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A Comparison of Identity and Emotional Expression Processing between Real and Line-Drawn Faces

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Face processing and recognition has been one of the most productive research areas in cognitive science over the past four decades, and in most studies images of real faces are the focus of inquiry. Owing to the proliferation of technology in social media in recent years, we have witnessed a significant surge of using line-drawn faces and expressions along with their real-face counterparts for purpose of communication. Here in two experiments we examined how line-drawn faces may differ from real faces in terms of identity and emotional expression processing. In Experiment 1, we used the part-whole task and showed that, compared to real faces, line-drawn faces were processed in a more part-based manner similar to non-face objects (i.e., houses). In Experiment 2, we tracked participants' eye movements while they performed a delayed matching-to-sample task, in terms of expressed emotion, where images of either real or line-drawn faces were used as the sample. In addition, we also examined the role a verbal label may play in identifying the facial expression that matched the description. We did this to test the idea whether facial expressions of line-drawn face were in general more symbolically coded than real faces such that a verbal label would be more effective in retrieving those expressed by line-drawn faces. The results indicated that while line-drawn faces differed from real faces in terms of identity processing, they may be quite similar in terms of expression processing. Furthermore, compared to real faces, providing a verbal label failed to offer any additional help locating the matched expression from line-drawn faces, after controlling for the potential speed-accuracy tradeoff with inverse efficiency scores. This might explain why it has become a common practice to exaggerate portrayed expression in line-drawn faces: To overcome the inherently vague signals of emotional expression.

Keywords: *emotion, eye movements, facial expression, face recognition, line-drawn faces*

Faces are perhaps the most powerful biological platform upon which meaningful and satisfying social interactions are engaged and unfolded. We not only can verify a person's identity via his or her face, but also can read out numerous kinds of information from the face, such as the person's intention and attention (gaze), emotional states, and even personality, among others.

Thanks in large part to the advent and proliferation

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of digital technologies such as internet, people literally are bombarded on a daily basis with images of real faces and their expressions as well as those portrayed by cartoon- or line-drawn faces, such as the so-called emoticons and *emoji*. According to a report from Associated Press, the emoticon in the form of ":-)" to denote a smiling face, was originally created and posted in 1982 (Fahlman, n.d.). This text-based emoticon was meant to generate the percept of a face that are made of typographic symbols that do not in and by themselves carry any meaning as face features. Nowadays, people have used extensively not only the text-based emoticons, but also the more pictorial emoticons, called emoji, as well as other cartoon-like emotional stickers in popular social media and online communications. In most cases, emoticons and emoji are used as visual cues for highlighting the affective undertone often diluted and/or obscured in text-based messages such as e-mail, and by so doing may help reduce the possibility of miscommunication (Byron, 2008).

Although people use the emoticons thousands of times every second (Steinmetz, 2014) when they are surfing on the Internet, research on the use of line-drawn faces and their intended effectiveness in online communication is relatively scarce. The study reported here represents an attempt to fill in the gap in this direction. More specifically, we ask the question of whether and how processing of line-drawn faces, in terms of processing of identity and processing of emotional expression, may differ from that of real faces.

Many investigators share the view that there are fundamental differences in processing between objects and faces (Duchaine & Yovel, 2008; Kanwisher & Yovel, 2006; McKone, 2010; McKone & Yovel, 2009; Piepers & Robbins, 2012; Richler, Palmeri, & Gauthier, 2012; Rossion, 2008; for reviews see McKone, 2010; Yang & Shyi, 2010). The processing of objects and the underlying representations are claimed to be part-based, whereas the processing and underlying representations are claimed to be holistic. Holistic processing entails integrating all features that are present in a face to form a whole and template-like representation (Peipers & Robbins, 2012; Rossion, 2008, 2013; Richler et al., 2012; Tanaka & Farah, 1993, 2003). This template-like holistic representation likely contains all the nameable parts in a face (eyes, nose, mouth, etc.), metrical distances among those parts, as well as local landmark points along the contours of nameable parts and distances radiating from the landmark points (McKone & Yovel, 2009).

A number of lines of research evidence have argued for the holistic nature of face processing and representation, including studies on inversion effects, face composite effect, part-whole task, among others (see Rossion, 2013, for a recent review). For example, Tanaka and Farah (1993) used a part-whole task to examine the holistic nature of face processing. Participants in their study first learned faces of six individuals with names. They were then tested with parts (e.g., nose) of learned faces either in isolation or being presented in the whole-face context. Participants were better able to identify the parts when they were tested with the original face context than in isolation. In contrast, recognition of an object part (e.g., windows of a house) was unaffected by such manipulation. Tanaka and Farah concluded that their findings implicate holistic processing of faces such that each nameable part is integral to the representation of the entire face. In Experiment 1, we employed the part-whole task to compare the processing of real faces and line-drawn faces. In addition, we also included house stimuli as control, which, based on Tanaka and Farah's (1993) results, should allow us to see whether line-drawn faces were similar to houses in that both would exhibit evidence of part-based processing.

The line-drawn faces used in present study, as illustrated in Figure 1, were created by tracing the outline of facial features from real faces. Thus created, the line-drawn faces contained two main facial features of the real faces, namely a pair of eyes and a mouth, which are the most consistently highlighted features used by a variety of emoji and similar symbols in various social-medium platforms. However, the line-drawn faces lack surface information such as pigmentation and shading due to illumination (McKone & Yovel, 2009; Vuong, Peissig, Harrison, & Tarr, 2005) of real faces, which may critically affect the perceptual representation of these faces. For example, as pointed out by Bruce and Langton

(1994) and Kemp, Pike, White and Musselman (1996), eliminating pigmentation and shading information was the main reason that negative photos of face are difficult to recognize. Furthermore, using 3D-laser scanned faces, Vuong et al. (2005) were able to demonstrate the separate influence of pigmentation and shading on face recognition, and found evidence suggesting these two factors were additive in affecting face recognition.

These previous findings would lead to the prediction that line-drawn faces are more likely to be represented as aggregate of discrete parts rather than as holistic template-like configuration. In other words, the representation of line-drawn faces may be more part-based (or at least less holistic), akin to those underlying non-face objects (Biederman, 1987; McKone, 2010), than their real-face counterparts. We examined this possibility via the whole-face superiority effect (Tanaka & Farah, 1993; Tanaka & Sengco, 1997) in Experiment 1. Alternatively, surface information such as pigmentation and shading may not play any essential role in the perceptual representation of a face inasmuch as face recognition relies upon holistic processing is concerned. If so, we may not find difference between real and line-drawn faces with respect to identity processing.

In addition to identity processing of line-drawn faces, we are also interested in their functionality in expressing emotions, and in particular how it may or may not differ from that of real faces. Harris, Young, and Andrews (2014) reported recently that photo negativity show differential effects on identity versus expression recognition. Specifically, while contrast-reversed photos had an adverse effect on identity recognition, it had very little effect on emotion recognition. Their finding suggests that pigmentation and shading may play different roles in expression processing, the underlying mechanism of which may differ from that of identity processing. We adopted a variant of the matching-to-sample task to examine this issue in Experiment 2, where the sample (cue) can be either a face, real or line-drawn, or a verbal label of emotional expression. Insofar as real faces possess not only nameable face parts but also additional information such as lighting, shading, and pigmentation of facial surfaces in between parts, they inherently may provide richer information regarding expression than line-drawn faces where those pieces of additional information are lacking. If so, we would expect to find superior performance in matching facial expression with real faces, especially when the sample cue also was a real face. On the other hand, a number of recent studies have suggested that processing of some facial expressions may be part-based in that they are disproportionally dominated by specific face parts (Calvo, Fernández-Martín, & Nummenmaa, 2013; Tanaka et al., 2012). In that case, we may predict real faces and their line-drawn counterparts should exhibit more similar, rather than different, results. Finally, we may encode the emotional expressions exhibited by line-drawn faces more symbolically than those exhibited by real faces, such that a label cue of expression may allow observers to retrieve and match the expressions carried by the corresponding line-drawn faces more efficiently than real faces. We examined these hypotheses in Experiment 2.

Moreover, we used an eye tracker in conjunction with the behavioral task in Experiment 2 to monitor participants' eye movements while they were making their matching judgments. Recent studies by Calvo and his colleagues also have shown that processing and identification of positive expression of happiness is disproportionally enhanced by the presence of a smiling mouth with wide opening and baring teeth (Calvo et al., 2013). In particular, they found that the latency of initial saccade landing on a smiling face was much shorter than those on other emotional expressions (Calvo & Nummenmaa, 2009). On the other hand, work by other researchers have reported that East Asians exhibited pattern of eye movements different from that exhibited by Westerns when they were making judgments regarding facial expressions. For example, Jack and her colleagues found that Westerns tend to have a more even distribution of eye movements among eyes, nose, and mouth regions, whereas East Asians tend to focus more on the eye region of a face. Such discrepancy may explain why, compared to Westerners, Eastern Asians showed a greater tendency to confuse between negative expressions such as disgust and fear where the difference between them resides predominantly in the mouth region (Jack, Blais, Scheepers, Schyns, & Caldara, 2009; Jack, Caldara, & Schyns, 2012). The biased tendency for focusing more on eye regions was also found in a recent study where Taiwanese college students were asked to rate facial expressions of basic emotions (Shyi & Yeh, 2011). Here we wanted to exploit eye movements to see whether differential saccades may be modulated by the fact that emotional expressions were conveyed by real versus line-drawn faces. For example, compared to face cues, the label cues may bias participants to shift their gazes more forcefully to regions that can best convey a specific expression (e.g., mouth for happiness, and eye region for anger) upon the display of test faces. Furthermore, we may see such biases to be stronger with line-drawn faces than with real faces, assuming line-drawn faces are processed in a more part-based or less holistic manner.

Experiment 1: Identity Processing of Real and Line-Drawn Faces

In Experiment 1, we adopted the part-whole task used by Tanaka and Farah (1993) and examined whether, compared to real faces, line-drawn faces were processed in a more part-based manner similar to non-face objects (i.e., houses).

Method

Participants

Twenty-four undergraduate students from the National Chung Cheng University (12 male, 12 female), with a mean age of 19.9 years (ranging from 18 to 22 years) participated in the experiment. All participants had normal or corrected-to-normal vision. Participants received a payment of NT$50 to compensate for their participation. They were given informed consent prior to the actual experiment, which took approximately 30 minutes to complete.

Stimuli and Apparatus

Twelve colored face photos (half male and half female) with neutral expressions were selected from the Taiwanese Face Database recently created by Shyi, Huang, and Yeh (2013). In order to minimize differences inherent in the colored images, the face photos were first transformed into gray-scale images. The grey-scale face images were then cropped so that only the internal facial area was visible, and used as targets for the real-face condition (see Figure 1a). The line-drawn version of target faces, as illustrated in Figure 1b, were created by tracing contours of (nameable) parts of real faces and used as targets for the line-drawn face condition. Finally, following Tanaka and Farah (1993), we also created a set

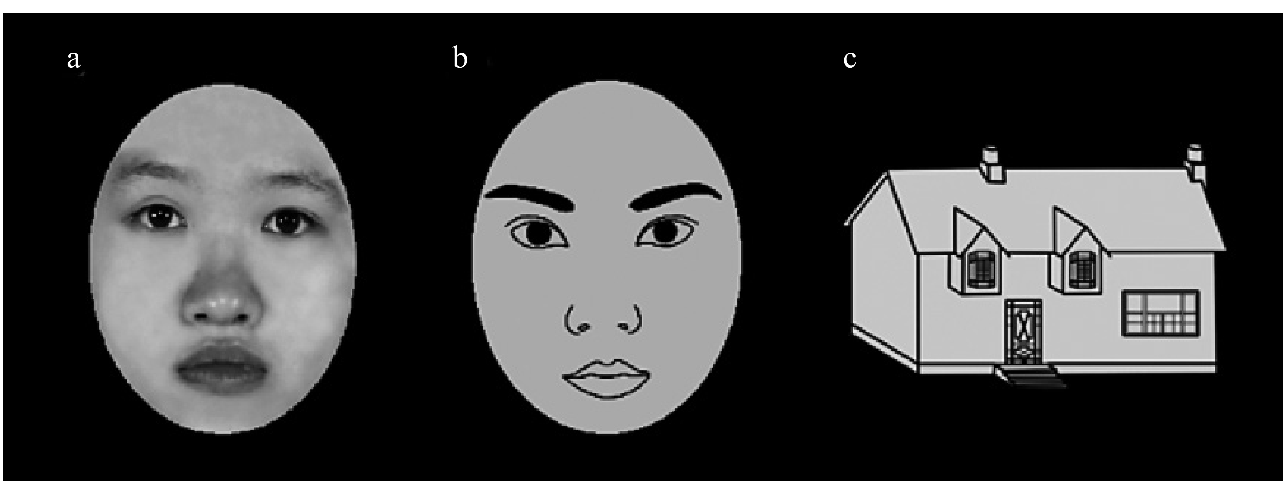

***Figure 1.* The stimuli used in Experiment 1.**

Source: This study.
Note. (a) is an example of real face, (b) is the line-drawn version of (a), and (c) is an example of house stimuli.

of 12 houses where each house had a shared configuration of two attic windows overhanging a door, emulating a facial configuration of eyes and mouth (see Figure 1c).

For purpose of learning, each face image, real or line-drawn, was paired with a different voiced Chinese name and each house image was paired with an English name (as purported identity of an owner) for the house condition. The distractors were created by altering parts in the images, for example, by replacing the eyes or mouth parts from other faces for face stimuli, and replacing windows or door from other houses for the house stimuli. The face and house images each had a size of about 7.0 × 9.2 cm and 11.0 × 7.0 cm, respectively, extending a visual angle of 6.2 × 8.1 and 9.7 × 6.2 at a viewing distance of approximately 65 cm.

The stimulus presentation and response recording were under the control of a computer program written with E-Prime 2.0 (Psychological Software Tools, Inc., USA). Face and house images were presented on a 19" LCD monitor (ViewSonic VA916g). The face and house stimuli were displayed while audible individual names accompanying each visual image were simultaneously presented via a pair of external speakers situated alongside the computer screen. Participants made their responses by pressing designated keys ("/" or "Z") on a regular computer keyboard.

Design and Procedure

A two-factor within-participant design was used, with type of stimuli (real faces, line-drawn faces, and houses) and test condition (where test stimuli were presented either in whole or part) as the two within-participant variables. Each participant learned and was tested for each type of stimuli in three separate blocks in randomized order. That is, they learned and were tested on one type of stimuli before learning and being tested on another. During the learning phase, participants were instructed to memorize all the target images (real faces, line-drawn faces, or houses) for a later memory test. In each trial, participants first saw a fixation point ("+") for 1 s, followed by the presentation of a target image along with its name (in Chinese for faces or in English for houses) voiced for 4 s. A random-dot mask was then presented for 1s. Each of the six target images was repeated five times for a total of 30 trials to ensure learning.

The corresponding testing phase then ensued, where each trial comprised a two-alternative forced choice test, as illustrated in Figure 2. There were 24 trials in each test block, where half of the trials were tested with whole images and the other half with parts images. For the whole-image test trials, participants were shown a pair of whole images of real faces, line-drawn faces, or houses, and they were to judge which image would go with the preceded name of enquiry as in "Which one is Joe (or Joe's house)?" The verbal enquiries were each presented for 2 s. The pair of test faces were each located 9.5 cm (approximately 8.36° of visual arc) from the center of display, and the center-to-center distance between the two test images was about 19 cm (approximately 16.63° of visual arc). Participants responded by pressing either "/" if the image presented on the right was the target, or "Z" if the image on the left was the target, using a regular computer keyboard.

For the part-image trials, participants again saw a pair of part images of real eyes or mouths, line-drawn eyes or mouth, or windows or door of a house, and they were to pick out the image that matched the name of enquiry as in "Which pair of eyes belonged to Joe?" that preceded the test display.

Both response accuracy and latency were recorded as dependent measures. The same procedure was used for all three types of stimuli in accordance with a counterbalanced order, for a total of 72 trials.

Results and Discussion

Response Accuracy

The mean accuracy of the two-alternative forced choice test in each condition was submitted to 3 (stimulus type) × 2 (test condition) repeated-measured analysis of variance (ANOVA). The main effect of stimulus type was significant, $F(2, 46) = 12.75$, $p < .001$, $\eta_p^2 = .36$; however, the main effect of test condition was not, $F(1, 23) = 2.07$, $p > .1$. The interaction of stimulus type and test condition

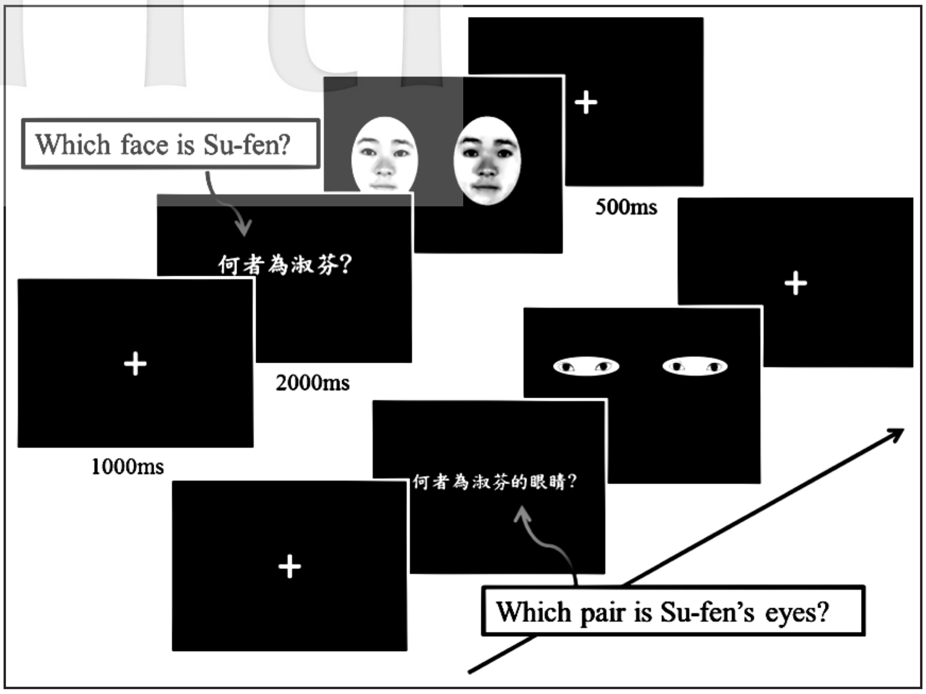

Figure 2. **The procedure used during test in Experiment 1.**

Source: This study.

Note. The procedure that was used during test in Experiment 1, where participants were asked to pick which whole image (face) or part image (eyes) was the correct answer corresponding to a verbal inquiry ("Which face is Su-fen" vs. "Which pair is Su-fen's eyes").

also was significant, $F(2, 46) = 7.64$, $p < .001$, $\eta_p^2 = .25$.

As shown in Figure 3a, participants performed best with houses (M = .83), followed by real faces (M = .78), and worst with line-drawn faces (M = .68). Post-hoc comparisons show the accuracy of line-drawn faces was significantly lower than that of both real faces and houses, $t(23) = 3.47$, $p < .01$, and $t(23) = 4.66$, $p < .01$, respectively, but the latter two did not differ from each other, $t(23) = 1.74$, $p = .096$. On other hand, participants performed equally well with the whole-image test (M = .78) as with the part-image test (M = .75), $t < 1$. More importantly, the interaction between stimulus type and test revealed an advantage of whole-image over part images with real faces (M's = .84 and .72), $t(23) = 11.95$, $p < .01$; however, such advantages failed to be significant for both houses (M's = .83 and .83), $t < 1$, and line-drawn faces (M's = .67 and .70), $t(23) = 1.37$, $p < .254$.

Response Latency

The mean response latency for correct responses in each condition was submitted to the same 3 × 2 repeated-measure ANOVA as for accuracy data. The main effects of stimulus type and test, as well as their interaction were significant, $F(2, 46) = 4.82$, $p < .05$, $\eta_p^2 = .173$, $F(1, 23) = 46.58$, $p < .001$, $\eta_p^2 = .669$, and $F(2, 46) = 13.163$, $p < .001$, $\eta_p^2 = .364$, respectively. As shown in Figure 3b, participants were fastest at making judgments about house images (M = 2.89 s), followed by those made about real faces (M = 3.15 s), and slowest with those made about line-drawn faces (M = 3.61 s). However, only the difference between house images and line-drawn images was significant, $t(23) = 2.67$, $p = .01$. Moreover, their judgments with part images (M = 2.60 s) in general were made faster than those made with whole images (M = 3.84 s), $t(23) = 3.25$, $p < .01$. More importantly, the two-way interaction revealed that while part-image advantage was evident for both house (M_w = 3.64 s, M_p = 2.15 s), t(23) = 7.48, and line-drawn face (M_w = 4.50 s, M_p = 2.72 s) images, $t(23) = 6.46$, p's $< .001$; it was not the case for the real-face (M_w = 3.39 s, M_p = 2.92 s) images, $t(23)$ =

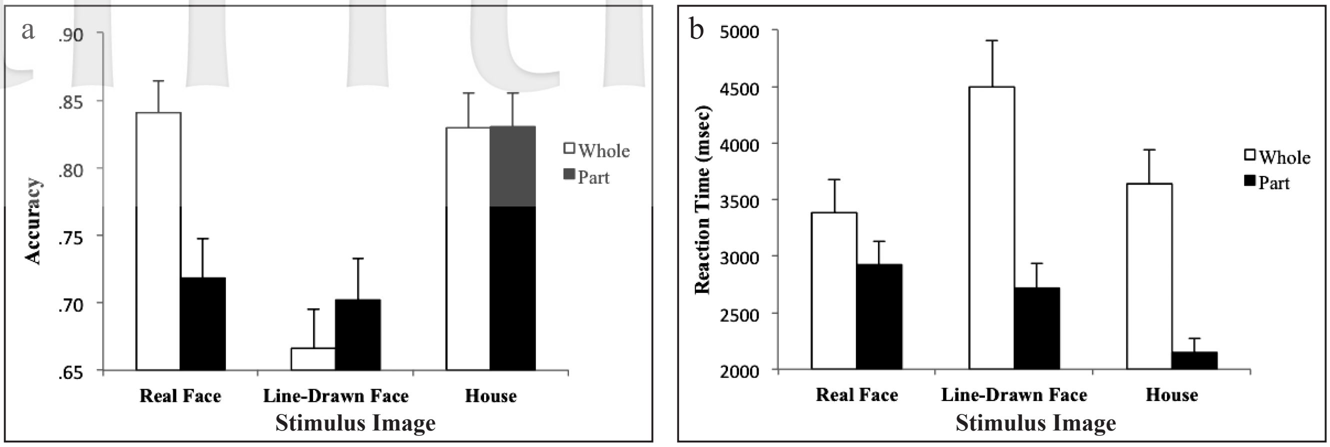

***Figure 3.* The results of Experiment 1.**

Source: This study.
Note. The results of mean accuracy (a) and mean reaction time (b) as a function of stimulus type and test type in Experiment 1 (N = 24).

1.92, $p > .05$. These findings suggest that both house images and images of line-drawn faces were processed in a more part-based manner such that the part images enjoyed faster processing because there were fewer parts in those images than in their whole-image counterparts. In contrast, real faces were processed more holistically such that the part-based advantage would not be evident with those images.

In summary, the results of both accuracy and latency measures in Experiment 1 clearly indicate that real faces were processed more holistically whereas line-drawn faces, like non-faces houses, were processed in a part-based or less holistic manner.

Experiment 2: Processing of Emotional Expression in Real and Line-Drawn Faces

The main goal of Experiment 2 was to compare further how real and line-drawn faces may be differentially processed in terms of emotional expression. Moreover, in order to better understand and compare the time course in processing emotional expressions conveyed by real versus line-drawn faces, we decided to record observers' eye movements while they were performing the matching task.

Method

Participants

Twenty-four undergraduate students (11 female, 13 male) from the National Chung Cheng University, with a mean age of 20.9 years (ranging from 18 to 24 years) participated in Experiment 2. All had normal or corrected-to-normal vision. Half of participants were randomly assigned to the FaceCue group, where the test display was always preceded by a face cue, real or line-drawn, and the other half were assigned to the LabelCue group, where the test display was always preceded by a verbal label depicting emotional expression. All participants gave their informed consent prior to the actual experiment.

Stimuli and Apparatus

Faces stimuli again were drawn from the Taiwanese face database created by Shyi et al. (2013). In addition to faces of neutral (NE) expression used in Experiment 1, we also included emotional faces depicting facial expressions of happiness (HA), sadness (SA), anger (AN) and surprise (SU), which, according to Shyi et al. (2013), were the most reliable facial expressions based on the entropy values of ratings from 160 raters. As in Experiment 1, we first selected 6 male and 6 female faces from the database, each with five facial expressions including the neutral one, to be the stimuli for real faces stimuli, and their line-drawn counterparts were created via outline tracing as done in Experiment 1. The image size of each face was about 421 × 320 pixels, extending a visual angle of approximately 19.6 × 15.0° at a viewing distance of about 45 cm, to simulate the size of faces encountered in daily life. The pair of test faces were presented 9.5 cm (approximately 12.05° of visual arc) away from the center of display, and the center-to-center distance between the two test face images was about 19 cm (approximately 23.84° of visual arc).

The stimulus presentation and response recording was under the control of a program written in Experiment Build (EB) 2.0 (SR Research, Canada). The eye-movement data were tracked and recorded by the Eyelink II system (SR Research, Canada), which had a sampling rate of 500 Hz, and a spatial resolution of 0.1°. Although Eyelink II could track both eyes, we only recorded the eye which showed better calibration result.

Design

Experiment 2 entailed a 2 (cue: face cue vs. label cue) × 2 (test face: real face vs. line-drawn face) × 5 (expression: HA, AN, SA, SU, NU) mixed design, with the first variable as a between-participants factor and the latter two as within-participant factors. A total of 60 trials were administered in each cue condition, where half of them were tested with real faces, and other half were tested with line-drawn faces. The 60 trials were evenly distributed across five types of facial expressions. Note in the FaceCue condition, as illustrated in Figure 4, the type of cue and the subsequently presented test faces were always of the same kind. For example, a real-face cue was followed by a pair of real faces for test, and likewise, a line-drawn face cue was followed by a pair of line-drawn faces. Whereas in the LabelCue condition, a verbal label of emotion was followed by a pair of real faces for test in half of the trials, and by a pair of line-drawn faces for test in the other half.

Procedure

In order to properly track and record their eye movements during the experiment, each participant was asked to undertake a 9-point calibration and validation so that the errors of tracking were well within acceptable criteria. Once passed, the actual experiment ensued.

In each trial for the FaceCue condition, a single face image was first presented for 1500 ms, followed by a

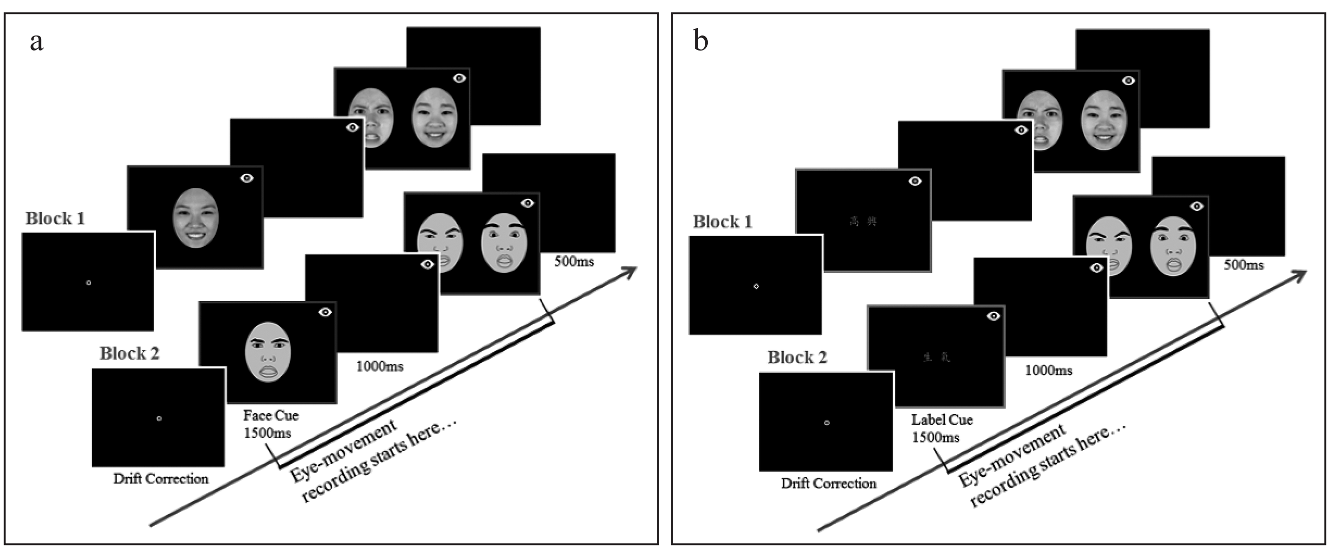

***Figure 4.* The procedure used in Experiment 2.**

Source: This study.

Note. Half of the participants were assigned to FaceCue condition (a) and the other half to the LabelCue condition (b). Each cue condition included a trial block of real faces and a trial block of line-drawn faces. Eye movements were recorded upon the onset of cue and lasted until participants made their judgments.

blank screen for 1000 ms. After that, a pair of face images was presented and participants had to decide which face, right or left, contained a facial expression matching that of the previously presented face cue. Only one of the test images matched the expression of the face cue. The facial expressions were randomly paired across participants. Note that the displayed face images were drawn from different individuals, and hence, participants could not make their judgments based on face identity. Trials using different kind of face cue, real or line-drawn, and their corresponding test face images were run in two separate blocks of 30 trials each for a total of 60 trials, and the order of testing was counterbalanced across participants.

Trials in the LabelCue condition were tested using a similar design and procedure, except that the face cue was replaced by a verbal label of emotion. The label cue was followed by a pair of images comprising either real faces or line-drawn faces, and participants had to decide which face image matched the emotional meaning of the label cue.

Participants made their judgments by pressing "Z" on a regular keyboard if they thought the left image matched the cue (face or label) in terms of emotional expression, or pressing "M" if they thought the image on the right matched. Participants were reminded that they should make their judgments in terms of matched facial expressions and not in terms of face identity because none of face images, cue or test, were identical. Eye-movement data were recorded from the onset of the cue until participants made their judgments (see Figure 4). In addition, both response accuracy and latency were recorded for data analysis. Participants were reminded to be as accurate as possible because pilot study showed clear sign of speed-accuracy tradeoff if participants were to make their judgments within less than a second after the onset of test display.

Results and Discussion

Response accuracy

The mean response accuracy in each condition was submitted to a 2 (cue) × 2 (test face) × 5 (expression) mixed-measured ANOVA. The main effects of all three variables were significant, $F(1, 22) = 64.24$, $p < .001$, $\eta_p^2 = .74$ for cue, $F(1, 22) = 6.19$, $p = .02$, $\eta_p^2 = .22$ for test face, and $F(4, 88) = 6.08$, $p < .001$, $\eta_p^2 = .22$ for expression, respectively. However, none of two-way interactions nor the three-way interaction was significant, F's < 1 or p's > .1. As shown in Figure 5a, participants were better at matching facial expressions to emotions depicted by

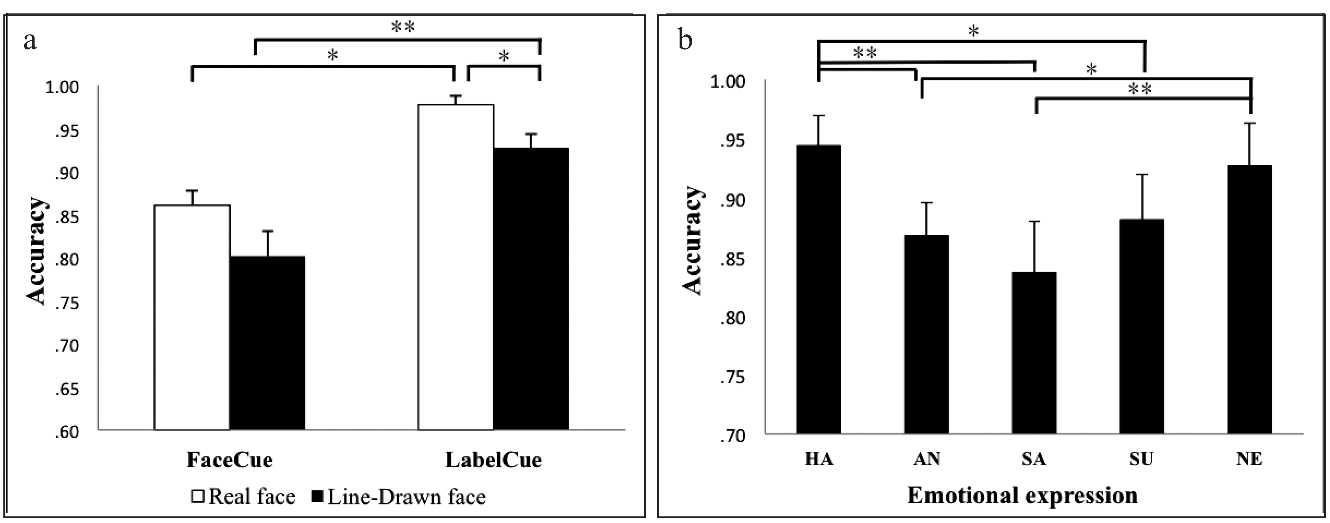

***Figure 5.* The results of mean accuracy in Experiment 2.**

Source: This study.

Note. The results of mean accuracy in Experiment 2 as a function of cue and test face (a) and displayed expression in a given trial (HA happy, AN = angry, SA = sad, SU = surprised, and NE = neutral) (b) (see text for details); $^{*}p < .05$, $^{**}p < .01$.

verbal label (i.e., LabelCue condition) (M = .95) than by faces (i.e., FaceCue condition) (M = .83). Moreover, participants were better at judging facial expressions displayed by real faces (M = .92) than those worn by line-drawn faces (M = .86), suggesting that again the image richness possessed by real faces allows better facial expression judgments than line-drawn faces do. Finally, as shown in Figure 5b, participants were equally good at judging happy (HA) (M = .94) and neutral (NE) (M = .93) faces (p > .5), which both were judged better than surprised (SU) (M = .88) and angry (AN) (M = .87) faces, and participants were worse at judging sad (SA) faces (M = .84) (p's < .01 for AN and SA, and p < .05 for SU).

Response Latency

Only response latency data of the correct trials were included for analysis. The mean response latency in each condition was submitted to the same 3-way mixed-measured ANOVA as for response accuracy. As for response accuracy, the main effect of all three variables were significant, $F(1, 22) = 5.14$, $p < .05$, $\eta_p^2 = .189$ for cue, $F(1, 22) = 18.46$, $p < .001$, $\eta_p^2 = .456$ for test face, and $F(4, 19) = 6.99$, $p < .01$, $\eta_p^2 = .595$ for expression, respectively. The 2-way interaction between cue and test face was also significant, $F(1, 22) = 4.79$, $p < .05$, $\eta_p^2 = .179$. As shown in Figure 6, participants made their judgments much faster in trials with face cues (M = 1.58 s) than in those with label cues (M = 2.05 s). Furthermore, their judgments were made faster when choosing between real faces (M = 1.63 s) as opposed to choosing between line-drawn faces (M = 2.00 s). However these observations should be qualified with the interaction which indicates that the difference between real and line-drawn faces was significant only in trials when test faces followed a verbal label cue, $t(11) = 3.99$, $p < .01$, and not in those where test faces followed a face cue, $t(11) = 1.73$, $p = .11$.

Inverse efficiency score

The fact that, compared to the FaceCue condition, longer response latency coupled with higher response accuracy in the LabelCue condition implicates the possibility of speed-accuracy tradeoff. Therefore, we computed the inverse efficiency score (IES) (Townsend & Ashby, 1983), which has the advantage of taking into account accuracy while comparing latency data, in order to minimize the chance of biased interpretation of response latency. Specifically, IES was calculated as

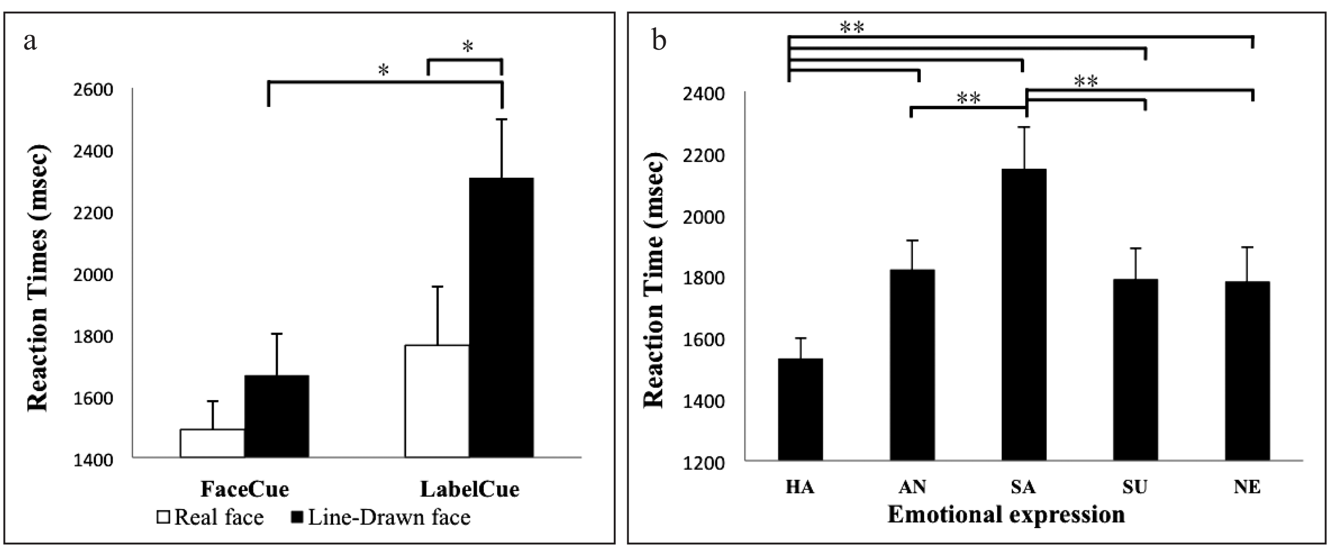

Figure 6. **The results of mean RT in condition.**

Source: This study.

Note. The results of mean RT in each condition as a function of cue and test face (a) and displayed expression in a given trial (HA happy, AN = angry, SA = sad, SU = surprised, and NE = neutral) (b) (see text for details); $^{*}p$ < .05, $^{**}p$ < .01.

the ratio between response latency (in sec) and response accuracy (in proportion) (i.e., IES = *RT/ACC*); the smaller IES is, the greater response efficiency it implies, and vice versa.

The IES in each condition was submitted to the same repeated-measured ANOVA. The results showed only the main effect of face type was significant, $F(1, 22) = 34.55$, $p < .001$, $\eta_p^2 = .61$. Neither the main effect of cue nor its interaction with test face reached significance, $F(1, 22) = 1.04$, $p > .1$, $\eta_p^2 = .05$, and $F(1, 22) = 3.22$, $p = .09$, $\eta_p^2 = .13$, respectively. As shown in Figure 7, participants' exhibited smaller IES with real faces ($M = 1.77$) than with line-drawn faces ($M = 2.3$), suggesting that, after excluding the influence of response accuracy, participants consistently showed greater efficient performance with real faces than with line-drawn faces, regardless of type of cue.

Eye-movement analyses

In order to analyze the eye movement data, we first defined two areas of interest (AOIs) from each face, namely the eyes area and the mouth area, which have been suggested to play important roles in expressing

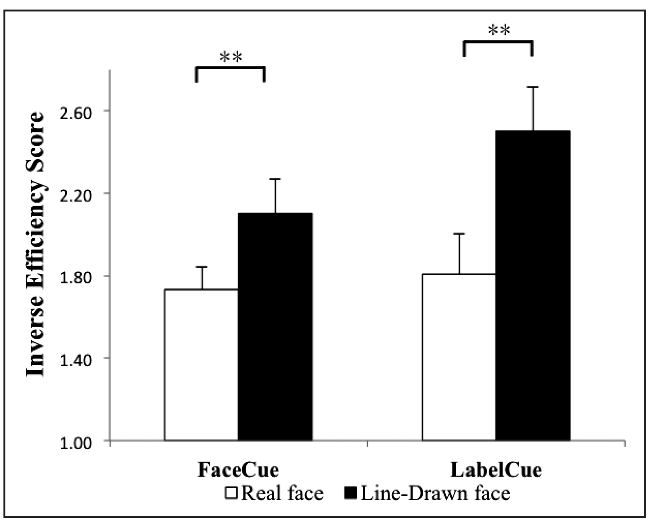

***Figure 7*. The results of inverse efficiency score in Experiment 2.**

Source: This study.

Note. The results of inverse efficiency score as a function of cue and test face in Experiment 2. $^{*}p < .05$, $^{**}p < .01$.

facial emotions (Calvo et al., 2013; Tanaka et al., 2012). As illustrated in Figure 8, we overlaid all face images on top of one another to find the largest area that could encompass the range of variation due to emotional expressions across all images, and this was done for both real faces and line-drawn faces. The area template for the eyes area was about 63,000 (6.3×10^4) pixels in size and was about 44,000 (4.4×10^4) pixels for the mouth area. Altogether, 4,002 fixation points were recorded from trials in the FaceCue condition across all participants in that condition, and 81.46% of them were located in the two AOIs. Analogously, 5,359 fixation points were collected from trials in the LabelCue condition across all participants, and 77.57% of them were located in the two AOIs. We consider the recorded fixations falling within the two AOIs were representative showing participants' eye movements in judging facial expressions.

We then computed the area normalized scores (ANS) for the mean number of eye fixation in each AOI to get rid of the bias due to difference in their physical sizes (Bindermann, Scheepers, & Burton, 2009). Note ANS of 1.0 is a signature of random distribution of eye fixations among AOIs, whereas ANS significantly different from 1.0 (greater or less) indicates systematic departure or bias from random distribution.

ANS for each condition was submitted to 2 (test face: real vs. line-drawn faces) × 2 (cue: face cue vs. label cue) × 2 (AOI: eyes vs. mouth) × 5 (expression: HA, AN, SA, SU, NE) mixed-measured ANOVA, with the cue as between-participants variable and the rest as within-participants variables. Only the main effect of expression and its interaction with AOI were significant, $F(4, 19) = 5.14$, $p < .01$, $\eta_p^2 = .577$, and $F(4, 19) = 8.10$, $p = .001$, $\eta_p^2 = .63$, respectively. None of other main effects nor interactions were found significant, F's < 1 or p's > .1. As illustrated in Figure 9, the eyes area and mouth area played about equal roles for the expression of happiness ("HA") in that the ANS for eyes area (1.02) was almost identical to that for the mouth area (1.00), and both were very close to 1.0. In contrast, the eyes area played a much larger role than the mouth area for the expression of other emotions (i.e., anger, sadness, surprise, and neural expression), in that ANS for the eyes

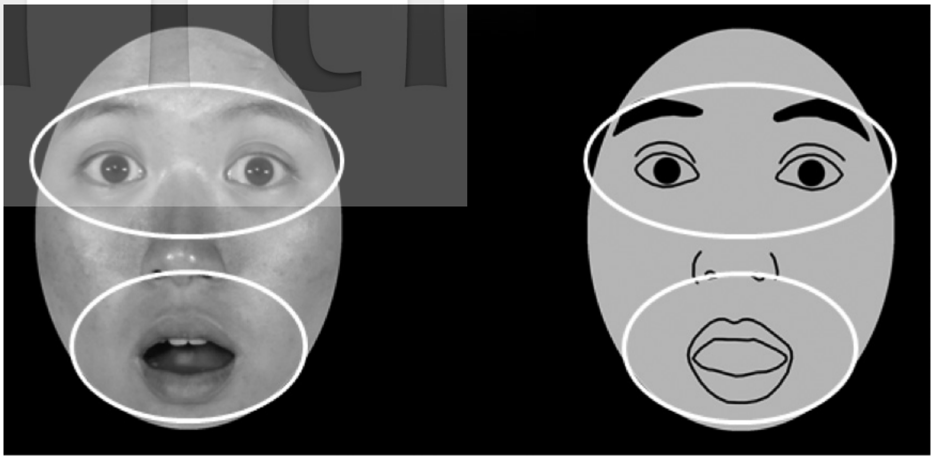

***Figure 8.* Areas of interest (AOIs) used in Experiment 2.**

Source: This study.

Note. Areas of interest (AOIs) used in Experiment 2, which were operationally defined by overlapping all the face images on top of one another to find the largest area that can cover the range of variation due to facial expressions. They were defined in the same manner for both real faces (left) and line-drawn faces (right).

area were consistently greater than 1.0 and those for the mouth area were consistently less than 1.0. These findings were quite consistent with those reported by Blaise, Jack, Scheepers, Fiset, and Caldara (2008), where they showed that, compared Westerners, East Asians relied more upon the eyes area for judging facial expressions.

In summary, in Experiment 2, unlike Experiment 1, we found more similarity than difference between real and line-drawn faces insofar as facial expressions are concerned. For instance, matching facial expressions of real faces were faster than matching those of line-drawn faces, but that was true only with label cues, and no difference in matching emotional expression was found between real and line-drawn faces with face

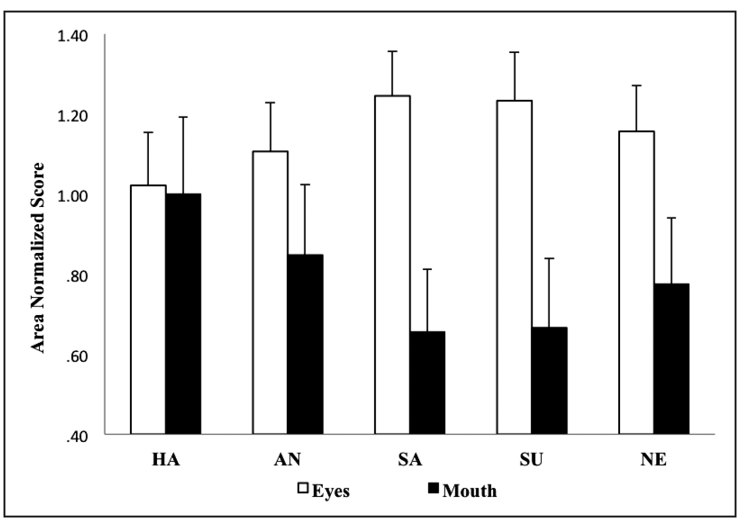

***Figure 9.* The results of area normalized score (ANS) in Experiment 2.**

Source: This study.

Note. The results of area normalized score (ANS) as a function of AOI and displayed expression in Experiment 2 (HA happy, AN = angry, SA = sad, SU = surprised, and NE = neutral) (see text for details; $^{*}p < .05$, $^{**}p < .01$.

cues (Figure 6a). Analogously, participants were more accurate matching the label cue with expression of real faces than with expression of line-drawn faces (Figure 5a), suggesting no speed-accuracy tradeoff in those conditions. Moreover, there was no significant difference in matching accuracy between real and line-drawn faces with face cues. The similarity in eye movement results also indicates essentially no difference in processing emotional expressions between real and line-drawn faces.

General Discussion

The main goal of the present study was to examine if and how real faces may be processed differently from line-drawn faces both in terms of identity processing and in terms of emotional expression processing. In Experiment 1, we employed the widely used part-whole task and found evidence suggesting that while real faces were processed more holistically, line-drawn faces were processed in a more part-based manner akin to the processing of non-face objects (i.e., houses). In Experiment 2, we used a variant of delayed match-to-sample task where participants were to choose one of the two facial expression alternatives that matched the expression of the preceding face cue. We found evidence suggesting that real and line-drawn faces shared a greater similarity insofar as processing of facial expression is concerned.

Processing Identity and Processing Expression

The disparate findings between Experiments 1 and 2 raise the interesting question as to the origin of differences between identity and expression processing. One possible reason to resolve the difference is that the part-whole task entails processing face identity, which may rely upon holistic processing of the face as a whole, whereas processing facial expressions can be achieved with information less than the entire face. Results reported in recent studies by Calvo et al. (2013) and Tanaka et al. (2012) suggest that at least some of the more distinct facial expressions such as happiness and anger may unevenly rely upon information from the mouth region (for expression of happiness) and from the corrugation of facial muscles around the eyes region (for expression of anger). If so, the part-based nature of expression processing may account for the similarity (or reduced difference) between real and line-drawn faces. Moreover, as pointed out by Beaudry, Roy-Charland, Perron, Cormier, and Tapp (2014), only fearful expression meets the criterion of holistic processing where both the top and bottom parts of a face were necessary but neither alone was sufficient for conveying the expression of being afraid.

In the present study, we found that happy expressions were matched with the highest accuracy (Figure 5b) and shortest response latency (Figure 6b), demonstrating the advantage of processing happy faces (Calvo & Nummenmaa, 2009; Calvo et al., 2013). On the other hand, while showing no differences in processing emotional expressions conveyed by real versus line-drawn faces, results from eye movements, in terms of ANS, did indicate differences in processing facial expressions used in Experiment 2, where eye movements for happy expression exhibited a pattern distinctly different from those for other expressions. As can be seen in Figure 8, participants tended to fixate the eye and mouth regions with equal proportion for happy expression. In contrast, for the other expressions, including the neutral ones, they tended to fixate more on the eye region than on the mouth region for their matching judgments. These findings suggest that, at least for the expressions used in Experiment 2, with the exception of happy faces, the eye region apparently was more informative than the mouth region for judging facial expression (Beaudry et al., 2014; Blais et al., 2008; Shyi & Yeh, 2011; Tanaka et al., 2012).

Differential Processing Between the FaceCue and LabelCue Conditions

It should be noted that, in Experiment 2, participants were more accurate judging faces under the LabelCue condition than under the FaceCue condition (Figure 5a). The better performance from the LabelCue condition may have to do with the fact that participants can compare emotionality of displayed faces more directly after the processing of a given face image has yielded a semantic label of that image. In contrast, in the FaceCue condition, an image-to-label conversion may have to take place before matching expressions of the face in the cue and those in the test display. The additional conversion that occurs in the FaceCue condition may lead to greater errors if either the process of label generation and/or the working memory for maintaining the generated label is at fault.

This explanation begs the important theoretical question of how exactly facial expressions are processed and in particular whether a semantic and/or conceptual representation would be at the final stage of such processing. The need for such a representation abstracted from sensory-perceptual representation may be particularly acute because the visual system must go beyond the identity representation so that the dynamic variation in expressions from different faces can yield reliable and distinguishable patterns of facial expression, and a semantic or conceptual label may provide a shortcut to achieve that goal.

On the other hand, was the superior performance with label cues a manifestation of speed-accuracy tradeoff because participants in that condition also exhibited longer time to make their judgments? We think not, because when we calculated the inverse efficiency scores (IES) incorporating both accuracy and latency results of each condition, we found that real faces were consistently processed more efficiently than the line-drawn faces (i.e., $IES_{real} < IES_{line\text{-}drawn}$) (see Figure 7). Moreover, there was no evidence that trials in the LabelCue condition were performed with a greater efficiency than those in the FaceCue condition (i.e., $IES_{LabelCue} = IES_{FaceCue}$).

A final alternative is that the lower accuracy of the FaceCue condition may have arisen from the fact of automatic processing of identity upon the presence of face cue. That is, participants in the FaceCue condition may have to suppress the automatic processing of identity in order to focus on processing expression to meet the task demand. The additional act of suppressing identity processing may lead to poorer performance when compared to the LabelCue condition where processing of face identity presumably is absent. This explanation, however, requires a better understanding of the larger issue of how identity processing and expression processing may interact (and/or interfere) with each other (Bruce & Young, 1986; for a recent review, see Yankouskaya, Humphreys, & Rotshtein, 2014).

It should be noted that in the current study we do not have the pertinent data or results to further evaluate the empirical adequacy of the alternatives discussed above, which clearly awaits further investigation.

A Continuum of Emotional Expressiveness

It is worth noting that while there were no clear differences between matching real faces versus line-drawn faces in terms of eye movements, the results of inverse efficiency scores (IES) for both the FaceCue and LabelCue conditions indicate that real faces were matched with higher efficiency than line-drawn faces were (see Figure 7). The relative deficiency in processing line-drawn faces may arise from the fact that we created them by tracing and outlining the facial features existed in their real-face counterparts. Created that way, the line-drawn faces lose the surface information (e.g., texture and pigmentation, etc.) that was present in the real faces, which in turn may have weakened the expression signal carried by the original real faces (McKone & Yovel, 2009; Vuong, et al., 2005).

It is also interesting to consider how line drawings used in our study may differ from emoticons that are created and used abundantly over the internet. Compared to line-drawn faces, emoticons depict facial expression much more symbolically in that arbitrary text symbols are deployed in places to represent different facial components (eyes, nose, and mouth) with minimal visual similarity. As such, emoticons are effective in emulating facial expressions to the extent that those symbols are placed in locations representing corresponding face components. Functionally speaking, this scheme is analogous to using smaller element (e.g., small *H*'s) to create a compound global character (e.g., *E*), where the structure is generated strictly based on spatial arrangement of components with little regard to their visual properties (Pomerantz, 1983).

Therefore, it is perhaps possible to conceive emotional expressiveness as a continuum where real faces would occupy the end of full or robust expressiveness, emoticon may occupy the other end of being most abstract in terms of emotional expressiveness, and line-drawn faces we used in our study would locate somewhere in between (see Figure 10). In fact, in their recent study, Yuasa, Saito, and Mukawa (2011) reported that emoticons failed to activate fusiform face area (FFA) (Kanwisher, McDermott, & Chun, 1997), while activating areas broadly related to processing emotion (e.g., inferior frontal gyrus, or IFG, in the right hemisphere). Their finding clearly suggests that emoticons were able to convey emotional expressions with minimal resemblance to real faces (for a recent review of brain-imaging study on emoticons, see Aldunate & González-Ibáñez, 2016).

The inadequacy of line-drawn faces in general and the reduction of expression signal of those faces in particular may explain why it has become a common practice to exaggerate portrayed expression in line-drawn faces used in social media: To overcome the inherently vague signals. For example, it is oftentimes the case in contemporary comic books and animated cartoons, where line drawings are predominantly used, to see enlarged facial features (eyes or mouth) in order to make the intended expression more distinct, and how much enlargement is required to effectively compensate the weakened expression signal would be an interesting issue for future investigation.

Limitations and Future Work

One limitation of the present study is the extent to which our conclusion that line-drawn faces are processed in a part-based manner may be limited to the part-whole task used in Experiment 1. For example, the composite task also has been considered as one of, if not the most, valid tools for measuring holistic processing (Gauthier & Bukach, 2007; Ross, Richler, & Gauthier, 2015; Rossion, 2013), and it would be interesting to see whether or not line-drawn faces would yield different results than their real-face counterparts, when both are tested with the composite task. Based on our findings from the part-whole task (Experiment 1), we are inclined to predict the evidence for holistic processing would be weaker for the line-drawn faces in comparison to their real-face counterparts. Of course, whether or not this prediction would pan out will await further investigation.

Another limitation is that we only tested the portrayed line-drawn faces, and our findings may not be able to generalize to other kinds of emoticons that are widely used in the various social media. It would be interesting to investigate in the future how various other kinds of emoticons may be processed to gain fuller understanding. Moreover, from a more theoretical perspective, it would also be interesting to further examine the image-to-label conversion hypothesis and the suppression of identity processing hypothesis to better understand how exactly facial expressions are processed.

Finally, we would like to note that we were able to identify in post-hoc manner individuals with biases in their eye-movement pattern. Out of the 24 participants tested in Experiment 2, there were 16 eye-scanners and 7 mouth-scanners, and one failed to show consistent bias. However, their presence was not manipulated systematically to see whether there would be consistent

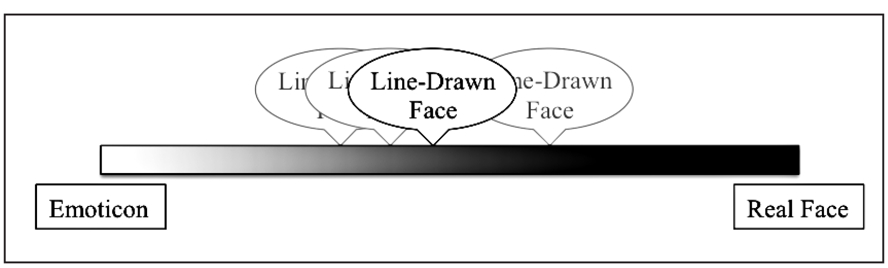

***Figure 10.* The (putative) continuum for emotional expressiveness.**

Source: This study.
Note. The (putative) continuum for emotional expressiveness.

individual differences in processing and matching facial expressions. For future work, it would be interesting to identify beforehand participants' biases in scanning strategy and see whether and how that would lead to difference in processing face identity, facial expression, or both.

Conclusion

Our findings indicate that the identity of line-drawn faces is processed less holistically than real faces and perhaps in a part-based manner similar to how non-face objects are processed. On the other hand, although there were resemblances in expression processing between line-drawn faces and real faces in terms of the pattern of eye-movement performances and the effect of semantic labels, the line-drawn faces were processed consistently less efficiently than the real faces were. This difference might explain the common practice of exaggeration used in line-drawn faces for purpose of overcoming the inherently vague signals of emotional expression.

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辨識真實臉孔與圖形化臉孔情緒表達之差異性探討

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拜科技之賜，人們的社交活動早已不限於面對面的交流，而吾人經常使用的各類通訊軟體皆包含豐富的表情圖案，為冰冷文字添上生動的情緒。在過去，人們的社交活動大多藉由實際的接觸來辨別彼此的情緒狀態，因此以往的研究亦多著重於辨識真實臉孔的情緒表達。本研究利用兩個實驗探討吾人辨識真實臉孔與圖形化臉孔在情緒表達歷程上可能存在的差異。實驗一比較真實臉孔、圖形化臉孔及物體在整體辨識及部件辨識上正確率的差異，發現圖形化臉孔的辨識已脫離辨識真實臉孔的範疇，而與物體辨識較為相近。實驗二則藉由眼動儀的紀錄，檢驗臉孔部件在真實臉孔與圖形化臉孔情緒表達上權重的差異性，並進一步探討語意訊息是否會改變吾人對不同臉孔部件在情緒表達上的權重結果顯示雖然真實臉孔與圖形化臉孔在辨識歷程上有所差異，情緒辨識上圖形化臉孔的正確率較低、反應時間較長，但在眼動儀的資料當中卻發現兩者擁有相似的情緒辨識歷程。再者，提供語意線索並無法提高圖形化臉孔的情緒辨識正確率。以上結果部分解釋了何以現行通訊軟體中的表情圖案需要放大表情特徵以可服圖形化臉孔所造成的訊息減損。

關鍵詞：情緒、眼動、臉孔表情、臉孔辨識、圖形化臉孔