Consciousness and Cognition 105 (2022) 103400

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog

A more featural based processing for the self-face: An eye-tracking study

Jasmine K.W. Lee [a,*], Steve M.J. Janssen [a], Alejandro J. Estudillo [a,b,*]

[a] University of Nottingham Malaysia, Malaysia
[b] Bournemouth University, UK

A R T I C L E I N F O

Keywords:
Holistic processing
Featural processing
Self-face processing
Eye-tracking

A B S T R A C T

Studies have suggested that the holistic advantage in face perception is not always reported for the own face. With two eye-tracking experiments, we explored the role of holistic and featural processing in the processing and the recognition of self, personally familiar, and unfamiliar faces. Observers were asked to freely explore (Exp.1) and recognize (Exp.2) their own, a friend's, and an unfamiliar face. In Exp.1, self-face was fixated more and longer and there was a preference for the mouth region when seeing the own face and for the nose region when seeing a friend and unfamiliar faces. In Exp.2, the viewing strategies did not differ across all faces, with eye fixations mostly directed to the nose region. These results suggest that task demands might modulate the way that the own face is perceived and highlights the importance of considering the role of the distinct visual experience people have for the own face in the processing and recognition of the self-face.

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, the present study addresses this question by exploring the quantitative and qualitative differences in the visual scanning between the own, familiar, and unfamiliar faces.

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

Abbreviations: AOI, Area of Interest; SF, Self-face; FF, Friend's face; UF, Unfamiliar Face.

* Corresponding authors at: University of Nottingham Malaysia, School of Psychology, Jalan Broga, Semenyih 43500, Selangor, Malaysia (J.K.W. Lee). Bournemouth University, Department of Psychology, Poole House Talbot Campus, BH12 5BB, UK (A.J. Estudillo).

E-mail addresses: khpy5jlk@nottingham.edu.my (J.K.W. Lee), aestudillo@bournemouth.ac.uk (A.J. Estudillo).

https://doi.org/10.1016/j.concog.2022.103400
Received 27 December 2021; Received in revised form 15 August 2022; Accepted 18 August 2022
Available online 26 August 2022

feature of a familiar face but 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.

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 lands 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 and 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 adults-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 changes 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 identity, 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 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/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, we 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 a 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 elucidate that task demands may modulate one's self-face processing.

1.3. The current study

With two different experiments, the present study 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. 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), we expected to find that compared to other faces, the self-face would receive a higher number of fixations and a longer fixation duration. 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 the mouth compared to eyes (e.g., Bukach et al., 2006; Ramon et al., 2010). For both friend and unfamiliar faces, we expected to observe a fixation pattern indicative of holistic processing and longer fixations to the nose area (see Van Belle, de Graef, et al., 2010).

We 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, we also expect a higher number of fixations for the inverted friend face an 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, we expected that the self-face would receive a similar number of fixations across its upright and inverted versions.

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

Overall, for Experiment 1, we expected the own face 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, we expected the friend and unfamiliar faces to be sampled more holistically with an overall lesser number of fixations and shorter fixation durations compared to the own face, and to show an inversion effect.

2.1. Method

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 a friend to 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 a normal or corrected-to-normal vision. All participation was completely voluntary, and all gave informed consent after the 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.

2.1.2. 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 heads on a chin rest to minimize head movements.

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 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* Fig. 1*a*). 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 401x 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 collinear. 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 Fig. 1*b*). Images were flipped vertically downwards to create an inverted image and flipped horizontally across to create a mirror-reversed version. All images were collected and processed at least one week before the experimental session.

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.

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 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. 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 min, and participants were given a short break between the two blocks, followed by a recalibration phase.

[1] Based on the effect size from previous research (i.e., $\eta_p^2 = 0.11$, Hills, 2018) and an alpha of 0.05, 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.

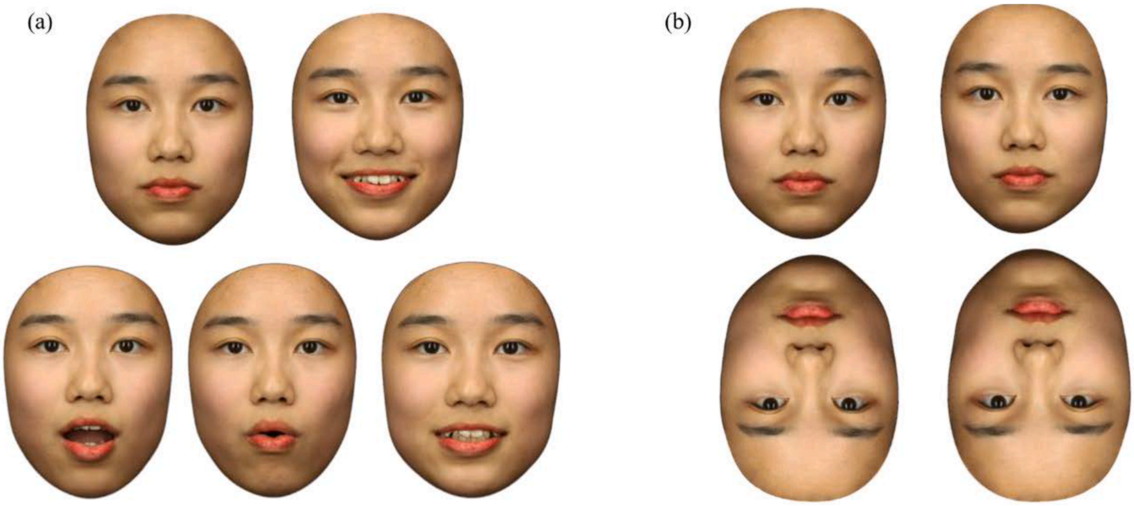

Fig. 1. Example of Face Stimuli used in Experiment 1.

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 (Pollastek 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 (Pollastek et al., 1984).

Predefined 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 Fig. 2). 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 Fig. 2). 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.".

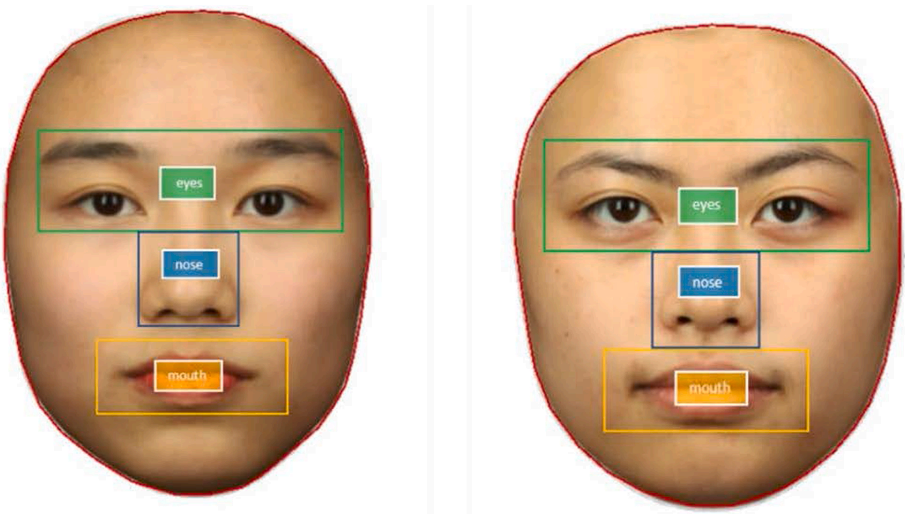

Fig. 2. Predefined Area of Interests (AOIs) for Face Stimulus. *Note.* An example of face stimulus of Experiment 2 with its predefined AOIs: a) eyes; b) nose; c) mouth; and d) rest of the face. Excluding the AOI for the rest of the face (i.e., the outline of the face), the size and location of all AOIs were identical across all presented face stimuli.

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*)) × (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. Results

2.2.1. Average total number of fixations

Fig. 3 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.

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.

Fig. 4 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. 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 3).

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 1.

Fig. 5 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. The analysis revealed a

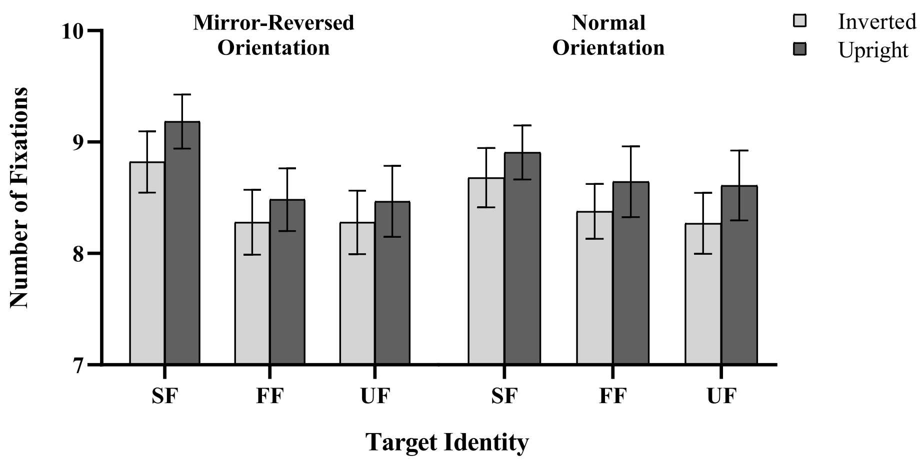

Fig. 3. The Average Total Number of Fixations for Different Identities (Exp. 1). *Note.* The average total number of fixations received by faces for each identity (SF, FF, and UF) across different inversion and orientation conditions. Error bars represent the standard error of the mean.

Table 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***	0.21	2, 58	2.99	0.09
Inversion	1, 29	16.81***	0.37	1, 29	3.80	0.12
Orientation	1, 29	0.004	0.00	1, 29	0.27	0.01
Identity × Inversion	2, 58	0.004	0.001	2, 58	0.73	0.03
Identity × Orientation	2, 58	1.79	0.06	2, 58	0.38	0.01
Inversion × Orientation	1, 29	0.04	0.001	1, 29	0.01	0.00
Identity × Inversion × Orientation	2, 58	0.30	0.01	2, 58	0.58	0.02

*** $p < .001$.

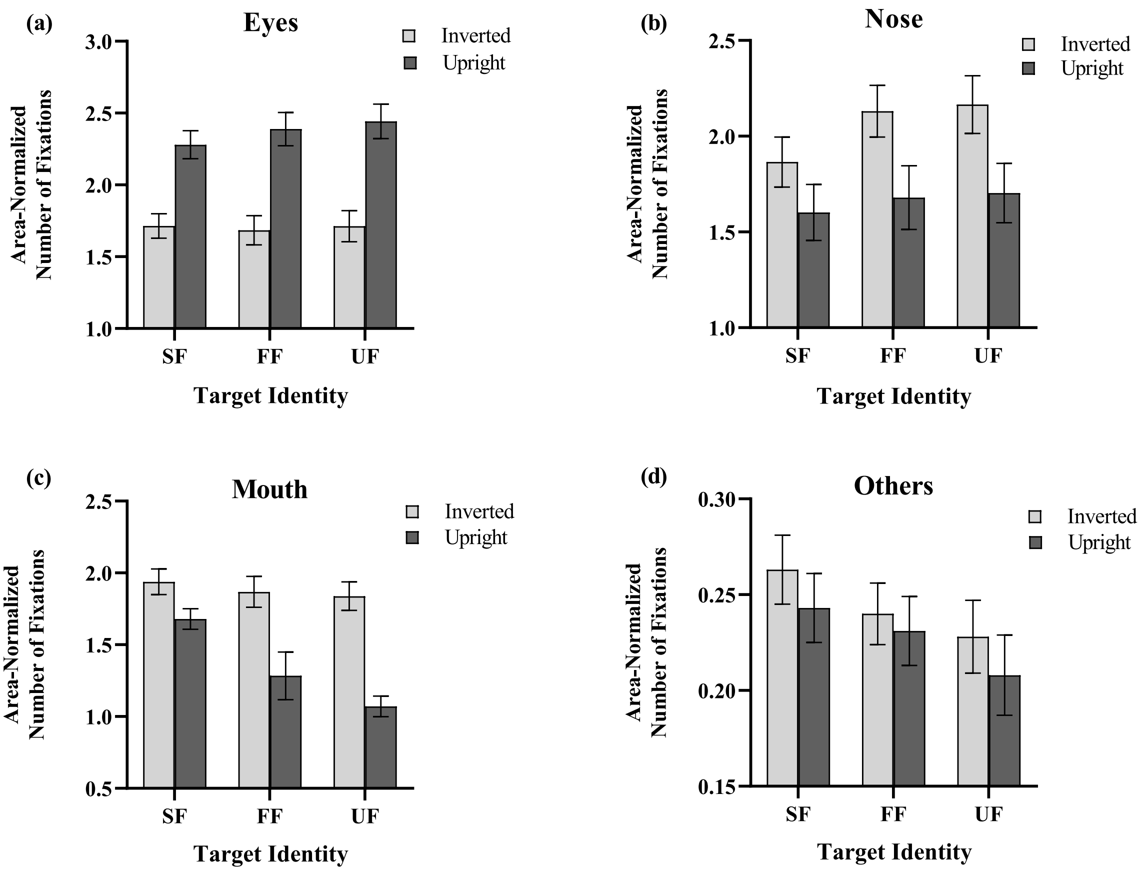

Fig. 4. Area-normalized Average Total Number of Fixations across Each Facial Feature (Exp. 1). *Note.* Area-normalized average total number of fixations received by (a) eyes, (b) nose, (c) mouth, and (d) other facial regions for each identity across different inversion conditions. The orientation factor is collapsed across each AOI. Error bars represent the standard error of the mean.

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 analyses 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)

Table 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***	0.25
Inversion	–	–	–	1, 29	43.55***	0.60
Orientation	–	–	–	1, 29	43.121***	0.60
Features	1.42, 41.20	90.75***	0.76	1.57, 45.56	67.44***	0.74
Features × Identity	4.47, 129.69	3.81**	0.12	3.57, 103.62	7.99***	0.22
Features × Inversion	1.35, 39.02	26.63***	0.48	1.78, 51.53	11.87***	0.29
Features × Orientation	1.95, 56.44	0.28	0.01	1.43, 41.32	22.16***	0.43
Features × Identity × Inversion	4.41, 127.73	1.49	0.05	4.30, 124.59	23.26***	0.45
Features × Identity × Orientation	4.42, 122.33	0.37	0.01	3.66, 106.19	19.21***	0.40
Features × Inversion × Orientation	1.63, 47.17	2.32	0.07	2.04, 59.06	24.00***	0.45
Features × Identity × Inversion × Orientation	4.66, 135.22	1.70	0.06	4.41, 127.90	23.16***	0.44

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

Table 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	0.05	–
Nose	2, 58	4.07*	0.12	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*	0.14	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*	0.12	SF = FF (p =.52, $d = 0.26$) SF > UF (p =.04, $d = 0.47$) FF = UF (p =.30, $d = 0.31$)

* $p < .05$.

compared to FF ($M = 0.22$, $SD = 0.11$; see Table 4*)*.

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 and 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) we did not find evidence supporting an inversion effect across all faces, such that upright faces were fixated more and longer compared to inverted faces. Lastly, (3) the mouth feature receives 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, we observed 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, we postulate 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. Whereas long central fixations to the nose denote holistic processing of faces (e.g., Hills, 2018; Van Belle, de Graef, et al., 2010), 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.

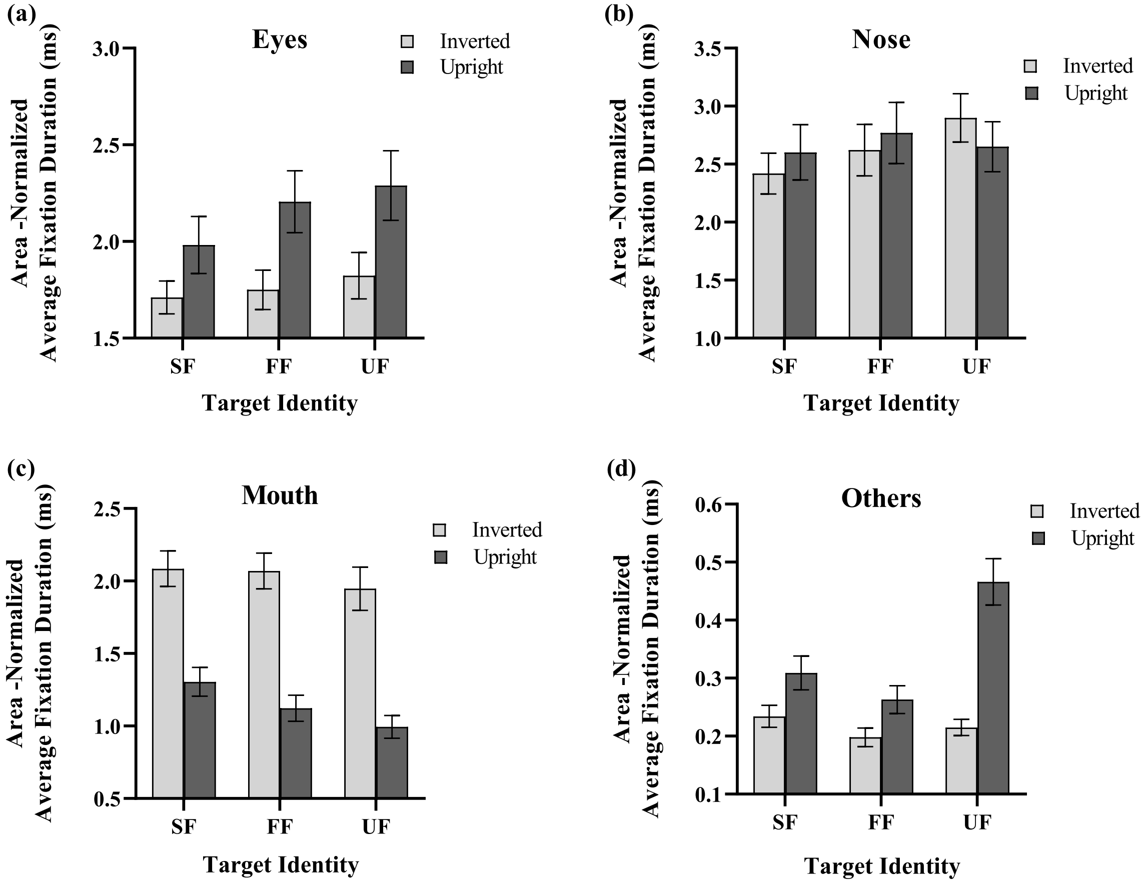

Fig. 5. Area-normalized Average Total Fixation Duration for Each Facial Feature (Exp. 1). *Note.* Area-normalized average total fixation duration received by (a) eyes, (b) nose, (c) mouth, and (d) other facial regions for each identity across different inversion conditions. The orientation factor is collapsed across each AOI. Error bars represent the standard error of the mean.

Table 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**	0.18	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*	0.15	upright faces > inverted faces
Nose	Identity × Inversion × Orientation	2, 58	39.07***	0.57	inverted, mirror-reversed, UF > upright, mirror-reversed, UF
Mouth	Identity	1.97, 57.07	7.02**	0.20	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**	0.58	inverted faces > upright faces (p <.001)
Others	Identity × Inversion × Orientation	2, 58	18.82**	0.39	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.

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.

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 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, we asked 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), we 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.

3.1. Method

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 a 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 a normal or corrected-to-normal vision. All participation was completely voluntary, and all gave informed consent after the 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.

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 Fig. 2 for examples of experimental stimuli.

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",

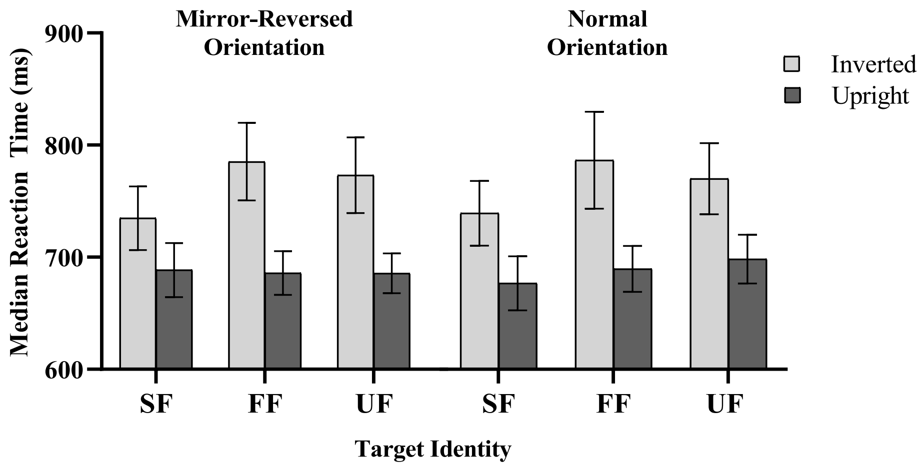

Fig. 6. The Median Reaction Time to Identify Faces. *Note*. The median reaction time (ms) per participant for each identity (SF, FF, and UF) across different conditions. Error bars represent the standard error of the mean.

and “L”, respectively). Face stimuli remained on the screen until the participants made a keyboard response. Twelve practice trials were presented before 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 min, and participants were given a short break between the two blocks, followed by a recalibration phase.

3.2. Results

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 %). Fig. 6 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, $F(1, 29) = 48.04$, $p < .001$, $\eta_p^2 = 0.62$, with a shorter median reaction time to upright faces compared to inverted faces. The analysis revealed no other significant main or interaction effects.

3.2.2. Average total number of fixations

Fig. 7 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 5 reports the summary of the ANOVA results. We found a significant main effect of inversion, 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.

Fig. 8 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 6 shows the detailed ANOVA results. A main effect of features was found, which was quantified by a significant interaction with identity. Simple main effects analyses 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 7).

This analysis further revealed a significant interaction between identity and orientation (see Table 6). 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.

3.2.3. Average total fixation duration

Fig. 9 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

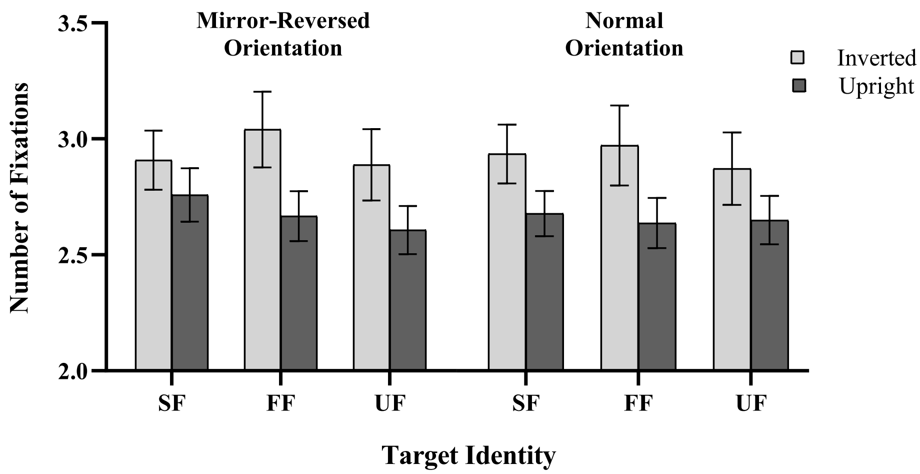

Fig. 7. The Average Total Number of Fixations for Different Identities (Exp. 2). *Note.* The average total number of fixations per participant received by faces for each identity (SF, FF, and UF) across different inversions and orientation. Error bars represent the standard error of the mean.

Table 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	0.02	2, 58	13.01***	0.31
Inversion	1, 29	19.71***	0.41	1, 29	0.06	0.002
Orientation	1, 29	2.00	0.07	1, 29	0.84	0.03
Identity × Inversion	2, 58	1.31	0.04	2, 58	0.11	0.004
Identity × Orientation	2, 58	1.00	0.03	2, 58	2.42	0.08
Inversion × Orientation	1, 29	0.01	0.00	1, 29	0.86	0.03
Identity × Inversion × Orientation	2, 58	3.04	0.10	2, 58	0.62	0.02

*** $p <.001$.

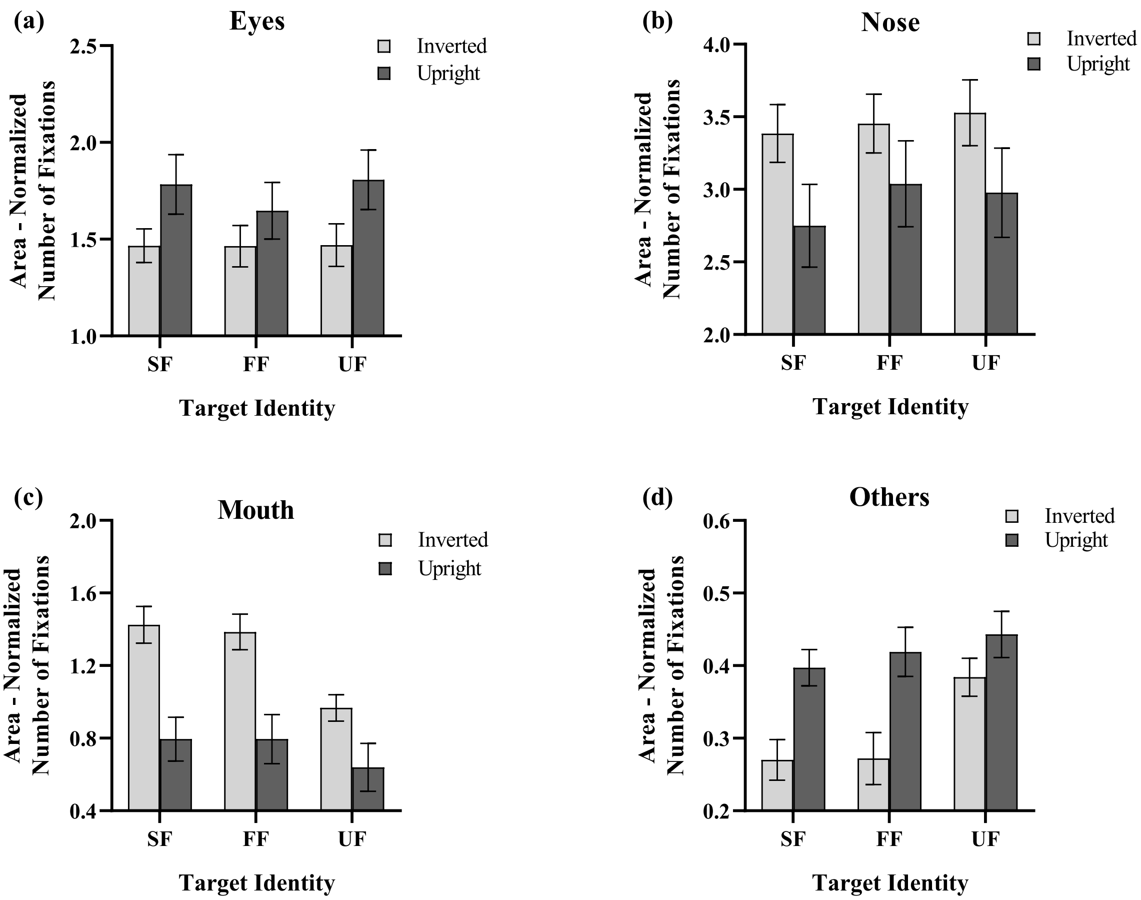

Fig. 8. Area-Normalized Average Total Number of Fixations for Each Facial Feature (Exp. 2). *Note.* Area-normalized total number of fixations received by (a) eyes, (b) nose, (c) mouth, and (d) other facial regions for each identity across different inversion conditions. The orientation factor is collapsed across each AOI. Error bars represent the standard error of the mean.

side of Table 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.

Fig. 10 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 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 analyses followed by Holm-Bonferroni corrected pairwise comparisons revealed that the mouth was fixated shorter on UF ($M = 0.77$, $SD = 0.67$)

Table 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***	0.79	1.54, 44.68	95.97***	0.77
Identity × Orientation	2, 58	4.39*	0.13	2, 58	3.36*	0.10
Features × Identity	3.66, 106.18	6.35***	0.18	3.21, 90.45	4.74***	0.14
Features × Inversion	1.56, 45.14	3.71*	0.11	1.54, 44.51	4.24	0.13
Features × Orientation	1.90, 55.15	0.73	0.02	1.64, 47.40	1.72	0.06
Features × Identity × Inversion	3.63, 105.14	1.27	0.04	3.33, 96.42	1.08	0.04
Features × Identity × Orientation	3.92, 113.74	1.58	0.05	3.40, 98.47	2.33	0.07
Features × Inversion × Orientation	1.59, 46.21	2.37	0.08	1.38, 39.96	2.37	0.08
Features × Identity × Inversion × Orientation	3.07, 89.15	0.39	0.01	2.72, 78.79	0.81	0.03

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

Table 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	0.15	–
Nose	2, 58	2.08	0.07	–
Mouth	2, 58	21.03***	0.42	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***	0.28	SF < UF ($p < .001$, $d = -0.87$) FF < UF ($p = .002$, $d = -0.68$) SF = FF ($p = 1.00$, $d = -0.11$)

*** $p < .001$.

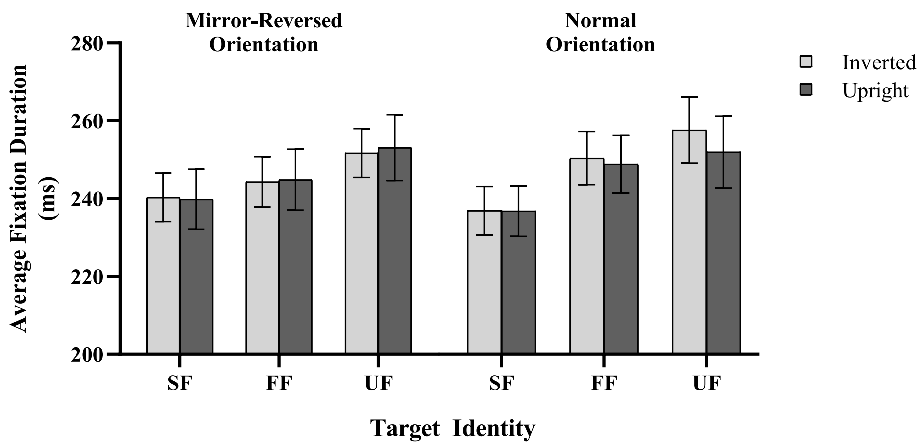

Fig. 9. Average Total Fixation Duration for Different Identities (Exp. 2). *Note.* The average total fixation duration received by faces for each identity (SF, FF, and UF) across different inversion and orientation. Error bars represent the standard error of the mean.

than SF ($M = 1.045$, $SD = 0.78$) or FF ($M = 1.053$, $SD = 0.79$), 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 8).

The analysis also revealed a significant interaction between identity and orientation (see Table 6). 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

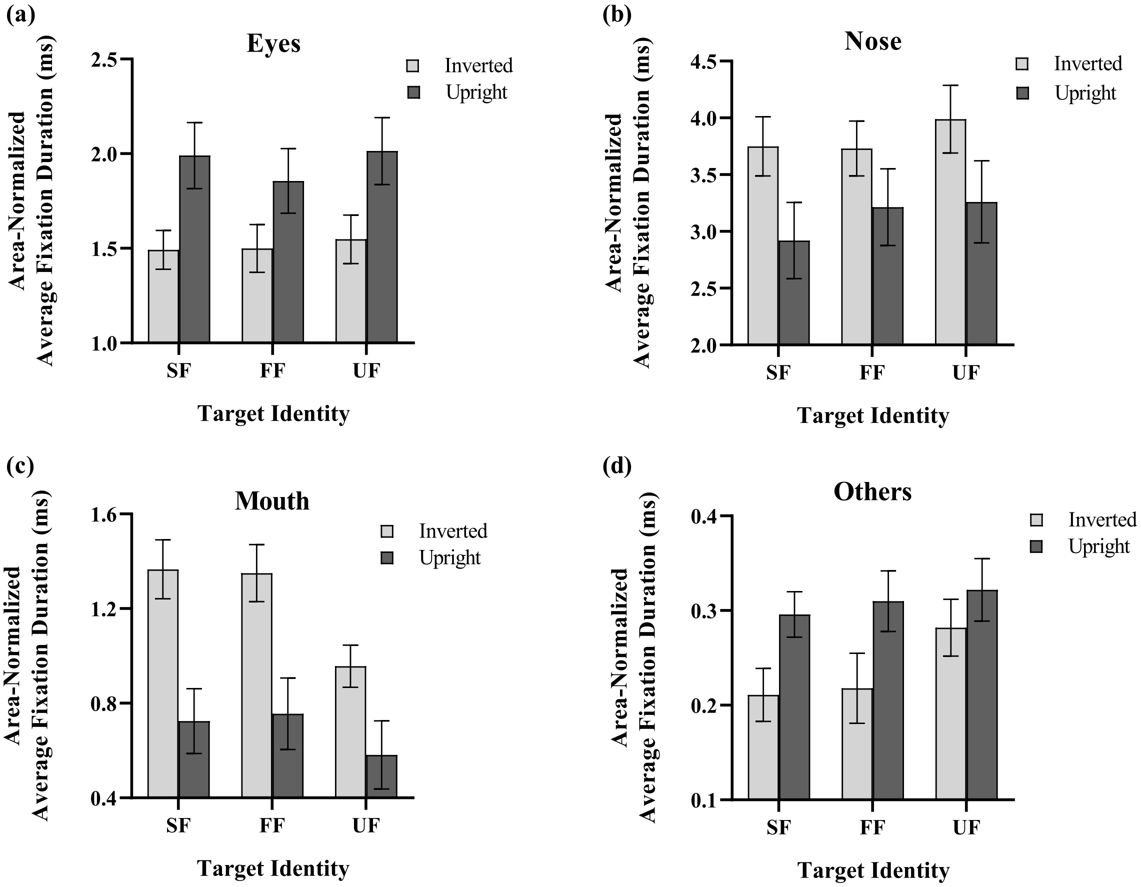

Fig. 10. Area-Normalized Average Total Fixation Duration for Each Facial Feature (Exp. 2). *Note.* Area-normalized average total fixation duration received by (a) eyes, (b) nose, (c) mouth, and (d) other facial regions for each identity across different inversion conditions. The orientation factor is collapsed across each AOI. Error bars represent the standard error of the mean.

Table 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	0.08	–
Nose	2, 58	2.31	0.10	–
Mouth	2, 58	14.71***	0.34	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*	0.13	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 <.05.

across the orientation conditions.

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. We observed that when 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) we reported an evident inversion effect on the viewing patterns for all faces.

When asked to identify the faces, we observed 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.

4. General discussion

In two experiments, we 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.

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, our results 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, we observed that a higher number of fixations are 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, we 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 we reanalysed the results of Experiment 1 including only the first two fixations (see Supplementary Material), we did not find any differences in the viewing patterns across all three faces. This finding replicates the results of Experiment 2 and confirm 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.

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. We observed 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, we obtained 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.

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, we reported an inversion effect for Experiment 2 which participants were asked to make identity judgements, whereas no such observation was reported for a 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, our findings suggest that the inversion effect for faces may also be modulated by the presence of task demands.

4.4. Limitations

One limitation of this study 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 an artificial method employed in laboratory settings. The everyday-life interactions between individuals are a dynamic process, thus using dynamic stimuli in face research would be more ecologically valid.

It is also 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 point (see Van Belle, Ramon, et al., 2010).

4.5. Conclusions

In conclusion, due to the personal significance and relevance of the own face, we showed that 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.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors are thankful to the participants who took part in this study.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.concog.2022.103400.

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