chinese and Caucasian participants, $t(18) = 1.09$, $p = .291$. Similarly, the stand-out scores between unfamiliar faces and distractor faces also did not differ significantly across Chinese and Caucasian participants, $t(18) = -0.84$, $p = .414$.

Independent and Interdependent Self-Construal Scale (SCS). This scale consists of 30 statements (15 independent and 15 interdependent items) that measure the two distinct dimensions of self-construal (Singelis, 1994). Participants were required to indicate their agreement with the statements on a seven-point Likert-type scale ranging from 1 = 'strongly disagree' to 7 = 'strongly agree'. Using Cronbach's alpha, previous research reported that the internal consistency of the interdependent self-construal subscale was .59, whereas the internal consistency of the independent self-construal subscale was .60 (Kim et al., 1994).

Horizontal and Vertical Individualism and Collectivism Scale (HVIC). This scale consists of 16 items that measure four different dimensions of collectivism and individualism, namely horizontal (H) and vertical (V) individualism (I) and collectivism (C), making up HI, VI, HC, and VC. Each dimension consists of four items. For instance, an item from HI dimension is "I rely on myself most of the time; I rarely rely on others"; an example item from VI is "It is important that I do my job better than others"; an item from HC is "I feel good when I cooperate with others"; and an item from VC is "It is important to me that I respect the decisions made by my groups". Participants were required to indicate their agreement with the statements on a nine-point Likert-type scale ranging from 1 = 'never or definitely no' to 9 = 'always or definitely yes'. Each dimension's items are summed up separately to create a HI, HC, VI, and VC score.

4.2.1.3 Procedure

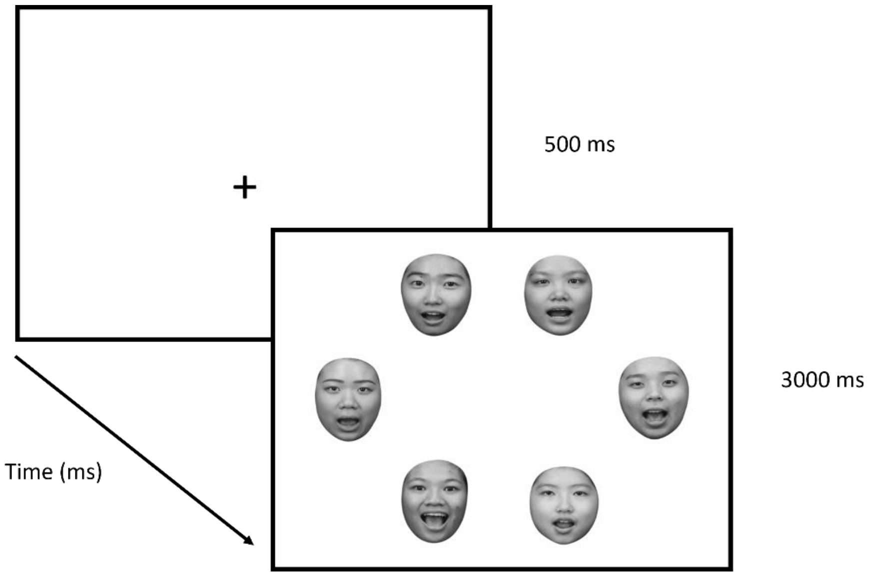
This study used a mixed design with one between-subjects variable (race: Chinese or Caucasian) and two within-subjects variables (target identity: self, friend, and unfamiliar; and target presence: present or absent). A total of six blocks with each target identity condition was presented twice. The presentation of blocks was counterbalanced for target identity (i.e., self, friend, or unfamiliar face) where target identity changed from one block to the next.

Each block consisted of a total of 80 trials wherein target faces appeared in only 50% of the trials (i.e., target present condition): 40 (5 different target images x 8 repetitions). The remaining 50% of the trials consisted of display of only unfamiliar distractor faces (i.e., target absent condition). The order of trials within each block was randomized as well. The distractor faces were randomly selected among the set of six distractors with no two identical faces presented within the same trial. For each trial, participants' set of stimuli (self, friend, unfamiliar, and distractor faces) would always consist of the same emotional expression, race, and gender. At the start of the study, participants performed a familiarization phase: 36 practice trials with the same unfamiliar target during the practice trials as during the subsequent test trials.

During the experiment, participants were seated 70 cm from the screen. The screen measured horizontally 51 cm and vertically 28.5 cm. Participants were then instructed to search for a given target identity among an array of distractor faces. At the start of each block, participants were cued with a target image (i.e., self-face, friend face, or unfamiliar face). With a key press by the participants, each trial was initiated with a central fixation cross appearing for 500 ms. Participants were asked to fixate the cross until an array of six faces is presented. All face stimuli (i.e., target face and distractor face) were randomly positioned to one of the six possible locations to form a hexagon around a fixation cross subtending to a visual angle of 10.1º x 7.7º (see *Figure 4.2*). The display remained on screen for 3 seconds or until participants made a response. The target face was present in 50% of the trials, and to respond, participants pressed the "/" key when the target was present and the "z" key when the target was absent. Participants were asked to respond as quickly and as accurately as possible, and visual feedback was provided when the response was incorrect or when participants did not respond within three seconds.

Figure 4. 2

The Experimental Paradigm



Note. On each trial, a central fixation cross was presented for 500 ms followed by an array of six faces for a maximum of 3000 ms.

Participants were also asked to complete the SCS and HVIC questionnaires. They were asked to answer these questionnaires prior to carrying out the visual search task. The study took about 40 minutes to complete.

4.2.1.4 Data Analyses

As processing efficiency (i.e., reaction time is often used as a criterion to determine an SFA) is our main interest, data analysis was performed on the median reaction times (RT) for correct responses. The median of RT was used instead of mean RT to remove the influence of extreme values. Accuracy was recorded and used as an outcome variable as well.

4.2.2 Results

To test for the effects of cultural modulation of the SFA, in the first part of the analysis, participants were grouped according to their ethnicity. Two 2 (*race:* Chinese or Caucasian) x 3 (*target identity:* self (SF), friend (FF), or unfamiliar (UF)) x 2 (*target presence:* present or absent) mixed-design ANOVAs were conducted on the correct median reaction time (RTs) and search accuracy, respectively, with race as the between-subject variable and target identity and target presence as the within-subject variables.

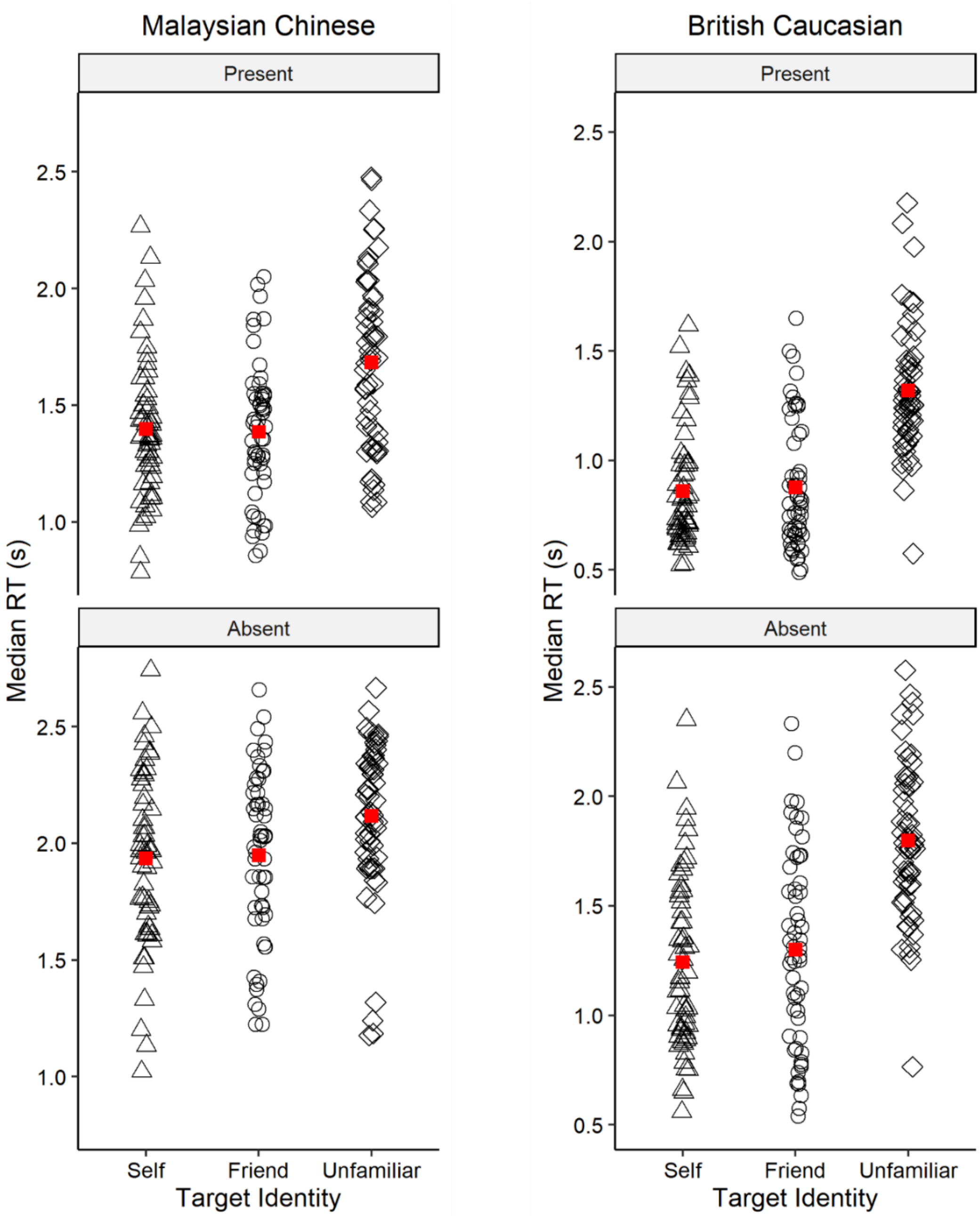
4.2.2.1 Median Reaction Time

Figure 4.3 shows the median RT for each race across different identity in target present and absent trials respectively. The analysis revealed a significant main effect for race, $F(1, 110) = 118.27$, $p <. 001$, $\eta_p^2 = .518$, with a shorter search time for the British Caucasians (M = 1.23, SD = 0.47) than for the Chinese Malaysians (M =

1.75, *SD* = 0.44) participants. In addition, a significant main effect of target identity was reported, $F(1.68, 185.48) = 86.23$, $p < .001$, $\eta_p^2 = .439$ (Huynh-Feldt corrected). Holm-Bonferroni post-hoc comparisons indicated that participants searched SF (*M* = 1.36, *SD* = 0.51) and FF (*M* = 1.39, *SD* = 0.54) faster than UF (*M* = 1.73, *SD* = 0.44; both *p*s < .001), but there was no significant difference in the search time for the SF and FF ($p = .435$). The analysis also revealed a significant main effect of target presence, $F(1, 110) = 706.484$, $p < .001$, $\eta_p^2 = .865$, with participants responding faster in the present trials (*M* = 1.25, *SD* = 0.42) compared to the absent trials (*M* = 1.73, *SD* = 0.51).

Figure 4. 3

The Search Time of Chinese Malaysians and British Caucasian Participants



Note. Median RT per participant for self-face, friend's face, and unfamiliar face across present and absent trials. Red shape denotes the group mean.

The analysis further showed a significant interaction effect between race and identity, $F(1.69, 185.48) = 12.43$, $p < .001$, $\eta_p^2 = .102$ (Huynh-Feldt corrected) and race and target presence, $F(1, 110) = 8.12$, $p = .005$, $\eta_p^2 = .069$. Both two-way interactions were qualified by a significant three-way interaction between race, identity, and target presence, $F(1.67, 183.80) = 9.68$, $p < .001$, $\eta_p^2 = .081$ (Huynh-Feldt corrected).

To understand these interactions further, a simple main effect analysis was carried out for each level of race. An ANOVA on the median RT for Chinese Malaysians showed a significant main effect of identity, $F(1.51, 83.29) = 11.47$, $p < .001$, $\eta_p^2 = .173$ (Huynh-Feldt corrected), a significant main effect of target presence, $F(1, 55) = 439.23$, $p < .001$, $\eta_p^2 = .889$, and a significant interaction effect between identity and target presence, $F(1.50, 82.46) = 7.96$, $p = .002$, $\eta_p^2 = .126$ (Huynh-Feldt corrected). Holm-Bonferroni post-hoc comparisons revealed that in target present trials, participants search the SF ($t = -4.56$, $p < .001$, $d = -0.61$) and FF ($t = -4.73$, $p < .001$, $d = -0.63$) faster than UF, but there were no significant differences in the search time for SF and FF ($t = 0.18$, $p = .849$, $d = 0.02$). In the target absent trials, participants searched the SF faster than UF ($t = -3.44$, $p = .002$, $d = -0.46$) but there were no significant differences in the search time between SF and FF ($t = -1.34$, $p = .182$, $d = -0.18$) and FF and UF ($t = -2.09$, $p = .077$, $d = -0.28$).

Next, an ANOVA on the median RT for British Caucasians also revealed a significant main effect of identity, $F(2, 110) = 149.67$, $p < .001$, $\eta_p^2 = .731$ (Huynh-Feldt corrected), a significant main effect for target presence, $F(1, 55) = 277.65$, $p < .001$, $\eta_p^2 = .835$, and a significant interaction between identity and target presence, $F(2, 110) = 3.78$, $p = .026$, $\eta_p^2 = .064$. Holm-Bonferroni post-hoc comparisons revealed in target present trials, SF ($t = -12.33$, $p < .001$, $d = -2.08$) and FF ($t = -11.90$, $p < .001$, $d = -2.01$) was searched faster than UF, but there were no significant differences in the search time for SF and FF ($t = -0.43$, $p = 1.00$, $d = -0.07$); in the target absent trials, SF ($t = -12.76$, $p < .001$, $d = -1.71$) and FF ($t = -11.42$, $p < .001$, d

= -1.53) was also searched faster than UF, whereas there were no significant differences in the search time between SF and FF (*t* = -1.34, *p* = .353, *d* = -0.18).

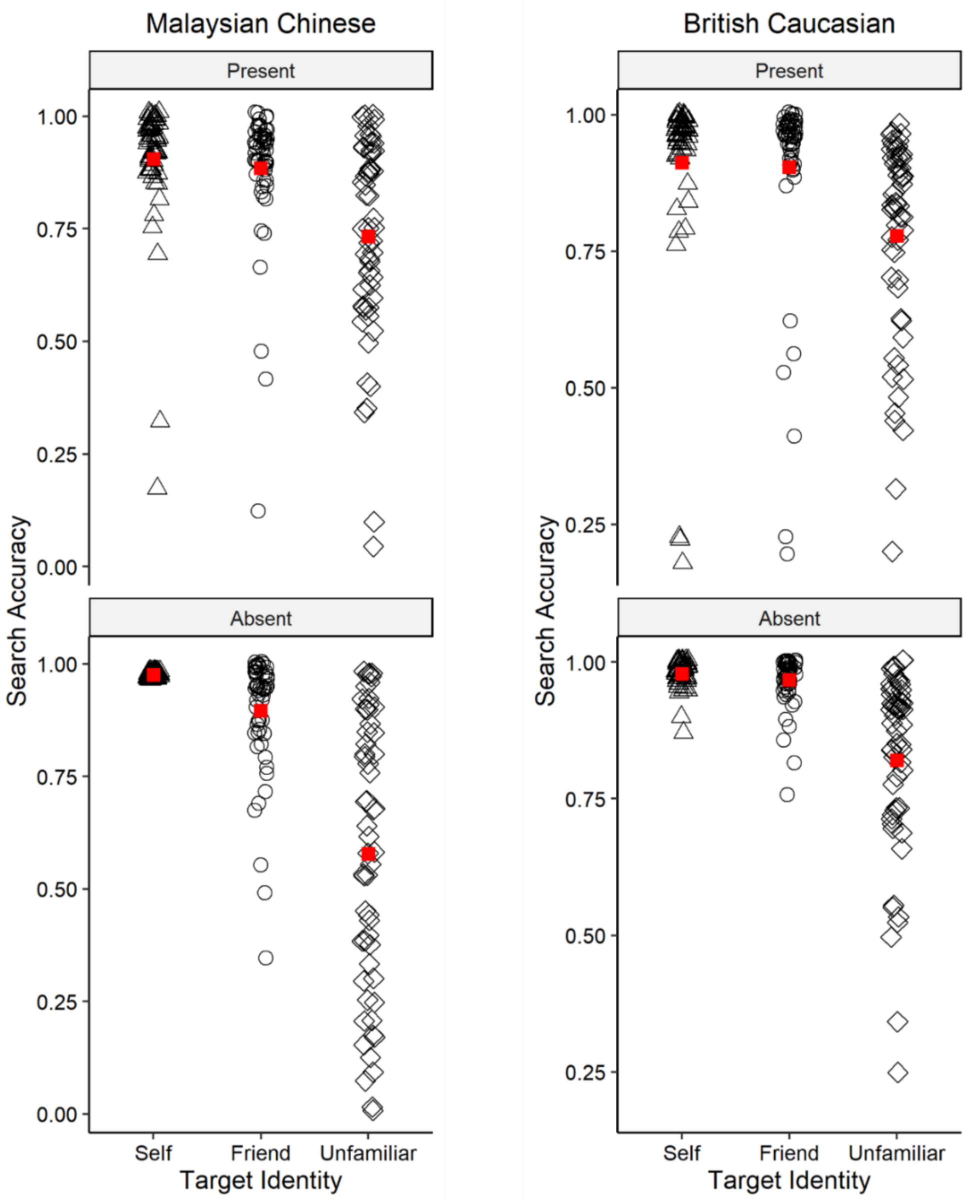
In summary, it was hypothesized that British Caucasians would search SF faster than FF, demonstrating a robust SFA, but Chinese Malaysians would show a smaller SFA than British Caucasians. However, results from Experiment 4 did not support this hypothesis. It was also expected that participants would search familiar faces (SF and FF) faster than UF, regardless of participants' race. Results from Experiment 4 supported this hypothesis, as both groups of participants were faster in searching for SF and FF than UF, but no differences were found between SF and FF. Finally, findings from Experiment 4 also revealed that compared to Chinese Malaysians, British Caucasians were overall faster in searching for faces, regardless of their identity.

4.2.2.2 Search Accuracy

Figure 4.4 shows the search accuracy for each race across different identity in target present and absent trials respectively. The analysis revealed a significant main effect for race, $F(1, 110) = 18.26$, $p < .001$, $\eta_p^2 = .142$, with a higher accuracy for British Caucasians (*M* = .893, *SD* = .16) than Chinese Malaysians (*M* = .820, *SD* = .23) participants. A significant main effect of target identity was also found, $F(1.34, 144.77) = 108.64$, $p < .001$, $\eta_p^2 = .497$ (Huynh-Feldt corrected). Holm-Bonferroni post-hoc comparisons indicated that participants performed significantly better when searching for the SF (*M* = .930, *SD* = .13; *t* = 13.26, *p* < .001, *d* = 1.26) and FF (*M* = .913, *SD* = .14; *t* = 12.14, *p* < .001, *d* = 1.15) than for the UF (*M* = .727, *SD* = .24), but there was no significant difference between the SF and FF (*t* = 1.12, *p* = .265, *d* = 0.11).

Figure 4. 4

The Search Accuracy of Chinese Malaysians and British Caucasian Participants



Note. The mean accuracy scores per participant for self-face, friend's face, and unfamiliar face across present and absent trials. Red shape denotes the group mean.

The analysis further showed a significant interaction effect between race and target identity, $F(1.34, 147.17) = 8.13$, $p = .002$, $\eta_p^2 = .069$, between race and target presence, $F(1, 110) = 8.52$, $p = .004$, $\eta_p^2 = .072$, and between identity and target presence, $F(1.34, 147.89) = 15.05$, $p < .001$, $\eta_p^2 = .120$ (Huynh-Feldt corrected). All two-way interactions were qualified by a significant three-way interaction between race, identity, and target presence, $F(1.34, 147.89) = 8.88$, $p = .001$, $\eta_p^2 = .075$ (Huynh-Feldt corrected).

To understand these interactions further, a simple main effects analysis was carried out for each level of race. An ANOVA on the accuracy data for Chinese Malaysians showed a significant main effect of identity, $F(1.35, 74.16) = 59.36$, $p < .001$, $\eta_p^2 = .519$ (Huynh-Feldt corrected). The analysis also revealed that identity interacted significantly with target presence, $F(1.20, 65.84) = 15.28$, $p < .001$, $\eta_p^2 = .217$ (Huynh-Feldt corrected). Holm-Bonferroni post-hoc comparisons revealed that in target present trials, participants searched the SF ($t = 7.26$, $p < .001$, $d = 0.97$) and FF ($t = 6.39$, $p < .001$, $d = 0.85$) better than UF, whereas there were no significant differences in the search accuracy for SF and FF ($t = 0.87$, $p = 1.00$, $d = 0.17$); in the target absent trials, participants searched the SF ($t = 9.10$, $p < .001$, $d = 1.22$) and FF ($t = 8.34$, $p < .001$, $d = 1.11$) better than UF, but there were no significant differences in the search accuracy for SF and FF ($t = 0.75$, $p = 1.00$, $d = 0.10$). The analysis revealed no main effect of target presence, $F(1, 55) = 2.90$, $p = .094$, $\eta_p^2 = .050$.

Next, an ANOVA on the accuracy data for British Caucasians revealed a significant main effect of identity, $F(1.30, 71.20) = 55.79$, $p < .001$, $\eta_p^2 = .503$ (Huynh-Feldt corrected). Holm-Bonferroni post-hoc comparisons showed that participants performed better when searching for the SF ($t = 9.43$, $p < .001$, $d = 1.26$) and FF ($t = 8.81$, $p < .001$, $d = 1.18$) compared to the UF, but there were no significant differences between the search accuracy for the SF and FF ($t = 0.62$, $p = .538$, $d = 0.08$). The analysis further revealed a significant main effect for target presence, $F(1, 55) = 6.01$, $p = .017$, $\eta_p^2 = .099$, with a higher search accuracy for absent trials compared to present trials. The analysis also revealed no significant interaction between target identity and target presence, $F(1.82, 100.29) = 0.89$, $p = .408$, $\eta_p^2 = .016$.

To summarize, it was hypothesized that British Caucasians would search SF better than FF demonstrating a robust SFA, and that this SFA would be smaller in Chinese Malaysians participants. Similar to the RTs analysis, accuracy results did not support this hypothesis. It was also hypothesized that participants, regardless of their race group, would search familiar faces (SF and FF) more accurately than UF. Results from Experiment 4 supported the hypothesis.. Finally, findings from Experiment 4 showed that compared to Chinese Malaysians, British Caucasians were overall more accurate in searching for faces, regardless of the identity.

4.2.2.3 Self-Construal Scale (SCS) Questionnaire Analyses

To examine whether the SFA reported can be significantly predicted by the self-construal, regardless of the race of participants, six two-step hierarchical regressions were conducted with the difference in search accuracy or median RT between two target conditions: SF – FF, SF – UF, or FF – UF as the criterion variable. Race of participants was entered in the first step of the regression, whereas self-construal (i.e., difference between the scores on the two subscales of the SCS questionnaire) was entered in the second step. *Table 4.1* shows the descriptive statistics for scores on SCS questionnaire and HCIV questionnaire, whereas the regression statistics for the median RT and accuracy are reported in *Table 4.2a* and *Table 4.2b*, respectively.

Table 4. 1

Mean Scores for the Self-Construal Scale and for the Horizontal and Vertical Individualism and Collectivism Scale reported by Chinese Malaysians and British Caucasian participants (N=112).

Questionnaire measure	Chinese Malaysians	British Caucasians
Independence (IND)	70.59 (8.45)	70.20 (9.80)
Interdependence (INT)	73.88 (7.68)	71.38 (7.84)
Horizontal Individualism (HI)	27.20 (4.61)	27.07 (4.55)
Vertical Individualism (VI)	21.82 (5.38)	19.71 (5.82)
Horizontal Collectivism (HC)	27.80 (4.36)	27.89 (4.02)
Vertical Collectivism (VC)	27.11 (4.98)	24.59 (4.64)

Note. Numbers in parentheses are *SD*s.

Table 4. 2

(a) Summary of Hierarchical Regression for Variables Predicting the SFA effect in Search Time

	Variable	*B*	*SE B*	β	*T*	*R*	R^2	ΔR^2
SF - FF	Step 1					.016	0	0
	Race	.008	.050	.016	.167			
	Step 2					.114	.013	.013
	Race	.014	.050	.026	.271			
	Self-Construal	-.038	.032	-.113	-1.19			
SF - UF	Step 1					.430	.185	.185

	Race	-.351	.070	-.430	-5.00***			
	Step 2					.431	.186	.001
	Race	-.349	.071	-.428	-4.93***			
	Self-Construal	-.015	.044	-.029	-.330			
FF - UF	Step 1					.443	.196	.196
	Race	-.359	.069	-.443	-5.18***			
	Step 2					.445	.198	.002
	Race	-.363	.070	-.447	-5.19***			
	Self-Construal	.023	.044	.045	.521			

Note. *N* = 112; *p < .05, **p < .01, ***p < .001

(b) Summary of Hierarchical Regression for Variables Predicting the SFA effect in Search Accuracy

	Variable	*B*	*SE B*	Β	*T*	*R*	R^2	ΔR^2
SF - FF	Step 1					.090	.008	.008
	Race	-.016	.016	-.090	-.946			
	Step 2					.114	.013	.005
	Race	-.017	.017	-.096	-1.00			
	Self-Construal	.008	.010	.070	.730			
SF - UF	Step 1					.282	.079	.079
	Race	-.113	.037	-.282	-3.08**			

	Step 2					.292	.085	.006
	Race	-.111	.037	-.275	-2.99**			
	Self-Construal	-.019	.023	-.077	-.839			
FF - UF	Step 1					.262	.069	.069
	Race	-.098	.034	-.262	-2.85**			
	Step 2					.287	.082	.013
	Race	-.094	.034	-.252	-2.74**			
	Self-Construal	-.027	.022	-.116	-1.26			

Note. N = 112; *p < .05, **p < .01, ***p < .001

Median RT. The hierarchical regression analysis revealed that race contributed significantly to the differences in the search time between SF and UF, $F(1, 110) = 25.01$, $p < .001$, and accounted for 18.5% of the variation of the differences whereas self-construal did not significantly predict the differences, $F(1, 109) = 0.11$, $p = .742$. Another hierarchical regression analysis revealed that race contributed significantly to the differences in the search time between FF and UF, $F(1, 110) = 26.81$, $p < .001$, and accounted for 19.6% of the variation in the search accuracy of the differences whereas self-construal did not significantly predict the differences, $F(1, 109) = 0.27$, $p = .603$. Finally, neither race, $F(1, 110) = 0.03$, $p = .868$, nor self-construal, $F(1, 109) = 1.41$, $p = .237$. contributed significantly to the differences between the search time of SF and FF.

Search Accuracy. The hierarchical regression analysis revealed that race contributed significantly to the differences in the search accuracy between SF and UF, *F*(1, 110) = 9.47, *p* = .003, and accounted for 7.9% of the variation of the differences whereas self-construal did not significantly predict the differences, *F*(1, 109) = 0.70, *p* = .403. Another hierarchical regression analysis revealed that race contributed significantly to the differences in the search accuracy between FF and UF, *F*(1, 110) = 8.14, *p* = .005, and accounted for 6.9% of the variation in the search accuracy of the differences whereas self-construal did not significantly predict the differences, *F*(1, 109) = 1.58, *p* = .212. Finally, neither race, *F*(1, 110) = 0.89, *p* = .346, nor self-construal, *F*(1, 109) = 0.53, *p* = .467, contributed significantly to the differences between the search accuracy of SF and FF.

It was hypothesized that, regardless of the race of the participants, individuals with higher scores on the independent self-construal subscale would show a stronger SFA whereas individuals with a higher score on the interdependent self-construal subscale would show a weaker SFA. However, contradicting the hypotheses, these results suggest that, for both the search time and search accuracy, the reported SFA relative to UF can be explained by participants' race but not by participants' self-construal as measured by the level of interdependence and independence on the SCS questionnaire.

4.2.2.4 HCIV Questionnaire Analyses

Lastly, due to the low internal consistency of the SCS questionnaire, an additional HCIV questionnaire was administered to provide support to the scores from SCS questionnaire. For this analysis, six two-step hierarchical regressions were conducted to examine whether the SFA effect reported can be significantly predicted by the level of individualism and collectivism of participants. The difference in search accuracy and median RT between of two target conditions: SF – FF, SF – UF, or FF –

UF were entered as the criterion variable. Race of participants was entered in the first step of the regression, whereas HI scores, VI scores, HC scores, and VC scores were entered in the second step. The regression statistics for the median RT and search accuracy are reported in *Table 4.3a* and *Table 4.3b*, respectively.

Table 4. 3

(a) Summary of Hierarchical Regression for Variables Predicting the SFA effect in Search Time

	Variable	*B*	*SE B*	*Β*	*T*	*R*	R^2	ΔR^2
SF - FF	Step 1					.016	0	0
	Race	.008	.050	.016	.167			
	Step 2					.101	.010	.010
	Race	.020	.054	.039	.381			
	HI scores	-.002	.006	-.032	-.305			
	VI scores	.005	.005	.101	.933			
	HC scores	-.002	.007	-.038	-.367			
	VC scores	.001	.006	.016	.146			
SF - UF	Step 1					.430	.185	.185
	Race	-.351	.071	-.430	-5.00***			
	Step 2					.433	.187	.002
	Race	-.351	.075	-.431	-4.68***			
	HI scores	-.000	.009	-.001	-.007			
	VI scores	.003	.007	.039	.401			
	HC scores	-.001	.009	-.007	-.072			
	VC scores	-.002	.008	-.029	-.294			

FF - UF	Step 1					.444	.196	.196
	Race	-.359	.069	-.443	-5.18***			
	Step 2					.445	.198	.002
	Race	-.372	.074	-.458	-5.00***			
	HI scores	.002	.008	.020	.213			
	VI scores	-.002	.007	-.026	-.267			
	HC scores	.002	.009	.018	.191			
	VC scores	-.003	.008	-.040	-.403			

Note. *N* = 112; *$p < .05$, **$p < .01$, ***$p < .001$

(b) Summary of Hierarchical Regression for Variables Predicting the SFA effect in Search Accuracy

	Variable	*B*	*SE B*	Β	*T*	*R*	R^2	ΔR^2
SF - FF	Step 1					.090	.008	.008
	Race	-.016	.016	-.090	-.946			
	Step 2					.247	.061	.053
	Race	-.027	.017	-.158	-1.59			
	HI scores	.000	.002	-.019	-.190			
	VI scores	-.002	.002	-.152	-1.44			
	HC scores	.000	.002	.016	.161			
	VC scores	-.003	.002	-.152	-1.42			
SF - UF	Step 1					.282	.079	.079
	Race	-.113	.037	-.282	-3.08**			
	Step 2					.326	.106	.027
	Race	-.112	.039	-.277	-2.87**			

	HI scores	-.003	.004	-.064	-.650			
	VI scores	-.003	.004	-.074	-.721			
	HC scores	-.006	.005	-.129	-1.31			
	VC scores	.003	.004	.068	.652			
FF - UF	Step 1					.262	.069	.069
	Race	-.098	.034	-.262	-2.85*			
	Step 2					.314	.099	.030
	Race	-.084	.036	-.227	-2.34*			
	HI scores	-.003	.004	-.061	-.609			
	VI scores	.000	.003	-.009	-.092			
	HC scores	-.007	.004	-.147	-1.48			
	VC scores	.005	.004	.144	1.37			

Note. $N = 112$; *$p < .05$, **$p < .01$, ***$p < .001$

Median RT. The hierarchical regression analysis revealed that race had contributed significantly to the differences in the search time between SF and UF, $F(1, 110) = 25.01$, $p < .001$, and accounted for 18.5% of the variation of the differences whereas individualism and collectivism did not significantly predict the differences, $F(4, 106) = 0.07$, $p = .992$. Another hierarchical regression analysis revealed that race contributed significantly to the differences in the search time between FF and UF, $F(1, 110) = 26.81$, $p < .001$, and accounted for 19.6% of the variation in the difference between the search times whereas individualism and collectivism did not significantly predict the differences, $F(4, 106) = 0.08$, $p = .990$. Finally, neither race, $F(1, 110) = 0.03$, $p = .868$, nor the levels of individualism and collectivism of participants, F(4,

106) = 0.27, *p* = .900, contributed significantly to the differences between the search time of SF and FF.

Search Accuracy. The hierarchical regression analysis revealed that race had contributed significantly to the differences in the search accuracy between SF and UF, *F*(1, 110) = 9.47, *p* = .003, and accounted for 7.9% of the variation of the differences whereas individualism and collectivism did not significantly predict the differences, *F*(4, 106) = 0.81, *p* = .524. Another hierarchical regression analysis revealed that race contributed significantly to the differences in the search accuracy between FF and UF, *F*(1, 110) = 8.14, *p* = .005, and accounted for 6.9% of the variation in the search accuracy of the differences whereas individualism and collectivism did not significantly predict the differences, *F*(4, 106) = 0.88, *p* = .480. Finally, neither race, *F*(1, 110) = 0.90, *p* = .346, nor the level of individualism and collectivism of participants, *F*(4, 106) = 1.49, *p* = .209, contributed significantly to the differences between the search accuracy of SF and FF.

It was expected that, regardless of the race of the participants, individuals with a higher score on both HI and VI would show a stronger SFA whereas individuals with a higher score on both HC and VC would show a weaker SFA. Contradicting the hypotheses, these results suggest that, for both the search time and search accuracy, the reported SFA relative to UF can be explained by participants' race but not by participants' self-construal as measured by the level of individualism and collectivism in the HCIV questionnaire.

4.2.3 Discussion

The aim of the current study was to identify the differences in the cultural background as a modulating factor of the SFA effect. It was hypothesized that the

SFA would be modulated by the cultural differences in the self-concepts of participants. Specifically, due to the cultural differences in the emphasis on the independent and interdependent self, the SFA effect relative to a friend's face would be larger in British Caucasians compared to Chinese Malaysians participants (i.e., SF – FF) whereas both race groups would show a comparable SFA effect relative to an unfamiliar face (i.e., SF – UF).

Findings from this study showed that British Caucasian participants searched more accurately and faster for all faces, regardless of the face identity, compared to Chinese Malaysians participants. In addition, across both race groups, there were no differences in the search accuracy and search time of the own face and friend's face whereas lower accuracy and longer search times were reported for unfamiliar faces than for those two types of familiar faces. In other words, the SFA effect was absent when the own face was compared to a friend's face but present when compared to an unfamiliar face, and this finding was observed in both British Caucasian and Chinese Malaysians participants.

Overall, these findings seemed to suggest that (1) one's own face does not receive preferential processing when compared to another overlearned face (i.e., the friend's face); (2) both familiar faces showed a processing advantage compared to unfamiliar faces; and (3) the absence of a SFA effect relative to a friend's face is not modulated by the cultural differences in the self-concepts of participants, not at least in a visual-search paradigm.

4.2.3.1 A Familiar Face Advantage rather than a Self-Face Advantage

Tong and Nakayama (1999) reported that the self-face was detected faster among distractor faces compared to an unfamiliar face, leading them to suggest a processing advantage for the self-face. However, the authors did not control for possible familiarity effects as the self-face is -due to extensive exposure- a highly overlearned face (Kircher et al., 2001). Hence, a personally familiar face, was included in the current study to control for such familiarity effects. The lack of differences between the SF and FF in the conjunction with the better detection of these faces compared to an unfamiliar face suggests that the SFA effect may be a result of mere familiarity effect rather than a “self-effect”.

On the other hand, results from Experiment 4 are in line with the findings of Devue et al. (2009). With a visual search task where the face identity was deemed irrelevant (i.e., participants were asked to identify a certain mouth configuration), Devue et al. concluded that the own face does not receive attentional prioritization compared to familiar and unfamiliar faces, such that there was no difference in the searching time between the self and friend’s face. Additionally, Devue et al. (2009) showed that the self-face did not receive faster saccade eye movements than other faces. Extending the findings from Tong and Nakayama’s (1999) and Devue et al.’s (2009) studies by including a personally familiar face and making the face identity to be task relevant, these findings seem to suggest that at the level of detection, preferential processing is not restricted only to the own face but also to other personally familiar faces.

One might also argue that in the modern era, individuals might see their own face in photographs and videos more often than individuals from previous generations did, and they might be more familiar with their normal-oriented instead of their mirror-oriented face. However, it should be noted that a substantial part of these photographs and videos are still mirror-reversed, as it is the case in *selfies*. More importantly, photographs and videos offer a poor visual experience about the self-face. In fact, a large amount of research has shown that self-face representations are built through the combination of multisensory information, such as visual, tactile, and proprioceptive (for review, see Estudillo & Bindemann, 2017a). In contrast to photographs and videos, self-reflection in a mirror offers this multisensory experience. For example, when one moves the arm in front of the mirror, the reflection provides synchronous dynamic feedback.

Notably, aside from observing a significant SFA effect relative to unfamiliar faces, a processing advantage for the friend's face compared to an unfamiliar face was also reported. Findings from this study seem to be consistent with the position that there are quantitative differences between the processing of familiar and unfamiliar faces (Bruce et al., 2001; Estudillo, 2012; Gobbini et al., 2013; Ramon et al., 2011; Van Belle, Ramon, et al., 2010). In other words, face processing varies according to face familiarity. For instance, although personally familiar faces and famous faces have a processing advantage over unfamiliar faces, personally familiar faces benefit from a processing advantage compared to famous faces (e.g., Herzmann et al., 2004; Keyes & Zalicks, 2016; but see Wiese et al., 2021). Accordingly, there seems to be a continuum of familiarity within faces that ranges from unfamiliar faces to familiar faces, which includes one's own face (see Bortolon et al., 2018). Regarding the comparison of the own face, friend's face, and an unfamiliar face, our findings suggest that there is no preference for the own face over a personally familiar face. Due to extensive exposure, the own face is an overlearned and highly familiar stimuli; hence, it is possible that the processing advantages for the self-face may be attributed to its familiarity rather than from any special "self-effects" (see Lee et al., 2007). Additionally, like the own face, the friend's face may also carry a high emotional load (see Cygan et al., 2014) and they too are encountered often in day-to-day life, and arguably, one may see the friend's face more often than one may see themselves. Consequently, there might be no difference in the attentional prioritization to the own face and friend's face.

Overall, the higher search accuracy and shorter search times for the own face in this current study might be better explained a familiarity effect. That is, the result of a more robust representation of one's own face (and friend's face) due to frequent exposure to one's own image through the mirror and photos and an extensive experience with highly familiar individuals (Tong & Nakayama, 1999). Likewise, the poorer performance for the unfamiliar faces can also be explained by a less robust representation of unfamiliar faces. In a similar vein, the processing advantage for familiar faces could also be explained by face processing models, such that the person identity nodes and face recognition units process information of familiar faces faster than less familiar faces (Bruce & Young, 1986) due to easier access of stored representation or semantic information (Kircher et al., 2001).

4.2.3.2 Discrepancies in Task Demands

Although findings from Experiment 4 suggest that the SFA can be explained in terms of familiarity, other studies have reported evidence of an SFA even when compared with personally familiar faces (e.g., Keyes et al., 2010; Liew et al., 2011; Ma & Han, 2010, 2012; Martini et al., 2015) and famous faces (e.g., Mengya et al., 2013; Miyakoshi et al., 2008; Tacikowski et al., 2011). The lack of consistency across studies may be attributed to the high variability in the design and tasks used by researchers. In their meta-analysis, Bortolon and Raffard (2018) reported that whilst an SFA was reported for memory (i.e., judging identity) and perception (i.e., identifying head orientation) based tasks, SFA was not reported for attention-based tasks (i.e., simple detection or visual search). Specifically, participants recognized the own face faster compared to other familiar and unfamiliar faces (e.g., Keyes et al., 2010; Liew et al., 2011) but there were no differences between the own, familiar (close others or famous people), and unfamiliar faces in visual search (e.g., Devue et al., 2009; Lee et al., 2007) and face detection tasks (e.g., Cygan et al., 2014; Kotlewska et al., 2015). The latter finding led Bortolon and Raffard (2018) to suggest that all faces, regardless of identity, are detected at a similar speed in a task involving attentional processes. In line with this view, it is possible that the advantages of self-relevant information (i.e., the self-face) may not affect a prioritization in the early perceptual stages but rather reflect a prioritization in later processing stages, such as memory encoding and response selection (e.g., Firestone & Scholl, 2015).

Arguably, it is also conceivable that participants are likely inexperienced at searching for their own face, such that they are asked to search for a small grey scaled image of their face among an array of distractor faces. In contrast, it is a much more familiar task for participants to search for faces of their close friends. In other words, individuals may be more accustomed to the task of picking out a familiar face in a crowd rather than identifying the own face among an array of different faces (Kircher et al., 2001). Likewise, participants could also be inexperienced in searching for an unfamiliar face among other faces, but due to the own face benefiting from a more robust mental representation, the own face was still searched faster and more accurately than the unfamiliar face.

Hence, one may argue that the lack of SFA relative to a friend’s face in Experiment 4 may be due to the type of task employed. It should be highlighted that even though these findings showed that there were no differences in the search performance between the own face and friend’s face, there is an advantage in the search time and search accuracy for familiar faces (i.e., self-face and friend's face) compared to unfamiliar faces. Rather than attributing the lack of SFA relative to a friend's face to the type of task employed, these findings are in line with the hypothesis that familiar faces are processed faster and more accurately due to a more robust mental representation and further reinforced the proposition that the own face might just be another highly familiar face.

4.2.3.3 No Cultural Modulation Effects on SFA

Contradicting the hypothesis for this experiment and findings from previous studies (e.g., Liew et al., 2011; Sui et al., 2009; Zhang & Zhou, 2019), findings from Experiment 4 showed that the search for self-faces was not influenced by the cultural differences in self-concept. These findings showed that British Caucasian participants searched the self-face faster than Chinese Malaysians participants across both present and absent trials, but British Caucasian participants also searched the friend's and unfamiliar faces faster (and more accurately) than Chinese Malaysians participants.

These findings imply that the advantage in the search time for the self-face in British Caucasians compared to Chinese Malaysians cannot be accounted by the cultural differences in self-concept for two reasons. First, the findings showed that British Caucasian participants were overall more accurate and faster than Chinese Malaysians participants when searching for faces, regardless of their identity. Second, findings from the regression analyses further indicated that the SFA (in terms of search accuracy and search time) relative to an unfamiliar face cannot be explained by the cultural differences in self-construal (i.e., operationalized in terms of the scores on the SCS and HCIV questionnaires) of the participants. Race of participants, however, could account for the variability in the search accuracy and search time between the self-face and the unfamiliar face and between the friend's face and the unfamiliar face. Although, previous research has shown cultural differences in the visual search of simple patterns between Asian and British Caucasian participants (Ueda et al., 2018), the current data cannot determine whether the British Caucasian participants in this experiment were simply more engaged with the task or whether, compared to Chinese Malaysians, they present a stronger bias towards faces. Future studies could test this idea by comparing British Caucasian and Chinese Malaysians participants searching for faces and non-face stimuli (e.g., shapes).

4.3 Experiment 5

Experiment 5 aims to explore the modulation effects of depressive personality traits on an SFA in a neurotypical sample. In this study, depressive traits are measured using the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977), with a higher score reflecting a higher presence of depressive symptoms. On the basis of the theory of implicit positive associations with the self (Ma & Han, 2010) and the self-positivity bias (Greenwald, 1980), the own face may be treated and processed as an emotionally positive face (i.e., a happy face) and positive emotion may be implicated as an underlying factor for an SFA. However, based on the negative self-concept theory (Beck, 1967), evidence have shown that depressed individuals were less likely to accurately identify positive self-referential information due to having low levels of positive self-evaluations (e.g., Ma & Han, 2010).

Following this line of thought, for Experiment 5, individuals with more depressive traits are expected to show longer search times and lower search accuracy for the own face (i.e., a weakened SFA) compared to those with lesser depressive traits. On the other hand, individuals across the low and high depressive personality group are expected to perform comparably for the search time and search accuracy for an unfamiliar face. To test these hypotheses, Experiment 5 compared the search times and search accuracy for frontal view images of self and unfamiliar faces among an array of unfamiliar distractor faces across individuals with low and high depressive traits.

4.3.1 Methods

4.3.1.1 Participants

One-hundred ten Chinese Malaysians participants (34 males) were recruited from the University of Nottingham Malaysia. A power analysis performed in G*Power 3.1 (Faul et al., 2007) with an effect size of 0.10 and an adjusted alpha of .055 gives a required sample size of 86 participants to achieve 80% power in a mixed-design ANOVA analysis. Participants' age ranged from 19 to 30 years old (*M* = 22, *SD* = 2.39 years old). Participants were awarded with either course credits or compensated financially for their participation. Participants provided informed consent and were debriefed at the end of the study. Ethics approval for this study was obtained from the Science and Engineering Research Ethics Committee of the University of Nottingham Malaysia.

4.3.1.2 Design

This experiment used a mixed design. The between-subjects variable was group (low depressive traits or high depressive traits). The within-subjects variable was target identity (self or unfamiliar). The dependent variables being measured were the median reaction time and accuracy to searching for the self-face and the unfamiliar face.

4.3.1.3 Stimuli

Face Image Collection and Processing. The face stimuli are collected and processed in a similar manner to Experiment 4, except that each participant's stimuli set consists of only three sets of images: one target self-face set (with five different images), one target unfamiliar face set (with five different images), and six distractor faces sets (each with five different images). Examples of experimental stimuli is shown in *Figure 4.1*.

Center for Epidemiologic Studies Depression Scale (CES-D). This short self-report scale measures the current level of depressive symptomatology among the general population (Radloff, 1977). Participants were required to indicate how often the symptoms occurred in the week prior to the interview with response options from 0 = 'rarely' to 3 = 'most or all of the time'. The score ranges from 0 to 60 and the total depression score is calculated by adding all items together in which a higher total score represents a higher presence of depressive symptoms. Using Cronbach's alpha, previous research reported that the internal consistency of the scale ranged between .45 and .70 (Campo-Arias et al., 2007; Cosco et al., 2017).

4.3.1.4 Procedure

The experiment was conducted in a mostly similar manner as Experiment 4, except that there was only a total of two blocks with the presentation of blocks counterbalanced for target identity (i.e., self or unfamiliar). The 'friend' block was excluded in this experiment as the familiar face is not a useful control in this experiment, as Experiment 5 wanted to explore if the own face is associated with positive or negative valences, depending on the depressive traits of participants. After the visual search task, participants were then required to complete the CES-D questionnaire. This study took approximately 50 minutes to complete.

4.3.1.5 Data Analyses

Data analysis was performed on both the median search reaction times (RTs) and search accuracies for correct responses. The median of RTs was used instead of the mean RTs to remove the influence of extreme values. Additionally, a normalization procedure was adopted to quantify the SFA, such that the SFA on RTs was calculated as a ratio (SF – UF)/ (SF + UF), where SF and UF were the median search RTs for self-face and unfamiliar face, respectively (see Qian et al., 2017). Furthermore, to examine whether the normalized SFA effects correlate with the depressive personality traits of participants, a Pearson's correlational analysis was conducted with scores from the CES-D.

4.3.2 Results

Experiment 5 aimed to explore the self-face advantage (SFA) across the lower and higher end of depressive personality traits. Using a cut-off score would result in an unequal sample size across those of low and high depressive traits group. Hence, to ensure a rather equal sample size across the groups, participants were grouped into four quartiles following their scores in the CES-D questionnaire (see *Table 4.4*). Following this method, two different participants with the same scores in the CES-D questionnaire will always be included to the same quartile. For the first quartile, the range of scores were 4–11; for the second quartile, 12–17; for the third quartile, 18–24; and for the fourth quartile, 25–50. As this experiment is interested in only exploring the SFA across individuals in the lower and higher end of depressive traits, all further statistical analyses were conducted using scores from the first quartile (i.e., low depressive traits group) and from the fourth quartile (i.e., high depressive traits group).

Table 4. 4

CES-D scores of participants in Exp. 5 for the total sample and across each quartile.

CES-D Quartile	*N*	*Mean*	*SD*	*CES-D scores*
Q1	28	8.32	2.36	4 – 11
Q2	28	14.71	1.78	12 – 17
Q3	28	20.50	2.19	18 – 24
Q4	26	32.69	6.42	25 – 50
Total	110	18.81	9.60	4 – 50

Mixed-design analyses of variance (ANOVAs) were then performed on the search accuracy, median reaction time (RTs) for correct responses, and a normalized SFA effect. The between-subject variables were depressive traits group (low/high depressive traits), and the within-subject variables was target identity (self/unfamiliar). *Table 4.5* shows the descriptive statistics for search accuracy, and median RTs across each variable.

Table 4. 5

Mean Accuracies and Median RT (s) across Low and High Depressive Traits Groups.

Target Identity	Depressive Traits Group	Accuracy	RT
Self	Low	.892 (.142)	1.311 (0.39)
	High	.934 (.081)	1.350 (0.38)
Unfamiliar	Low	.673 (.152)	1.632 (0.30)

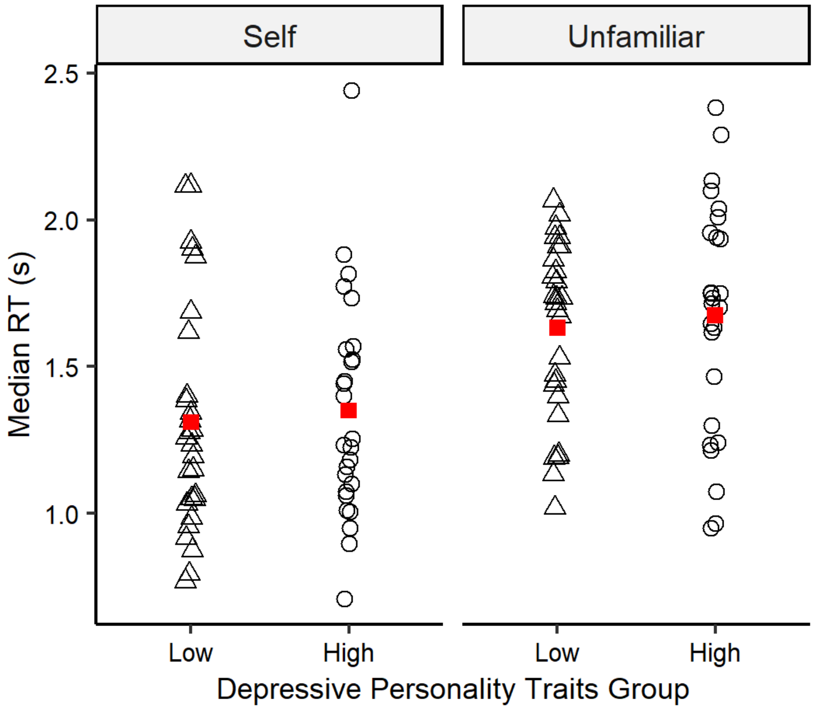
High	.640 (.186)	1.675 (0.35)

Note. Number in parentheses are *SD*s.

Median RT. *Figure 4.5* shows the median RTs for each face identity across the low and high depressive traits groups. The analysis revealed a main effect of target identity, $F(1, 52) = 25.02$, $p < .001$, $\eta_p^2 = .325$, with shorter RTs for the self than the unfamiliar face. The analysis further revealed no significant main effect of depressive traits groups, $F(1, 52) = 0.29$, $p = .590$, $\eta_p^2 = .006$ and no significant interaction effect between target identity and depressive traits groups, $F(1, 52) = .001$, $p = .979$, $\eta_p^2 = .000$.

Figure 4. 5

The Search Time of Low and High Depressive Traits Group

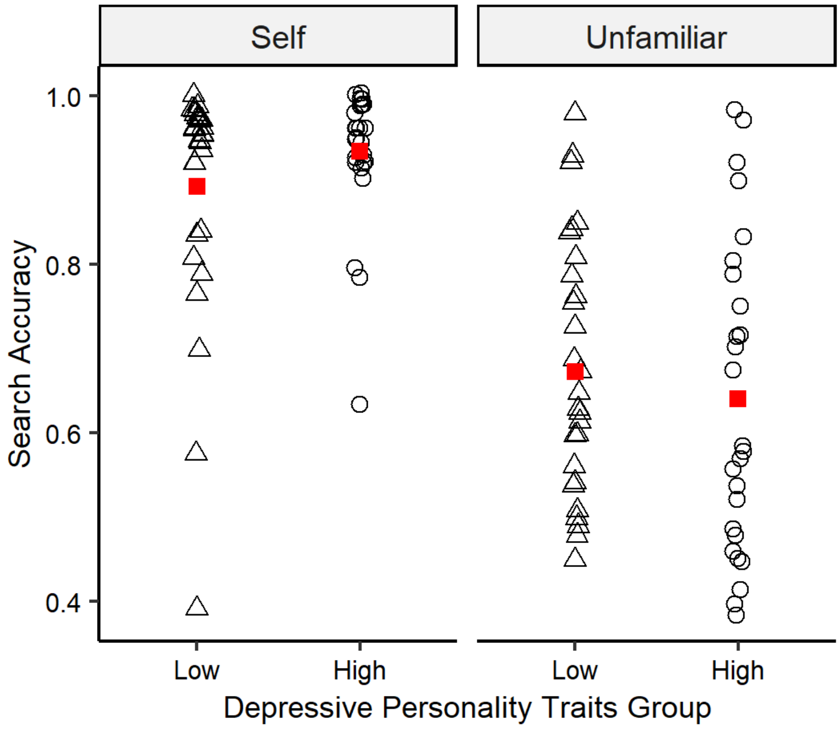


Note. Median RT per participant for self and unfamiliar faces condition across high and low depressive traits group. Red shape denotes the group mean.

Search Accuracy. *Figure 4.6* shows the performance accuracy for each face identity across the low and high depressive traits groups. A significant main effect of target identity was reported, $F(1, 52) = 102.18$, $p < .001$, $\eta_p^2 = .663$, with a higher mean accuracy reported for the self than the unfamiliar face. The analysis further revealed no significant main effect of depressive traits group, $F(1, 52) = 0.02$, $p = .878$, $\eta_p^2 = .000$, and no significant interaction effect between target identity and depressive traits groups, $F(1, 52) = 2.13$, $p = .151$, $\eta_p^2 = .039$.

Figure 4. 6

The Search Accuracy of Low and High Depressive Traits Group

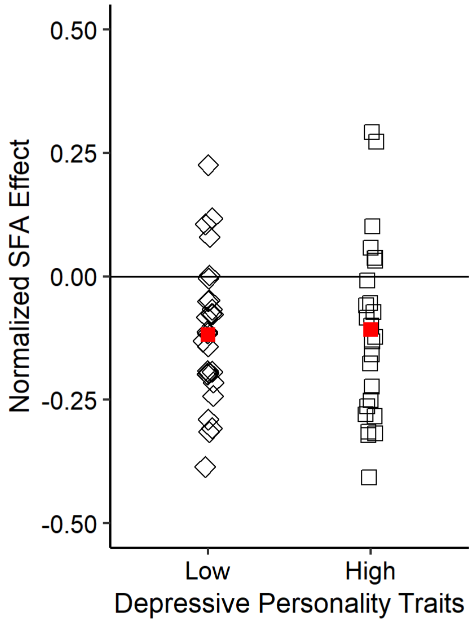


Note. The mean accuracy scores per participant for self and unfamiliar faces conditions across high and low depressive traits group. Red shape denotes the group mean.

Normalized Self-Face Advantage (SFA). As aforementioned, a normalization procedure was adopted to quantify the processing advantage of self-face, where negative values represent faster responses to self-face. *Figure 4.7* shows the normalized SFA across for low and high depressive traits group. An independent-samples t-test on the normalized SFA showed no significant differences between the low and high depressive traits groups, $t(52) = -0.24$, $p = .814$.

Figure 4. 7

The Normalized SFA Effect for Different Emotion Valence across Low and High Depressive Traits Group.



Note. Normalized SFA effect per participant across high and low depressive traits group. Red shape denotes the group mean.

Normalized SFA Effect and CES-D scores. A Pearson's correlation test was conducted with the normalized SFA effect and the scores on the CES-D scale. Findings showed that the normalized SFA effect did not correlate significantly with the scores on the CES-D scale (r = -.015, p = .877, 95% CI [-0.202, 0.173]).

4.3.3 Discussion

Experiment 5 explored the SFA across individuals with low and high depressive traits using a visual search paradigm wherein participants searched for the own face and a stranger's face. Based on the negative self-concept (i.e., Beck, 1967, 2008) and implicit positive association theory (i.e., Ma & Han, 2009), depressive individuals are more likely to avoid their face (i.e., a positive self-referential stimulus) due to low levels of positive self-evaluations. Hence, participants with more depressive symptoms were expected to show a reduced SFA when searching their face compared to those with lesser depressive symptoms.

However, contradicting the hypothesis, findings from Experiment 5 suggest that all participants showed a preference for the self-face, regardless of the levels of their depressive personality traits. Specifically, across both the low and high depressive traits groups, the own face was consistently searched faster and more accurately compared to an unfamiliar face. There were also no significant differences in terms of the normalized SFA effect shown by both groups. Additionally, there was no significant correlation between the SFA and depressive personality traits (i.e., scores from the CES-D questionnaire). Findings also showed that there were no differences when searching for a stranger's face between the high and low depressive traits groups. These findings seemed to suggest that the SFA is not modulated by depressive personality traits, not at least in a visual-search paradigm.

One possible explanation for such a finding could be that, rather than showing a lesser preference to the own face (i.e., an emotionally positive face), depressive individuals might instead show a processing bias to a negatively valenced own face (i.e., a sad self-face) that is congruent with their affective states (i.e., sadness or negative valenced). It is worth noting that Beck's (1967) negative self-concept theory stipulates that the negative self-representation of a depressed individual would bias the perception and interpretation of self-related information negatively. In fact, studies have presented evidence wherein depressive individuals are more prone to selectively process information that is congruent with their affective states (e.g., sadness). For example, compared to non-depressed individuals, depressive individuals are more likely to show biases to negatively-valenced information (e.g., Clark & Teasdale, 1982; Gotlib et al., 2004; Moritz et al, 2005).

This attentional bias may be interpreted as a mood-congruent bias – "an enhanced coding or retrieval of positive or negative" stimuli corresponding with the individual's mood or affective state (Dalgleish & Watts, 1990). In fact, there is considerable evidence for a mood-congruency bias in the context of self-referential processing among depressed individuals. For instance, depressive individuals recalled more negative autobiographical memories (e.g., Lloyd & Lishman, 1975; Rottenberg et al., 2005), and negative self-traits (e.g., Burke et al., 2015) and showed better head-pose recognition and increased brain activity to a sad self-face compared to a happy self-face (e.g., Caudek & Monni, 2013; Quevedo et al., 2016). Findings from these studies seem to suggest that depressive individuals exhibit a mood-congruent bias such that, compared to a neutral or positive self-referential stimulus, they are more likely to show biases to negative self-referential stimuli that are congruent with their affective states.

The evidence reviewed in the previous section converges on the idea that the mood-congruency bias hypothesis may account for the negative processing biases in depressed individuals. Specifically, negatively valenced self-referential stimuli would be more congruent with the negative self-perception of a depressed individual. Taking this account into consideration, Experiment 6 was conducted to further examine the role of a mood-congruent bias on the modulation effects of depressive traits on a SFA in a general population.

4.4 Experiment 6

Taking into consideration the mood-congruent bias hypothesis, Experiment 6 further explored the modulation effects of depressive traits on SFA while introducing the role of emotional valence of stimuli by presenting the own and unfamiliar face in a neutral, happy, or sad emotion. Participants had to search for target faces among an array of distractor faces whilst the facial emotion was task irrelevant. According to the mood-congruency bias hypothesis, participants with more depressive traits are expected to be slower in detecting their own face but only when the self-face expression is incongruent with their affective state (i.e., their happy/neutral face) compared to those with lower depressive traits. On the other hand, similar to Experiment 5, all participants, regardless of the group, are expected to perform comparably for the search time and search accuracy for an unfamiliar face, regardless of the facial emotion.

4.4.1 Methods

4.4.1.1 Participants

Sixty-eight Chinese Malaysians participants (19 males) were recruited from the University of Nottingham Malaysia. A power analysis performed in G*Power 3.1 (Faul et al., 2007) with an effect size of 0.10 and an alpha of .05 gives a required sample size of 58 participants to achieve 80% power in a mixed-design ANOVA analysis. Participants' age ranged from 18 to 26 years old (*M* = 21.0, *SD* = 1.55 years old). Participants were rewarded with either course credits or compensated financially for their participation. Participants provided informed consent and were debriefed at the end of the study. Ethics approval for this study was obtained from the Science and Engineering Research Ethics Committee of the University of Nottingham Malaysia.

4.4.1.2 Design

This experiment used a mixed design. The between-subjects variable was group (low depressive traits or high depressive traits), and the within-subjects variables were target identity (self or unfamiliar) and emotional valence (neutral, happy, or sad).

4.4.1.3 Stimuli

The stimuli are collected and processed in an almost similar manner to Experiment 5, except that, participants were photographed while assuming a neutral, happy, and sad expression rather than articulating three different speech sounds as in Experiment 5. *Figure 4.8* shows an example of the face stimuli being presented to a participant.

Figure 4. 8

Example of the Face Stimuli used in Experiment 6

Note. An example of three different emotion valence for each target identity. From left: “neutral”, “happy”, and “sad” expression. All images were cropped based on its individual contours and converted to grayscale.

4.4.1.4 Procedure

The experiment was conducted in a similar manner as Experiments 5 where participants were required to indicate the presence or absence of a target face (regardless of the emotion valence) by pressing a key on the keyboard. There was a total of two blocks with each target identity (i.e., self and unfamiliar) presented twice and counterbalanced across participants. Each block consisted of 180 trials with target faces appearing in only 50% of the trials (i.e., target present condition): 90 (3 different emotion valence x 30 repetitions). After the visual search task, participants were then asked to complete the CES-D questionnaire. The study took approximately 50 minutes to complete.

4.4.2 Results

Experiment 6 aimed to explore the SFA across the lower and higher end of depressive traits while considering the role of emotion valence. Similar to Experiment 5, participants were grouped into four quartiles following their scores in the CES-D questionnaire (see *Table 4.6*). Following this method, two different participants with the same scores in the CES-D questionnaire will always be included to the same quartile. For the first quartile, the range of scores were 6–10; for the second quartile, 12–20; for the third quartile, 21–26; and for the fourth quartile, 28–43. As this experiment is interested in only exploring the SFA across individuals in the lower and higher end of depressive traits, all further statistical analyses were conducted using scores from the first quartile (i.e., low depressive traits group) and from the fourth quartile (i.e., high depressive traits group).

Table 4. 6

CES-D scores of participants in Exp. 6 for the total sample and across each quartile.

CES-D Quartile	*N*	*Mean*	*SD*	*CES-D scores*
Q1	20	8.45	1.23	6 – 10
Q2	16	15.50	2.45	12 – 20
Q3	15	23.80	1.97	21 – 26
Q4	17	33.35	5.49	28 – 43
Total	68	19.72	10.14	6 – 43

A mixed-measure analyses of variance (ANOVA) was then performed on the search accuracy, median reaction time (RTs) for correct responses, and the normalized SFA effect. The between-subject variables were depressive traits groups (low/high depressive traits). The within-subject variables were target identity (self/unfamiliar) and emotion valence (neutral/happy/sad). *Table 4.7* shows the descriptive statistics for search accuracy and median RTs across each variable.

Table 4. 7

Mean Accuracies and Median RTs (s) across Different Emotion and Depressive Traits Group

Target Identity	Group	Emotion Valence	Accuracy	RT
Self	Low	neutral	.958 (.043)	1.516 (0.34)
		happy	.966 (.041)	1.512 (0.34)
		sad	.949 (.059)	1.557 (0.37)
	High	neutral	.961 (.063)	1. 277 (0.33)
		happy	.968 (.034)	1.316 (0.35)
		sad	.946 (.078)	1.350 (0.35)
Unfamiliar	Low	neutral	.670 (.188)	1.895 (0.38)
		happy	.642 (.179)	1.877 (0.40)

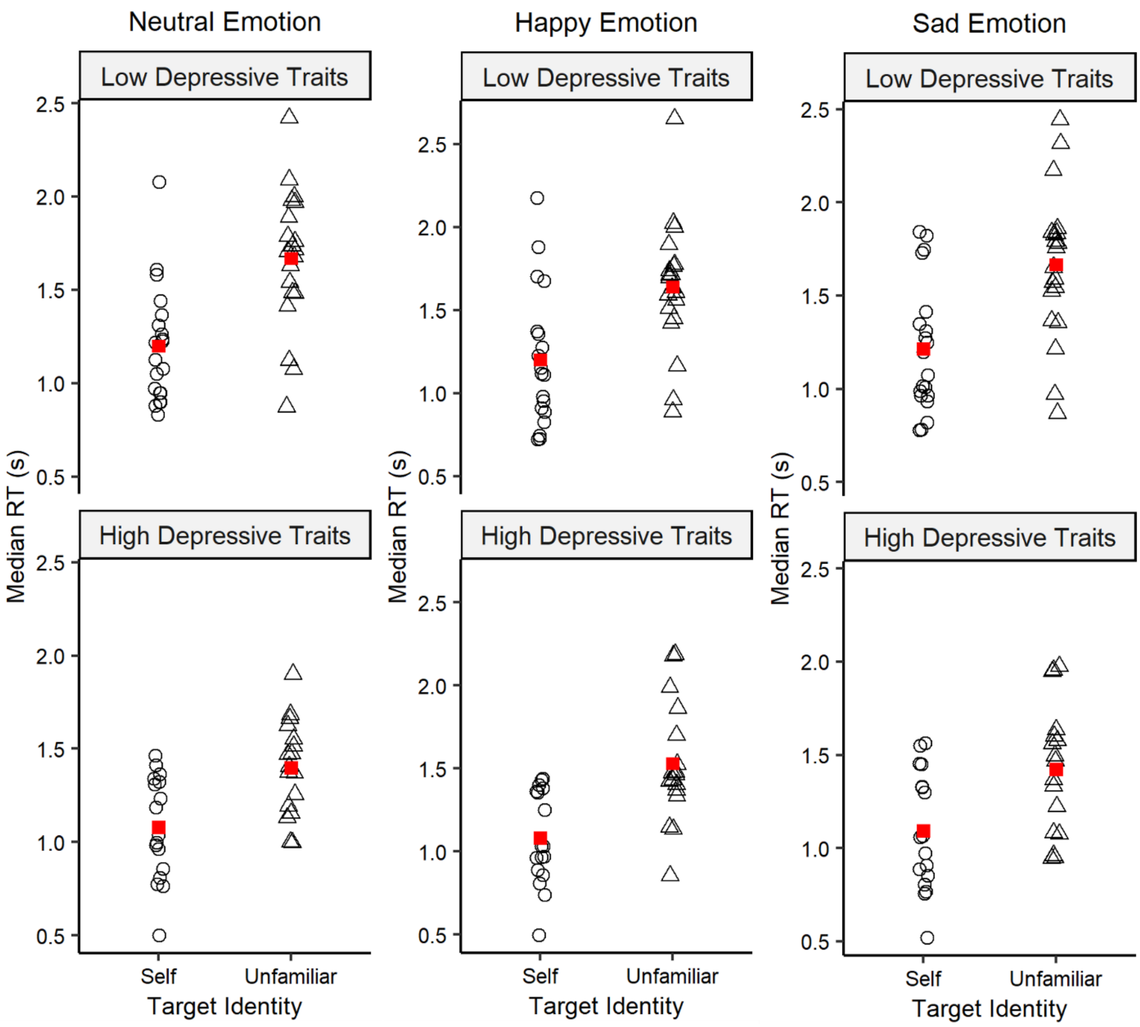
		sad	.631 (.201)	1.862 (0.37)
	High	neutral	.734 (.173)	1.648 (0.26)
		happy	.658 (.191)	1.721 (0.35)
		sad	.665 (.192)	1.641 (0.36)

Note. Numbers in parentheses are *SD*s.

Median RT. *Figure 4.9* shows the median RT for each face identity across the different emotion valence and depressive traits group. The corresponding analysis revealed a significant main effect for target identity, $F(1, 35) = 19.91$, $p < .001$, $\eta_p^2 = .363$, with shorter search RTs reported for the self-face than for the unfamiliar face. Next, a significant main effect of depressive traits group was reported, $F(1, 35) = 7.11$, $p = .012$, $\eta_p^2 = .169$, with participants from the high depressive traits group showing shorter search RTs compared to the low depressive traits group. The analysis revealed no significant main effect of emotion, $F(2, 70) = .798$, $p = .454$, $\eta_p^2 = .022$, and no significant interaction effects between target identity and depressive traits group, $F(1, 35) = .002$, $p = .967$, $\eta_p^2 = .000$.

Figure 4. 9

The Search Time for Different Emotion Valence across Low and High Depressive Traits Group.



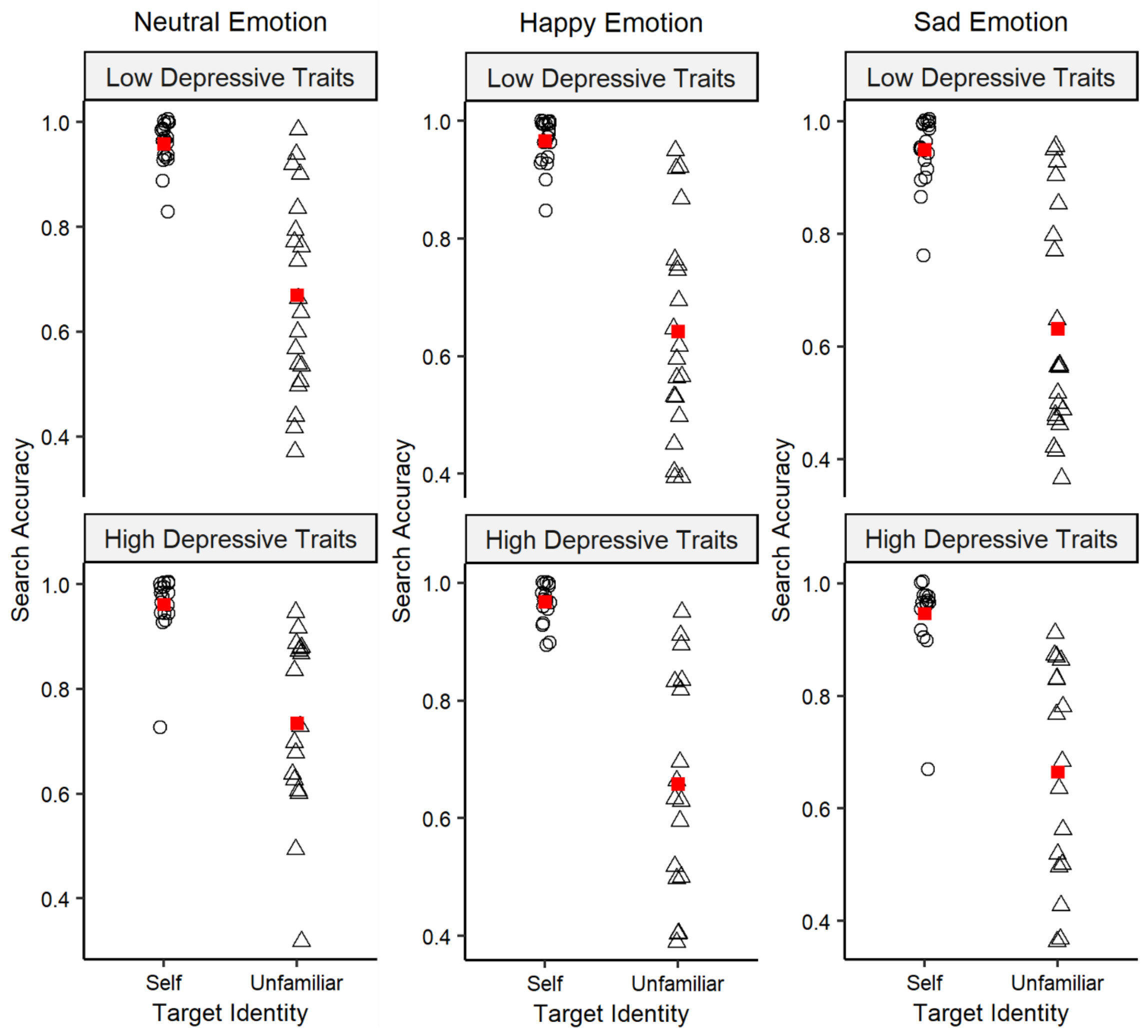
Note. Median RT per participant across three emotion conditions for self and unfamiliar faces condition across low and high depressive traits group. Red shape denotes the group mean.

However, the analysis showed an interaction effect between target identity and emotion, $F(2, 70) = 3.26$, $p = .044$, $\eta_p^2 = .085$. To understand this interaction further, ANOVAs were performed on the median RTs for self and unfamiliar separately. An ANOVA on the median RTs for "self" showed a significant main effect of emotion, $F(2, 72) = 4.26$, $p = .018$, $\eta_p^2 = .106$. Holm-Bonferroni post-hoc comparisons revealed that participants showed a longer search time for sad emotion compared to neutral (*p* = .018, *d* = -0.47) whereas there were no significant differences between neutral and happy emotion (*p* = 1.00, *d* = -0.13) and happy and sad emotion (*p* = .138, *d* = -0.33). An ANOVA on the median RTs data for "unfamiliar" however, showed no significant main effect of emotion, $F(2, 72) = 0.99$, $p = .377$, $\eta_p^2 = .027$. Lastly, the analysis revealed no significant interaction effect between target identity, emotion valence, and depressive traits group, $F(2, 70) = 0.31$, $p = .733$, $\eta_p^2 = .009$.

Search Accuracy. *Figure 4.10* shows the performance accuracy for each face identity with different emotion valence across the low and high depressive traits group. The analysis revealed a significant main effect for target identity, $F(1, 35) = 110.66$, $p < .001$, $\eta_p^2 = .760$, with a higher mean accuracy reported for self-face than the unfamiliar face. Next, a significant main effect of emotion valence was reported, $F(2, 70) = 7.36$, $p = .001$, $\eta_p^2 = .174$. Holm-Bonferroni post-hoc comparisons indicated a higher accuracy for neutral emotion compared to both happy (*p* = .013, *d* = 0.42) and sad (*p* = .002, *d* = 0.62) emotions, whereas there was no significant difference between sad and happy emotions (*p* = .914, *d* = 0.20). The analysis revealed no significant main effect of depressive traits group, $F(1, 35) = 1.55$, $p = .562$, $\eta_p^2 = .010$, and no significant interaction between target identity and depressive traits group, $F(1, 35) = 0.47$, $p = .497$, $\eta_p^2 = .013$.

Figure 4. 10

The Search Accuracy Scores for Different Emotion Valence across Low and High Depressive Traits Group



Note. The mean accuracy scores per participant across three emotion conditions for self and unfamiliar faces condition across low and high depressive traits group. Red shape denotes the group mean.

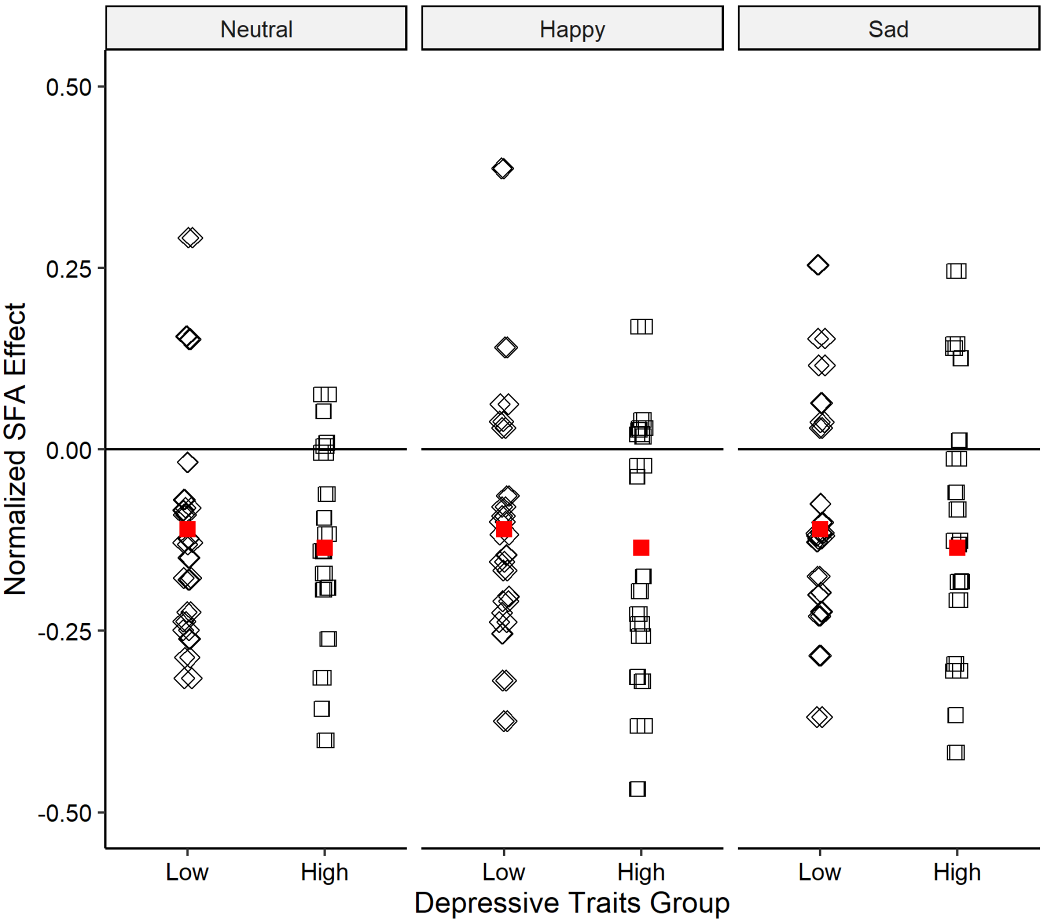
Nevertheless, the analysis revealed an interaction effect between target identity and emotion, $F(2, 70) = 5.76$, $p = .005$, $\eta_p^2 = .141$. To understand this interaction further, ANOVAs were performed on the accuracy data for self and unfamiliar separately. An ANOVA on the accuracy data for "self" showed a significant main effect of emotion, $F(1.52, 54.77) = 2.58$, $p = .014$, $\eta_p^2 = .10$ (Huynh-Feldt corrected). Holm-Bonferroni post hoc comparisons revealed that participants showed a higher accuracy for happy compared to sad emotion ($p = .037$, $d = 0.37$), whereas there were no significant differences between neutral and happy emotions ($p = .129$, $d = -0.14$) and neutral and sad emotions ($p = .129$, $d = 0.23$).

Next, an ANOVA on the accuracy data for “unfamiliar” also showed a significant main effect of emotion, $F(2, 72) = 7.27$, $p < .001$, $\eta_p^2 = .168$. Holm-Bonferroni post-hoc comparisons indicated a higher accuracy for neutral emotion compared to both happy ($p = .006$, $d = 0.53$) and sad emotions ($p = .003$, $d = 0.56$), whereas there was no significant difference between happy and sad emotion ($p = 1.00$, $d = 0.03$). Lastly, the analysis revealed no significant interaction effect between target identity, emotion valence, and depressive traits group, $F(2, 70) = 0.91$, $p = .408$, $\eta_p^2 = .025$.

Normalized Self-Face Advantage (SFA) Effect. *Figure 4.11* shows the normalized SFA across different emotion valence and across the low and high depressive traits group. An ANOVA on the normalized SFA effect revealed no significant main effect of group, $F(1, 35) = 0.18$, $p = .671$, $\eta_p^2 = .005$, but there is a significant main effect for emotion valence $F(1.80, 63.04) = 3.51$, $p = .040$, $\eta_p^2 = .091$ (Huynh-Feldt corrected). Holm-Bonferroni post hoc indicated no significant differences between neutral and happy emotions ($p = .851$, $d = -0.03$), neutral and sad emotions ($p = .060$, $d = -0.39$), and sad and happy emotions ($p = .063$, $d = -0.36$) The analysis further revealed no interaction effect between depressive traits group and emotion valence, $F(1.80, 63.04) = 0.50$, $p = .588$, $\eta_p^2 = .014$ (Huynh-Feldt corrected).

Figure 4. 11

The Normalized SFA Effect for Different Emotion Valence across Low and High Depressive Traits Group.



Note. Normalized SFA effect per participant across three emotion conditions for low and high depressive traits group. Red shape denotes the group mean.

Normalized SFA effect and CES-D scores. Three Pearson's correlation tests were conducted with the normalized SFA effect across the three emotion valence conditions and the scores on the CES-D scale. Findings showed that scores on the CES-D scale did not correlate significantly with a normalized SFA effect for a neutral (r = .034, p = .782, 95% CI [-0.21, 0.27]), happy (r = .010, p = .937, 95% CI [-0.23, 0.25]), or sad face (r = .034, p = .781, 95% CI [-0.21, 0.27]).

4.4.3 Discussion

Experiment 6 investigated the modulation effects of depressive traits on SFA while considering the role of emotional valence of stimuli. Based on the mood-congruency bias hypothesis (i.e., Dalgleish & Watts, 1990), it is expected that participants with more depressive symptoms to be slower in detecting their own face but only when the self-face expression would be incongruent with their affective state (i.e., their happy face or neutral face) compared to those with lower depressive traits.

Findings from Experiment 6 show that participants demonstrated a significant processing bias for the own face compared to an unfamiliar face, regardless of their group and emotion valence condition. Furthermore, the results also show that the normalized SFA effect was similar across groups and across different emotions. These findings therefore do not conform to Beck's (1967) negative self-concept theory and the mood congruency bias hypothesis (Bower et al., 1981). In other words, Experiment 6 did not find evidence of a relationship between an attenuated self-bias for the own face and specific emotion biases in individuals with more depressive traits.

One possible reason explaining why a depression specific attenuated advantage for the own face was not observed could be that negative self-concepts would are only activated in distressing situations (i.e., Ingram, 1984). For instance, Caudek and Monni (2017) induced a negative affective state (i.e., distress) in participants with a negative mood induction procedure and reported that those who were distressed and had a negative cognitive thinking style showed a negative self-referential bias, whereas participants with a negative cognitive thinking style did not show a negative self-referential bias when they were not distressed. This account would, however, stand in contrast to the notion that depression specific cognitive biases operate regardless of a negative affective mood state (see Joorman et al., 2007). Consequently, one might expect that the mood-congruency bias hypothesis would only be relevant when one's negative affective state is triggered or elicited for the depression specific cognitive biases to be activated.

Nevertheless, findings from Experiment 6 demonstrated that individuals have a positivity bias to the own face (i.e., self-positivity bias). Specifically, all participants, regardless of their levels of depressive traits, showed a higher accuracy when searching for their happy self-face compared to their sad and neutral self-faces whereas they performed comparably for their sad and neutral self-faces. This study also shows that participants also take a longer time to search for their sad self-face compared to both their happy and neutral self-faces. On the other hand, this positivity bias was not observed for unfamiliar faces, such that participants showed a higher search accuracy for a neutral unfamiliar face compared to both happy and sad unfamiliar faces. They were, however, faster in searching for a sad unfamiliar face compared to a happy unfamiliar face.

These findings lend support to the theory of implicit positive association with the self (i.e., Ma & Han, 2010) and the self-positivity bias (Greenwald, 1980), wherein the own face may be treated and processed as an emotionally positive face (i.e., a happy face) and a positive emotion may be implicated as an underlying factor for the SFA. Interestingly, this specific positivity bias was only observed for the own face. Results from this experiment may imply a relationship between self-perception and positive emotions. On the other hand, one could not dismiss the possibility of an exposure account. Specifically, participants are better at identifying a happy self-face because they might be more familiar with or be exposed more to their own face with a happy expression as they tend to gather the visual experience of their own face through photographs where one's happy face is seen more often than one's sad self-face.

Lastly, findings from Experiment 6 also show that individuals with higher depressive traits searched for all faces, regardless of their identity and emotion, faster compared to those of lower depressive traits. These findings are in line with findings of Wu et al. (2012), which showed that participants with higher depressive traits verbally labelled emotional facial expressions faster than participants with lower depressive traits. One plausible account is that individuals with higher levels of depressive traits show a global hypersensitivity to emotional facial expressions due to the depressive related negative schema inducing an enhanced emotional processing (e.g., Harkness et al., 2005, 2010). Specifically, when confronted with the presence of other's facial expression, the negative schema in individuals with higher depressive traits may trigger more avoidant behaviour and higher levels of distress (e.g., Persad & Polivy, 1993). Consequently, those with higher depressive traits may then be more motivated to complete the searching task faster by responding faster to the face stimuli to reduce the exposure time to facial expressions.

4.5 General Discussion

Chapter 4 explored the potential factors modulating attentional prioritization to the own face compared to other faces. Specifically, using a visual search paradigm, Experiment 4 looked at the modulation effects of cultural differences whereas Experiments 5 and 6 investigated the modulation effects of a negative self-concept (i.e., depressive traits). With Experiment 4, the cultural modulation effects on an SFA were explored by asking British Caucasians and Chinese Malaysians to search for the own, a friend, and unfamiliar face among an array of distractor faces. Experiment 5 explored the SFA across individuals in the lower end and higher end of depressive personality traits by asking participants to search for their face and an unfamiliar face among other distractor faces. Finally, taking into account the mood-congruency hypothesis, Experiment 6 explored the modulation effects of depressive traits on SFA while considering the role of emotional valence of the stimuli by having participants to search for their face and unfamiliar face presented in neutral, happy, or sad expressions.

Overall, findings from Experiment 4 indicated that the cultural differences of one's self-concept did not modulate the SFA. Specifically, across both British Caucasians and Chinese Malaysians, individuals searched the self and friend's face faster and better than unfamiliar face, but there were no differences in the search performance for the self and friend's face. In other words, there is no SFA relative to a friend's face, but a SFA is reported when compared to an unfamiliar face, and this pattern of findings was consistent across both race groups. Next, findings from Experiments 5 suggested that SFA relative to an unfamiliar face was not modulated by one's depressive personality traits. In other words, there is no attenuated self-bias for the own face as was hypothesized for individuals with higher levels of depressive traits. Even when emotion valence was introduced in Experiment 6, a similar pattern of findings was observed but there was a positivity bias for the own face: individuals searched their happy self-face faster more accurately than neutral and sad self-faces. Interestingly, this positivity bias was not found for the unfamiliar face.

4.5.1 Attentional Advantage of Self-Face Better Explained by Familiarity

Firstly, findings from this chapter seem to highlight that on a behavioural level, the attentional prioritization for the self-face is better explained by familiarity effects rather than self-specificity effects for the self-face (Bortolon et al., 2017; Lee et al., 2007). For instance, the comparison of search performance between the own face, friend's face, and an unfamiliar face in Experiment 4 suggest that there is no attentional preference for the own face over a personally familiar face, whilst both familiar faces were searched more accurately and faster than an unfamiliar face.

There is a continuum of familiarity among faces that ranges from unfamiliar faces to familiar face and there is mounting evidence suggesting that face processing varies according to face familiarity (e.g., Bruce et al., 2001; Estudillo, 2012; Gobbini et al., 2013; Ramon et al., 2011; Van Belle, Ramon, et al., 2010), with processing advantages for familiar faces over unfamiliar faces (Herzmann et al., 2004; Keyes & Zalicks, 2016; but see Wiese et al., 2021). The repeated and extensive exposure of a familiar face may result in an overlearned representation which facilitates visual processing, and in turns results in a processing advantage (i.e., more accurate and more rapid) for familiar face processing compared to the processing of unfamiliar faces (Ramon & Gobbinni, 2018). Furthermore, rather than the retrieval of visual information of a face, familiar face processing is also associated with the retrieval of personal knowledge and emotional response, altogether contributing to a processing advantage for familiar faces (Gobbini & Haxby, 2007). Accordingly, the own face - due to extensive exposure- is also considered an overlearned and highly familiar stimuli (Bortolon et al., 2017); hence, it is possible that the attentional prioritization for the own face to be accounted for by mere familiarity effects. In other words, the own face might be treated as another familiar face, at least in a visual search paradigm.

Additionally, the familiarity account could also explain the findings obtained in Experiment 6 where all participants, regardless of their severity of depressive traits, searched their happy face faster and more accurately compared to their neutral and sad face. Interestingly, this pattern of findings was not observed for unfamiliar faces. Although this finding is consistent with the self-positivity bias account (Greenwald, 1980), one could not dismiss the possibility of an exposure account (or familiarity effects). For instance, individuals searched the happy self-face faster because they might be more familiar with (or exposed to) their own face showing a happy expression as one is more experienced in seeing their smiling face in photos whereas it is not often that one sees the sad (or neutral) face of themselves. In sum, the better and faster search performance for the own face in this chapter might be better explained by a familiarity effect. That is, the attentional prioritization for the self-face is due to a robust representation of one's own face.

4.5.2. Individual Differences in Cultural Self-Concepts

Studies have presented inconsistent evidence on the cultural differences in self-concept. For instance, in a meta-analysis study, Levine et al. (2003) reported that even though East Asians demonstrated a higher interdependent self-concept than North Americans, they do not have a higher interdependent than independent self-concept. Similarly, another meta-analysis (Matsumoto, 1999) also reported that East Asians do not have a higher interdependent self-concept than North Americans, who -in turn- do not have a higher independent self-concept than East Asians. Of note, these reviews have not only presented examples that are incongruent with the expected differences in self-concept where North Americans demonstrated a higher interdependent self-concept compared to East Asians (e.g., Kitayama et al., 2009; Sato & Cameron, 1999), but also presented an absence of cultural differences in self-concept where North Americans and Japanese demonstrated similar levels of independent self-concept (e.g., Sato & Cameron, 1999). This pattern of findings led Matsumoto (1999) to take the view that culture does not predict self-concept reliably.

It is also important to note that self-concept may be difficult to be measured by fixed scales, such as the Self-Construal Scale (SCS; Singelis, 1994), as the self is after all a "dynamic concept" that may change according to context (see Nisbett et al., 2001). For instance, Jiang et al. (2019) explored the self-bias effect in Hong Kong Chinese and UK Caucasians with a shape-label matching task to eliminate the confounding effects of familiarity and reported a higher self-bias effect for UK Caucasians compared to Hong Kong Chinese. However, the authors observed no significant relationship between the measure of SCS and the self-bias effect.

Overall, findings from studies on cultural differences in self-concept needs to be treated with caution as the current literature seem to converge on the idea that there are individual differences between and within culture groups. Some individuals from interdependent cultures may be more independent, whereas some from independent cultures may be more interdependent. It is also important to keep in mind that the self is a dynamic concept that may shift and evolve depending on other factors (i.e., social context or social relations). Thus, future studies should consider the fact that the culture may not be the sole determining factor on the self-advantage effect.

4.5.3 Depressive Traits and A Self-Face Advantage

Research seems to point towards the direction that depressed individuals tend to show a preference for negative stimuli (e.g., Krompinger & Simmons, 2009; Moritz et al., 2005) and/or show an avoidance for positive stimuli (e.g., Hankin et al., 2010; Milders et al., 2016). As the self-face is generally deemed as an emotionally positive stimuli (Greenwald, 1980; Ma & Han, 2010), it is hypothesized in Experiment 5 that individuals with higher depressive traits (or negative self-concept) would show an attenuated self-bias (i.e., absent or reduced SFA). However, contradicting this hypothesis, all participants, regardless of the severity of their depressive traits, showed an attentional prioritization to self-face compared to an unfamiliar face (i.e., an SFA).

Hence, to further explore the role of a negative self-concept (or self-perception) on an SFA, Experiment 6 took into consideration the mood-congruency hypothesis (e.g., Dalgleish & Watts, 1990) which suggests that the emotionally negative stimuli are more congruent with the depressed individual’s self-concept and self-perception, thereby promoting an attentional bias to negative stimuli. However, contradicting the hypothesis that individuals with higher depressive traits would be slower in searching their face but only when the self-face expression is incongruent with their affective state (i.e., their happy or neutral face), findings from Experiment 6 showed that all participants searched their face faster and more accurately than an unfamiliar face, regardless of the emotion and depressive traits condition. It is possible that rather than presupposing that depression specific cognitive biases (i.e., a preference for negative stimuli) would operate regardless of a negative affective mood state, that the negative self-concept in depressed individuals would only be activated in distressing situations (see Ingram, 1984; Caudek & Monni, 2017). Therefore, future studies could control the current mood of the participants by inducing sad mood before asking participants to conduct the experiment (e.g., Caudek & Monni, 2017).

Findings of Experiment 6 also indicate that individuals showed a preference for a happy self-face compared to a neutral and sad self-face, and interestingly, this preference was not observed for the unfamiliar face. This pattern of findings seems to suggest a self-positivity bias, lending support to the theory of implicit positive association with the self (i.e., Ma & Han, 2010) and the self-positivity bias

(Greenwald, 1980), wherein the own face may be treated and processed as an emotionally positive face (i.e., a happy face) and a positive emotion may be implicated as an underlying factor for an SFA. Interestingly, this specific positivity bias was only observed for the own face. Results from this experiment may imply a relationship between self-perception and positive emotion. Altogether, findings from Experiments 5 and 6 seem to suggest that individuals with higher depressive traits did not show an attenuated self-bias but rather, showed a consistent preference for the own face over an unfamiliar face.

4.5.4 Strengths and Limitations

One of the limitations of Experiments 5 and 6 is that it focuses on depression levels as a continuum wherein individuals were distributed into low and high depression group based on their depression scores using a quartile method, instead of using cut-offs for clinical levels of depression. Therefore, it is left unclear whether these findings would vary in a clinically depressed population. Also, one could argue that Experiments 5 and 6 are underpowered as the data were categorized into four quartiles, and data was only analysed for the first (i.e., low depressive traits group) and last quartile (i.e., high depressive traits group). Therefore, a similar analysis was conducted using data across all four quartiles for Experiments 5 and 6, respectively. However, it was reported that the pattern of findings using data across all four quartiles was similar to the pattern of findings using only the two quartiles (see *Appendix D* for the supplementary analysis).

In addition, factors, such as stress levels and current mood of participants, were not controlled for; hence, it is also unclear if these factors influenced or contributed to the findings in Experiments 5 and 6. Moreover, it is also important to acknowledge that the presence of an SFA is affected by type of task used. For instance, whilst an SFA was reported for memory and perception-based task, SFA was, however, not reported for attention-based task (see Bortolon & Raffard, 2018 for a review). Hence, findings of this chapter may not be able to be generalized across other task paradigms. Future studies could also take into consideration of the different type of tasks that is used when exploring for an SFA.

Nevertheless, the visual search task paradigm allows one to mimic a demanding real-world task similar to searching for a friend in a crowd with the presence of heterogenous face images (i.e., distractor faces). Furthermore, a visual search paradigm also allows researchers to discriminate between the initial allocation and dwell of attention (Wisco, 2009). For instance, in the context of Experiment 6, if participants are faster to identify the target stimulus that is negatively-valenced, this may suggest an initial allocation of attention to targets that are depression-relevant. Conversely, if participants are slower to identify a neutral target among other depression-relevant stimuli, this may offer evidence of a tendency to dwell on negative information (e.g., Weierich et al., 2008).

4.6 Conclusions

In conclusion, findings of this chapter indicated that an SFA is not modulated by the cultural differences in one's self-concept or having a negative self-concept. This chapter also highlighted that the SFA is better explained by a familiar face advantage rather than a processing advantage for the self-face, and that a positive emotion for the own face could also be implicated as an underlying factor for an attentional prioritization of the own face.

Chapter 5

Summary, Conclusions and Future Research

5.1 Summary and Conclusions

This thesis investigated the cognitive mechanisms involved in self-face recognition. Due to the own face being a significant stimulus that is critical to one's identity, the own face is suggested to show a processing advantage compared to other faces. Specifically, the SFA is reflected through individuals demonstrating a faster and more accurate recognition to a self-face than to a stranger's and familiar face (e.g., Keenan et al., 2000; Tong & Nakayama, 1999). Nevertheless, when discussing the SFA, majority of the studies explored behavioural (e.g., Brédart et al., 2006; Devue et al., 2009) and neural differences (e.g., Kircher et al., 2000; Platek et al., 2006) and there is little understanding of the cognitive processes involved in self-face processing.

More specifically, whether these processes differ from those for other familiar and unfamiliar faces has remained unanswered. For instance, although it is widely accepted that faces are processed at a global or holistic level (Estudillo, 2012; Maurer et al., 2002; Rossion, 2013; Wong et al., 2021), the own face may be processed in a more featural manner compared to other faces (e.g., Greenberg & Goshen-Gottstein, 2009; Keyes & Brady, 2010) due to the distinct visual experiences an individual has with the own face. To address this gap in the self-face recognition literature, the work in Chapters 2 and 3 explored the role of holistic and featural processing involved in the processing for the self, a friend, and an unfamiliar face.

As eye movements are postulated to provide an indication of the processing style for faces (e.g., Bonifacci et al., 2015; Hills, 2018; Rossion, 2008), Chapter 2 used eye-tracking technique to explore the differences in the gaze behaviour across faces with different familiarity in a passive viewing paradigm and a face identification task. In Experiment 1, external features of the face were removed to ensure observers to look only at the internal diagnostic features (e.g., eyes, nose, and mouth). Observers sampled the own face more often and longer compared to both a friend and an unfamiliar face, with a preference for the mouth region when seeing the own face and for the nose region when seeing the friend and unfamiliar faces. In Experiment 2, observers were asked to identify the faces. Interestingly, in this experiment, there were no differences in the sampling manner for faces across all identities: with eye fixations mostly directed to the nose region, as this position allows for easy extraction of facial information to promote efficient face identification (e.g., Van Belle, Ramon, et al., 2010).With the notion that featural processing is generally associated with a higher number of fixations to individual facial features compared to in holistic processing (Bombari et al., 2009; Hills, 2018) and studies with prosopagnosic patients, who rely on featural processing of faces, directing a greater proportion of eye fixations towards the mouth (e.g., Bukach et al., 2006; Ramon et al., 2010), findings of Chapter 2 seem to suggest that the own face is processed in a more featural manner compared to other faces. However, this distinctive approach seems to be true only when observers are asked to freely explore faces.

Nevertheless, it is important to acknowledge that eye-tracking procedures are an indirect measure of holistic processing, such that, holistic processing is inferred from eye-fixation patterns. Hence, to complement the findings of Chapter 2, Chapter 3 further explored the role of holistic and featural processing in the identification of the own face with three standard but largely independent measures of holistic face processing: the face inversion task, the composite face task, and the part-whole task. In Experiment 3, observers were asked to identify their own face, a friend's face, and an unfamiliar face in three different experimental blocks: (1) inverted vs. upright; (2) top and bottom halves of the face aligned vs. misaligned; and (3) facial features presented in isolation vs. whole foil face context. Inverting a face impaired its identification, regardless of the identity. However, alignment effects were only found when identifying a friend and an unfamiliar face. In addition, a stronger feature advantage, such that (i.e., a better recognition for isolated features compared to in a whole-face context) was observed for the own face compared to the friend and unfamiliar faces. Findings of Chapter 3 show that the own face is processed in a more featural manner but also relies on holistic processing. Specifically, there is a smaller 'holistic interference' by a task irrelevant bottom half face for the own face compared to other faces in the composite face task and a stronger feature advantage for the own face compared to other faces in the part-whole task, but the identification of the self-face is also impaired by inversion.

Next, with the notion that an individual needs to have a self-concept to be able to recognize their face (Gallup, 1970) and how one's self-concept could be modulated by culture (Markus & Kitayama, 1991; Liew et al., 2011) and depressive traits (Beck, 2008), the final experimental chapter explored the modulation effects of these potential factors on the attentional prioritization for the own face (i.e., SFA) compared to other faces with a visual search paradigm. A visual search paradigm was used as it allows one to mimic the demanding real-world task that is similar to searching for a friend in a crowd with the presence of heterogenous face images. In Experiment 4, the modulation effects of cultural differences on the SFA were explored by asking British

Caucasians (i.e., independent self-concept) and Chinese Malaysians (i.e., interdependent self-concept) to search for the own, a friend, and an unfamiliar face among an array of distractor faces. Experiment 5 explored the modulation effects of a negative self-concept on an SFA by asking individuals in the lower and higher end of depressive traits to search for their face and an unfamiliar face. Lastly, taking into account of the mood-congruency hypothesis (Bower et al., 1981), Experiment 6 explored the modulation effects of depressive traits on SFA while considering the role of emotional valence of the face stimuli.

Overall, findings of Chapter 4 showed that the attentional prioritization of the own face is neither modulated by the cultural differences of one's self-concept nor one's depressive personality traits. Specifically, in Experiment 4, the own face did not receive attentional prioritization compared to a friend's face but was prioritized compared to an unfamiliar face, and this pattern of findings was consistent across both race groups. Findings of Experiment 5 suggest that one's depressive traits do not modulate the attentional prioritization to the own face. Specifically, individuals with higher levels of depressive traits did not show an attenuated self-bias for the own face. This pattern of finding was reported even when emotion valence was introduced in Experiment 6. However, there was a positivity bias for the own face, such that, individuals showed a preference for their happy self-face over their neutral and sad self-faces and this positivity bias was not found for unfamiliar face.

In sum, the work in Chapter 4 showed that the own face is processed quantitatively different (i.e., showed an attentional advantage) than an unfamiliar face but this attentional prioritization is not modulated by the cultural differences in one's self-concept nor one's negative self-concept. Additionally, findings in Experiment 6 seem to suggest that a positive emotion for the own face might be an underlying factor contributing to an attentional prioritization of the own face. However, individuals prioritized both the own face and a friend's face, demonstrating no processing advantage for the own face over a personally familiar face. Such a finding may suggest that the attentional prioritization to the own face is better explained by a familiar face advantage than a processing advantage for the own face.

More globally, work across the three experimental chapters has highlighted that in terms of qualitative differences, the self-face is processed differently compared to both a personally familiar and unfamiliar face; however, in terms of quantitative differences, the self-face is only processed differently compared to an unfamiliar face. More specifically, whilst the own face is processed in a more featural manner compared to a friend and an unfamiliar face, the own face also receives attentional prioritization compared to an unfamiliar face, regardless of the cultural differences in one's self-concept or having a negative self-concept. All in all, although the specific face processing strategies for the own face may be due to the distinct visual experience that one has with their face, the attentional prioritization of the own face is however, better explained by a familiar face advantage rather than a self-specificity effect.

5.2 Theoretical Implications

The findings of this thesis have clear theoretical implications for accounts of the cognitive mechanisms involved in self-face recognition. Foremost, work in Chapters 2 and 3 show that due to the distinct and extensive visual experience with the own face, individuals process the own face in a more featural manner compared to friends' and unfamiliar faces. In other words, there is a qualitative difference in the processing mechanisms involved in own-face processing compared to other-face processing. Nevertheless, these findings do not deny the role of holistic processing that might be involved in self-face processing. Specifically, due to the personal significance and relevance of the own face, self-face recognition may be supported by both featural and holistic processing (see also Hills, 2018) to ensure that the self-face is processed efficiently. Of note, these processes are dependent on the task demands. For instance, as shown in Chapter 2, when asked to freely view the own face, individuals adopt a more featural processing strategy whereas when prompted to extract facial information, a more holistic approach is adopted. More importantly, this finding seems to suggest that the more featural processing for the own face is not associated to face identification.

In addition, work in Chapters 2 and 3 also lent support to the finding that the own face is not just another familiar face (e.g., Cygan et al., 2014; Kotlewska & Nowicka, 2015). More specifically, the familiarity account, could not explain for the finding that the self-face is processed qualitatively different than other faces. In other words, the work in Chapters 2 and 3 suggest that the qualitative differences observed for self-face are associated with more self-specificity effects rather than with familiarity effects. For instance, eye-tracking data from the free-viewing tasks indicated that the self-face is processed less holistically compared to the friend’s face, with lesser and shorter eye fixations to the nose on the self-face compared to the friend’s face. In addition, there was no difference in the proportion of gaze for the friend and unfamiliar face, suggesting that both faces are sampled in a similar manner: with more eye fixations positioned on the nose compared to the self-face that received more eye fixations on the mouth. Furthermore, as shown in Chapter 3, when asked to identify the top part of the face stimulus in the composite face task, the self-face is less affected by the “holistic interference” from the task irrelevant bottom half compared to a friend and unfamiliar face. Individuals were also better and faster in recognizing one's own facial features presented in isolation compared to when presented in a whole-face context, but there were no differences in the behavioural performance for the identification of friend's and unfamiliar facial features between the two conditions, altogether suggesting a feature advantage for the own face compared to the friend and unfamiliar face.

Such findings are interesting as both the self-face and friend's face are highly familiar faces. Nevertheless, one should acknowledge that familiarity may be modulated by the level of experience with a person (e.g., Bortolon & Raffard, 2018). Thus, due to the extensive contact and distinct visual experience with their own face, the own face may be processed in a qualitatively different manner than a friend or an unfamiliar face. Conversely, there is a contribution of familiarity effects to the SFA observed in an attention-based task wherein the attentional prioritization of the own face can be explained by a familiar face advantage rather than self-specificity effects. The lack of consistency across the contribution of familiarity effects in reporting a SFA across these studies may be attributed to the task demands that were employed. Specifically, in their meta-analysis, Bortolon and Raffard (2018) reported that an SFA was reported for memory and perception-based task (i.e., identity judgment task or identifying head orientation), but SFA was not reported for attention-based tasks (i.e., simple detection or visual search). Therefore, one may argue that the processing advantages for a self-face may not be reflected in the early perceptual stages but rather reflected a prioritization in the later processing stages, such as memory encoding (e.g., Firestone & Scholl, 2015).

In sum, findings across experimental chapters 2 and 3 seem to imply that the own face is processed qualitatively different compared to a friend and unfamiliar face and these differences could not be accounted by familiarity effects. Such findings also postulate that self-face recognition is coupled with more self-specificity effects rather than with general face recognition abilities. Specifically, such specific face processing strategies for the own face may be due to the distinct visual experience and different processing goals individuals have with the own face.

5.3 Limitations and Future Research

Although eye movements provide an indication of the processing styles for faces (e.g., Bonifacci et al., 2015; Rossion, 2008), one simply cannot measure the cognitive processes directly with eye-tracking but is able to make inferences and capture them indirectly by making manipulations and measuring changes in the behaviour (Holmqvist et al., 2011, p 71). In addition, when interpreting the findings across the three standard holistic measure tasks (i.e., face inversion task, composite face task, and part-whole task), it is important to acknowledge that the inversion, composite, and part-whole effects might be tapping into different perceptual mechanisms (see Rezlescu et al., 2017; Richler et al., 2012). Taking into consideration that these tasks might be indexing different forms of holistic processing, future research could consider the use of gaze-contingent window (e.g., Van Belle, de Graef, Verfaillie, Busigny, et al., 2010) to further explore the role of holistic and featural processing for the own face as this technique allows a clear and direct demonstration whether the observer’s perceptual field comprises of one facial feature at a time or the whole face.

Next, self-face recognition studies should also consider the individual differences concerning looking at pictures of their face (or performing any self-face related tasks). Specifically, the inspection of one’s own face (in images) may be influenced by different personality traits, such as self-disgust and self-esteem (Potthoff & Schienle, 2021). In other words, whilst some individuals enjoy looking at their faces, others may experience emotional distress. For instance, participants with high self-disgust showed attentional avoidance (i.e., reduced eye-fixation duration) of their faces (e.g., Ypsilanti et al, 2020), suggesting that dissatisfaction with one's visual appearance is associated with an avoidance of the own face. Future research could further explore self-face recognition in individuals with elevate self-disgust such as individuals with disordered eating (Bell et al., 2017; Moncrieff-Boyd et al., 2014) and body dissatisfaction (Spreckelsen et al., 2018). For instance, body dysmorphic disorder (BDD) is associated with a high self-disgust (Stasik-O'Brien & Schmidt, 2018), but not with avoidance of self-viewing, such that, many BDD patients reported spending a significant amount of time checking and scrutinizing themselves in the mirror (Veale & Riley, 2001).

Although self-disgust is generally less reported in mentally healthy individuals (e.g., Ille et al., 2014), some individuals could experience negative emotions (i.e., embarrassment) when viewing their faces in photos (or in the mirror), especially when the photos deviate substantially from the standard self (Carver & Scheier, 1998; Duval & Wicklund, 1972). Specifically, one's own perceptual feedback would focus attention onto the self, initiating an automatic comparison against the standard self (see Morita et al., 2014). On the other hand, one's self-esteem may modulate one's self-viewing behaviour too. For example, individuals with higher self-esteem identified their faces faster and showed a greater pupil size when viewing the own face compared to an unfamiliar face (Hu et al., 2013). In a recent study by Potthoff and Schienle (2021), the authors reported that compared to those with low self-esteem, individuals with higher self-esteem were associated with lesser viewing time of the own face. The authors postulated that because people with high self-esteem are less critical of their looks, they need less time to evaluate themselves whereas those with lower self-esteem would have a more thorough and more prolonged evaluation of one's facial appearance. Taken together, this evidence seems to suggest that self-face recognition may be affected by such personality traits, and it is important to consider these individual differences in future research.

Additionally, most of the self-face recognition studies uses face images whilst it should be noted that there are differences in viewing oneself in a picture vs. through a mirror. Foremost, when one look into the mirror, their face is mirror-reversed (i.e., the left side of one's face is reflected on the right side) and because individuals are used to this mirror-reversed image of themselves, they tend to show a preference of their face in a mirror compared to when in a photo (e.g., Frautschi et al, 2021; Mita et al., 1977). Next, mirror viewing is dynamic and can be adjusted via visual feedback. Aside from the distinct visual experience people have for the self-face, there is also evidence suggesting that the mental representation of one's self-face may be enhanced by the multisensory stimulation (Tajadura-Jiminez et al., 2012; Tsakiris, 2008). Specifically, the recognition of one's own face or body (i.e., self-recognition) relies on the 'sensorimotor schema', that is, the combination of information from visual, proprioceptive, and motor information (Sugiura 2013; see also Estudillo & Bindemann, 2017b). Hence, to ensure the ecological validity of research in self-face recognition, future research could include the use of mirror into self-face recognition studies as the use of a mirror would transform a self-representation task from one that relies solely on memory, to one that captures a combination of both a memory and perception based processed (see Zell & Balcetis, 2012).

Finally, when designing a study involving the self-face, one must also consider a major problem of controlling the emotional salience and over learnedness (i.e., high familiarity) of the self-face as both factors are known to influence cognitive processing (e.g., Yoon & Kircher, 2005). Hence, familiarity is an important factor that had to be matched by choosing an appropriate stimulus and the face of a highly familiar person (a friend of the same sex) was used across all the experiments. Nevertheless, one should note that there are differences in the type of friendship, such that, there is variability within experience with these friends (e.g., Burton et al., 2016) as well as the shared emotion aspects (Guerra, Shanchez-Adam, et al., 2012; Guerra et al., 2012). Hence, it is possible that these subtle differences present in the type of friendship may be one of the factors that modulate the observation or reporting of a SFA across studies and future research could control for these differences when using the friend’s face to eliminate the confounding familiarity effects.

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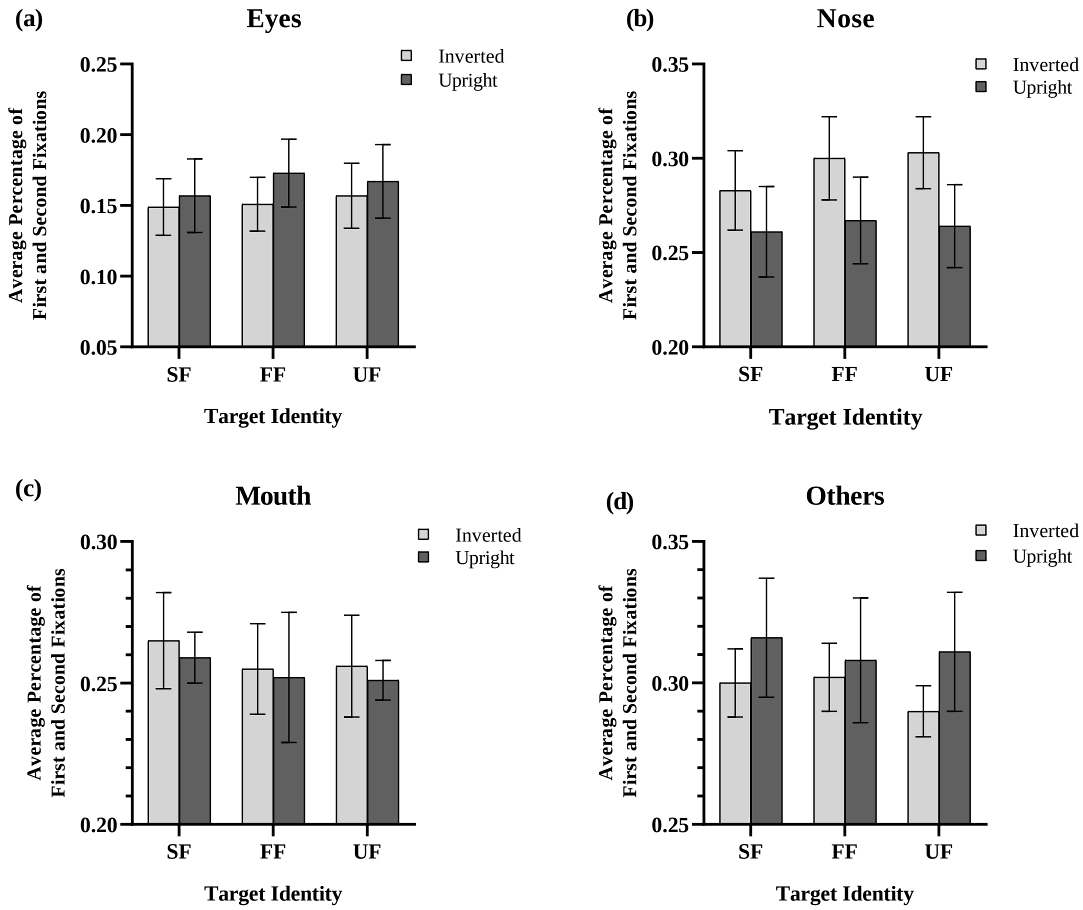
Appendices

APPENDIX A

Average Percentage of First Second Fixations. *Figure 1* presents the average percentage of first and second fixations across all factors. A 3 × 2 × 2 × 4 mixed measures ANOVA, with the variables: identity, inversion, orientation, and features were conducted on the average percentage of first fixations. The detailed ANOVA results are summarized on the left side of *Table 1*. The analysis revealed a significant main effect of features, with Holm-Bonferroni corrected pairwise comparisons indicating that the average percentage of first second fixations to the eyes (M = .159, SD = .139) were lesser compared to nose (M = .280, SD = .131; p < .001, d = -0.89), mouth (M = .256, SD = .083; p < .001, d = -0.72), and the rest of the face (M = .304, SD = .101; p < .001, d = -1.07). In contrast, there were no significant differences in the average percentage of first second fixations between the nose and the mouth (p = .640, d = 0.17), between the nose and the rest of the face (p = .640, d = -1.18), and between the mouth and the rest of the face (p = .167, d = -0.35). The analysis revealed no other significant main effects and interactions.

Figure 1

Average Percentage of First and Second Fixations across Each Facial Feature in Experiment 1.



Note. Average percentage of first and second fixations received by (a) eyes, (b) nose, (c) mouth, and (d) other facial regions for each identity across different inversion conditions. Error bars represent the standard error of mean.

Table 1

Statistical Analysis of Average Percentage of First and Second Fixations and Average First and Second Fixations Duration corresponding to Features, Identity, Inversion, and Orientation.

Variables	Average % of First Fixations			Average First Fixation Duration		
	df	*F*	η_p^2	*df*	*F*	η_p^2
Identity	1.45, 41.98	0.32	.011	2, 58	0.47	.016
Inversion	1, 29	0.63	.021	1, 29	0.00	.000
Orientation	1, 29	0.11	.000	1, 29	1.23	.041
Identity x Inversion	1.39, 40.30	0.84	.003	2, 58	0.06	.002
Identity x Orientation	1.57, 45.62	0.63	.021	2, 58	0.55	.019
Inversion x Orientation	1, 29	0.50	.017	1, 29	0.88	.029
Identity x Inversion x Orientation	1.48, 42.79	0.18	.006	1.73, 50.15	1.38	.045
Features	2.29, 66.43	13.14***	.312	1.44, 41.61	74.33***	.719
Features x Identity	4.03, 116.86	0.48	.016	2.90, 84.10	0.79	.027
Features x Inversion	3, 87	1.17	.039	1.38, 40.04	0.42	.014
Features x Orientation	3, 87	0.10	.003	1.53, 44.34	1.11	.037
Features x Identity x Inversion	4.62, 133.98	0.26	.009	2.78, 80.68	0.21	.007
Features x Identity x Orientation	4.89, 141.83	0.19	.007	3.73, 108.30	0.30	.010
Features x Inversion x Orientation	3, 87	1.15	.038	1.89, 52.11	2.09	.067
Features x Identity x Inversion x Orientation	5.20, 150.76	0.39	.013	2.94, 85.18	1.19	.040

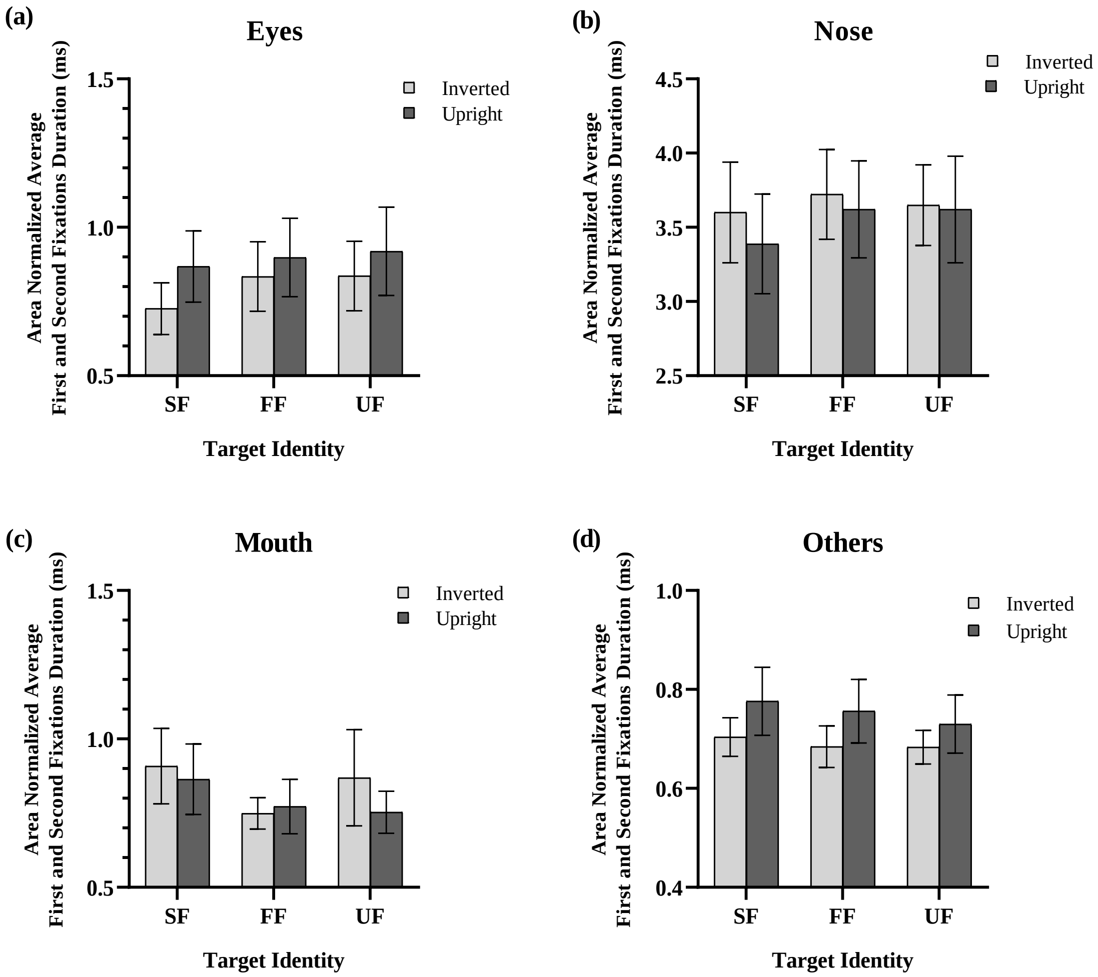
Note. Huynh-Feldt corrections were applied to the *df* for all analyses with the ‘features’ variable; ***$p < .001$, ** $p < .01$, *$p < .05$

Average Total First Second Fixations Duration. *Figure 2* presents the average total first and second fixations across all factors. A 3 × 2 × 2 × 4 mixed measures ANOVA, with the variables: identity, inversion, orientation, and features were conducted on the average total first second fixations duration. The detailed ANOVA results are summarized on the right side of *Table 1*. The analysis revealed a significant main effect of features, with Holm-Bonferroni corrected pairwise comparisons indicating that the average total first second fixations duration to the nose (*M* = 3.60, *SD* = 1.94) were longer compared to the eyes (*M* = 0.85, *SD* = 0.77; *p*

< .001, *d* = 2.18), the mouth (*M* = 0.82, *SD* = 0.60; $p < .001$, *d* = 2.21), and the rest of the face (*M* = 0.72, *SD* = 0.33; $p < .001$, *d* = 2.28). In contrast, there were no significant differences in the average total first second fixations duration between the eyes and the mouth (*p* = 1.00, *d* = 0.22), between the eyes and the rest of the face (*p* = 1.00, *d* = 0.10), and between the mouth and the rest of the face (*p* = 1.00, *d* = 0.08). The analysis revealed no other significant main effects of interactions.

Figure 2

Area Normalized Average Total First and Second Fixations Duration across Each Facial Feature in Experiment 1.



Note. Average total first and second fixations duration received by (a) eyes, (b) nose, (c) mouth, and (d) other facial regions for each identity across different inversion conditions. Error bars represent the standard error of mean.

APPENDIX B

INDEPENDENT AND INTERDEPENDENT SELF-CONSTRUAL SCALE

For each of the statements listed below please identify to what extent you agree for each item: (1= strongly disagree; 2= disagree; 3= somewhat disagree; 4= don't agree or disagree; 5= agree somewhat; 6= agree; 7= strongly agree)

1. I enjoy being unique and different from others in many respects.	1	2	3	4	5	6	7
2. I can talk openly with a person who I meet for the first time, even when the person is much older than I am.	1	2	3	4	5	6	7
3. Even when I strongly disagree with group members, I avoid an argument.	1	2	3	4	5	6	7
4. I have respect for the authority figures with whom I interact.	1	2	3	4	5	6	7
5. I do my own thing, regardless of what others think.	1	2	3	4	5	6	7
6. I respect people who are modest about themselves.	1	2	3	4	5	6	7
7. I feel it's important for me to act as an independent person.	1	2	3	4	5	6	7
8. I will sacrifice my self interest for the benefit of the group I am in.	1	2	3	4	5	6	7
9. I'd rather say "No" directly, than risk being misunderstood.	1	2	3	4	5	6	7
10. Having a lively imagination is important to me.	1	2	3	4	5	6	7
11. I should take into consideration of my parents' advice when making education/career plans.	1	2	3	4	5	6	7
12. I feel my fate is intertwined with the fate of those around me	1	2	3	4	5	6	7
13. I prefer to be direct and forthright when dealing with people I've just met.	1	2	3	4	5	6	7
14. I feel food when I cooperate with others.	1	2	3	4	5	6	7
15. I am comfortable with being singled out for praise or rewards.	1	2	3	4	5	6	7
16. If my brother or sister fails, I feel responsible.	1	2	3	4	5	6	7
17. I often have the feeling that my relationships with others are more important than my own accomplishments.	1	2	3	4	5	6	7
18. Speaking up during a class (or a meeting) is not a problem for me.	1	2	3	4	5	6	7
19. I would offer my seat in a bus to my professor.	1	2	3	4	5	6	7
20. I act the same way no matter who I am with.	1	2	3	4	5	6	7

21. My happiness depends on the happiness of those around me.	1	2	3	4	5	6	7
22. I value being in good health above everything.	1	2	3	4	5	6	7
23. I will stay in a group if they need me, even when I am not happy with the group.	1	2	3	4	5	6	7
24. I try to do what is best for me, regardless of how that might affect others.	1	2	3	4	5	6	7
25. Being able to take care of myself is a primary concern for me.	1	2	3	4	5	6	7
26. It is important to me to respect decisions made by the group.	1	2	3	4	5	6	7
27. My personal identity, independent of others, is very important to me.	1	2	3	4	5	6	7
28. It is important for me to maintain harmony within my group.	1	2	3	4	5	6	7
29. I act the same way at home that I do at school (or work)	1	2	3	4	5	6	7
30. I usually go along with what others want to do, even when I would rather do something different.	1	2	3	4	5	6	7

Q1, Q2, Q5, Q7, Q9, Q10, Q13, Q15, Q18, Q20, Q22, Q24, Q25, Q27, Q29: Independent Subscale

Q3, Q4, Q6, Q8, Q11, Q12, Q14, Q16, Q17, Q19, Q21, Q23, Q26, Q28, Q30: Interdependence Subscale.

APPENDIX C

HORIZONTAL AND VERTICAL INDIVIDUALISM AND COLLECTIVISM SCALE

For each of the statements listed below please identify to what extent you agree for each item:

(1= highly disagree; 9= highly agree)

1. I'd rather depend on myself than others	1	2	3	4	5	6	7	8	9
2. It is important that I do my job better than others.	1	2	3	4	5	6	7	8	9
3. If a co-worker gets a prize, I would feel proud.	1	2	3	4	5	6	7	8	9
4. Parents and children must stay together as much as possible	1	2	3	4	5	6	7	8	9
5. I rely on myself most of the time; I rarely rely on others.	1	2	3	4	5	6	7	8	9
6. Winning is everything.	1	2	3	4	5	6	7	8	9
7. To me, pleasure is spending time with others.	1	2	3	4	5	6	7	8	9
8. It is my duty to take care of my family, even when I have to sacrifice what I want.	1	2	3	4	5	6	7	8	9
9. I often do "my own thing".	1	2	3	4	5	6	7	8	9
10. Competition is the law of nature.	1	2	3	4	5	6	7	8	9
11. To me, pleasure is spending time with others.	1	2	3	4	5	6	7	8	9
12. Family members should stick together, no matter what sacrifices are required.	1	2	3	4	5	6	7	8	9
13. My personal identity, independent of others, is very important to me.	1	2	3	4	5	6	7	8	9
14. When another person does better than I do, I get tense and aroused.	1	2	3	4	5	6	7	8	9
15. I feel good when I cooperate with others.	1	2	3	4	5	6	7	8	9
16. It is important to me that I respect the decisions made by my groups.	1	2	3	4	5	6	7	8	9

Q1, Q5, Q9, Q13 measures HI; Q2, Q6, Q10, Q14 measures VI; Q3, Q7, Q11, Q15 measures HC; Q4, Q8, Q12, Q16 measures VC.

APPENDIX D

Supplementary Analyses for Chapter 4

Experiment 5

A mixed-design analyses of variance (ANOVAs) were then performed on the search accuracy and median reaction time (RTs) for correct responses. The between-subject variables were depressive traits group (low, mid-low, mid-high, and high depressive traits) and the within-subject variables was target identity (self vs. unfamiliar).

Median RT. The analysis revealed a main effect of target identity, $F(1, 106) = 36.29.02$, $p < .001$, $\eta_p^2 = .255$, with shorter RTs for the self ($M = 1.35$, $SD = 0.40$) than the unfamiliar face ($M = 1.64$, $SD = 0.34$). The analysis further revealed no significant main effect of depressive traits groups, $F(1, 106) = 0.77$, $p = .511$, $\eta_p^2 = .021$ and no significant interaction effect between target identity and depressive traits groups, $F(3, 106) = .065$, $p = .978$, $\eta_p^2 = .002$.

Search Accuracy. The analysis revealed a significant main effect of target identity was reported, $F(1, 106) = 155.49$, $p < .001$, $\eta_p^2 = .595$, with a higher mean accuracy reported for the self than the unfamiliar face. The analysis further revealed no significant main effect of depressive traits group, $F(1, 106) = 0.02$, $p = .305$, $\eta_p^2 = .033$, and no significant interaction effect between target identity and depressive traits groups, $F(3, 106) = 1.96$, $p = .125$, $\eta_p^2 = .052$.

Normalized Self-Face Advantage (SFA). A one-way ANOVA test on the normalized SFA showed no significant differences between the levels of depressive traits groups, $F(3, 106) = 0.02$, $p = .985$.

Experiment 6

A mixed-measure analyses of variance (ANOVA) was then performed on the search accuracy, median reaction time (RTs) for correct responses, and the normalized SFA effect. The between-subject variables were depressive traits groups (low, mid-low, mid-high, and high depressive traits). The within-subject variables were target identity (self/unfamiliar) and emotion valence (neutral/happy/sad).

Median RT. The analysis revealed a significant main effect for target identity, $F(1, 64) = 65.16$, $p < .001$, $\eta_p^2 = .504$, with shorter search RTs reported for the self-face than for the unfamiliar face. Next, the analysis further revealed no significant main effect of depressive traits group, $F(3, 64) = 1.61$, $p = .196$, $\eta_p^2 = .070$. The analysis revealed no significant main effect of emotion, $F(2, 128) = 1.63$, $p = .201$, $\eta_p^2 = .025$, no significant interaction effects between target identity and depressive traits group, $F(3, 64) = .569$, $p = .638$, $\eta_p^2 = .026$. Finally, the analysis also revealed no significant interactions effects between target identity and emotion, $F(2, 128) = 2.69$, $p = .072$, $\eta_p^2 = .040$, and no significant interaction effects between identity, emotion, and depressive traits group, $F(6, 128) = .882$, $p = .510$, $\eta_p^2 = .040$.

Search Accuracy. The analysis revealed a significant main effect for target identity, $F(1, 64) = 167.75$, $p < .001$, $\eta_p^2 = .724$, with a higher mean accuracy reported for self-face than the unfamiliar face. Next, a significant main effect of emotion valence was reported, $F(2, 64) = 11.34$, $p < .001$, $\eta_p^2 = .151$. Holm-Bonferroni post-hoc comparisons indicated a higher accuracy for neutral emotion compared to both happy ($p < .001$) and sad ($p < .001$) emotions, whereas there was no significant difference between sad and happy emotions ($p = 1.00$). The analysis revealed no significant main effect of depressive traits group, $F(3, 64) = .718$, $p = .545$, $\eta_p^2 = .033$, and no significant interaction between target identity and depressive traits group, $F(3, 64) = .734$, $p = .535$, $\eta_p^2 = .033$.

Nevertheless, the analysis revealed an interaction effect between target identity and emotion, $F(2, 64) = 12.96$, $p < .001$, $\eta_p^2 = .168$. To understand this interaction further, ANOVAs were performed on the accuracy data for self and unfamiliar separately. An ANOVA on the accuracy data for "self" showed a significant main effect of emotion, $F(1.73, 110.58) = 5.16$, $p = .010$, $\eta_p^2 = .074$ (Huynh-Feldt corrected). Holm-Bonferroni post hoc comparisons revealed that participants showed a higher accuracy for happy compared to sad emotion ($p = .023$), whereas there were no significant differences between neutral and happy emotions ($p = .299$) and neutral and sad emotions ($p = .142$).

Next, an ANOVA on the accuracy data for "unfamiliar" also showed a significant main effect of emotion, $F(2, 128) = 13.06$, $p < .001$, $\eta_p^2 = .169$. Holm-Bonferroni post-hoc comparisons indicated a higher accuracy for neutral emotion compared to both happy and sad emotions (both *p*s < .001), whereas there was no significant difference between happy and sad emotion ($p = 1.00$). Lastly, the analysis revealed no significant interaction effect between target identity, emotion valence, and depressive traits group, $F(6, 64) = .964$, $p = .415$, $\eta_p^2 = .043$.

Normalized Self-Face Advantage (SFA) Effect. The analysis revealed no significant main effect of group, $F(3, 64) = 0.48$, $p = .698$, $\eta_p^2 = .022$, and no significant main effect for emotion valence $F(2, 128) = 2.79$, $p = .065$, $\eta_p^2 = .042$. The analysis further revealed no interaction effect between depressive traits group and emotion valence, $F(6, 128) = 0.62$, $p = .603$, $\eta_p^2 = .028$.