

Emotion Cues: Effects of Facial Expressions and Eyebrows on Experiencing Emotions

Hui Hsin Wang*
Deh Yu College of Nursing and Health

Abstract

Observing and interpreting emotions or behavioral tendencies through facial expressions is essential for interpersonal communication. Facial features are important factors in constructing facial expressions, and information regarding emotions can be gathered from the position of a person's eyebrows and mouth. We devised three experiments to observe and understand the influence of facial expressions (mouth shapes) and eyebrow movements on experiencing emotions. Specifically, we studied these elements through the stimulation of different eyebrow conditions with natural faces, faces with non-Duchenne smiles, and faces with Duchenne smiles. The results confirmed that the eyebrows and mouth are important aspects in the formation of facial expressions. They both influence experiencing emotions to different degrees and allow different emotional interpretations, especially in the presence of prominent facial features or when visual attention is focused on specific parts. The conclusions of this study contribute to the understanding of facial cues and the relationship between the eyes and the mouth in the interpretation of emotions. This study also provides a reference for enhancing specific impression needs when applying makeup or eyebrows.

Keywords: facial expressions, emotions, interpretation, mouth, eyebrow

*Corresponding Author

Introduction

Facial expressions contain hidden nonverbal information such as external conditions (physical and environmental) and internal psychological conditions, that are often used to predict and infer the behavior of others in interpersonal communication (Knutson, 1996; Laurentini & Bottino, 2014; Webster & Maclin, 1999). Dynamic facial expressions originate from the brain's reflex action after receiving information, which further trigger responses of emotions, cognition, perception, and movement. The key to visual cognition relates to the brain's visual distinction of time, manner, and information (Chyns et al., 2007; Sato et al., 2017; Van der Gaag et al., 2007). When the visual center of the brain is stimulated, physiological reactions will affect psychological reactions, resulting in happy or unhappy emotions (Lombardi, 1973). Emotions and intentions to communicate with others can be conveyed through expressions (Kujala et al., 2017; Schilbach et al., 2008).

Eyebrows and eyes are unique facial recognition markers and play an important role in facial expressions and aesthetics (Kunjur et al., 2006; Sadr, 2003; Yalçinkaya et al., 2016). They are factors that help recognize emotions and convey physical conditions (Chi, 2016; Roth & Metzinger, 2003). Eyebrow type is a stable feature and the emotional clues of facial expressions can be analyzed through their positioning. The shape of the eyebrows is a stable recognition feature. An automatic detection of a face can interpret the emotional clues of facial expressions through eyebrow positioning (Florea & Boia, 2011). Eyebrows are raised when individuals feel happy (Massaro, 2000), sad (Pitcairn et al., 1990), surprised, or frightened (Hsieh et al., 2015), and are lowered and frowned when angry or disgusted (Sun & Akansu, 2014). Therefore, it appears that inner emotional states can be predicted through eyebrow movements. In addition, eyebrows are also an important key to external recognition. Sadr (2003) noticed that lacking eyebrows is a major obstacle in the recognition of emotion, even in familiar faces.

For facial emotion recognition, besides eyebrow position, the shape of the mouth is also a channel for emotion recognition. A horizontal mouth conveys a neutral state without particular meaning (Mckelviet, 1973), while a mouth with drooping corners shows sadness (Preuschoft, 2000). By modifying the shape of the mouth in Leonardo da Vinci's "Mona Lisa" portrait, Kontsevich and Tyler (2004) showed that the mouth is flat in sad faces, while in happy faces, the corners of the mouth bend upward. Different degrees of emotional information can be interpreted through mouth movements. A smile is an observable signal during interactions and it is known to enhance beauty (Sarver & Ackerman, 2003; Scharlemann et al., 2001). An attractive smile can improve appearance and self-esteem (Moskowitz & Nayyar, 1995).

In order to express a smile, the face must shrink the muscles near the mouth to stimulate the big muscles. However, to express other emotional expressions, two to four muscles must contract (Ekman & Friesen, 2003). Surakka and Hietanen (1998) indicated that Duchenne

smiles express emotion and non-Duchenne smiles are without emotion. Duchenne smiles have a social signal value and are related to a pleasant experience. When a smile utilizes the eyeball muscles, the viewer will see the lines around the eyes. Its dynamic characteristics are speed, amplitude, time of maintenance, and symmetry of the mouth, which are slower and smaller than intentional smiles ((EKMAN, 1976)Ekman et al., 1990; Mehu et al., 2007;(Schmidt, 2006). When non-Duchenne smiles show social friendship signals, the muscles move more as the eyebrows are raised and the duration is shorter. The eyebrows also rise faster than with Duchenne smiles (Schmidt et al., 2009). The above studies have shown that the sincerity of a smile or its emotion is defined by the physiological response of the face (contraction of facial muscles, mouth shape, speed of mouth reactions, persistence, and raised eyebrows). The authenticity of a smile may be interpreted by the positioning of the eyebrows (Forgas & East, 2008). Current research indicates that eyebrow direction, high and low, influences the perception of expressions (Kontsevich & Tyler, 2004; Massaro, 2000; Pitcairn et al., 1990; Preuschoft, 2000; Sun & Akansu, 2014). However, the shape of the mouth offers different interpretations in defining emotion (Kontsevich & Tyler, 2004; Mckelviet, 1973). Previous research on facial recognition focused on the interpretation of emotions through a single element. On the other hand, studies have not tackled the relationship between eyebrows and mouth in deciphering and understanding emotions. Therefore, this study assumes three facial expressions, including natural, non-Duchenne smiles, and Duchenne smiles, with four eyebrow types to identify if six emotional impressions are positively correlated.

Methods

Experiment Design

The subjects involved in this study were students of cosmetics who had received cosmetic training in the beauty department. One of the limitations of this sample was the great disparity in the male to female ratio that appeared at the time of sampling, because fewer males were enrolled in the cosmetics program. Nonetheless, this study selected those who have been trained in makeup courses as participants. However, another limitation of this sample is that the participants, who have cosmetic experience, might have opinions different from those with no cosmetic experience. These restrictions can guide future research.

A total of 12 photos (Figures 1–3) were used in the three experiments. The facial features, face shapes, and hairstyles in these photos were all the same, and their partial or total deviations were approximately the same. Experiment 1 studied the photographs of facial expression with four types of eyebrows at different angles and positions on natural faces. Experiment 2 evaluated these elements on faces with non-Duchenne smiles while experiment 3 investigated these factors on faces with Duchenne smiles. In all three experiments, the direction and positioning of the eyebrows was systematically manipulated to show horizontal eyebrows that

were raised, drooped, high, and low to the eyes, respectively. The photographs were used as stimulation tasks for subjects to identify happy, sad, angry, pleasantly surprised, frightened, and surprised expressions. In all three experiments, participants were asked to observe the facial



expressions to identify facial emotions.

Figure 1. Raised, drooping, low, and high eyebrows respectively from left to right on natural faces (Experiment 1).

Figure 2. Raised, drooping, low, and high eyebrows respectively from left to right on faces with non-Duchenne smiles (Experiment 2).

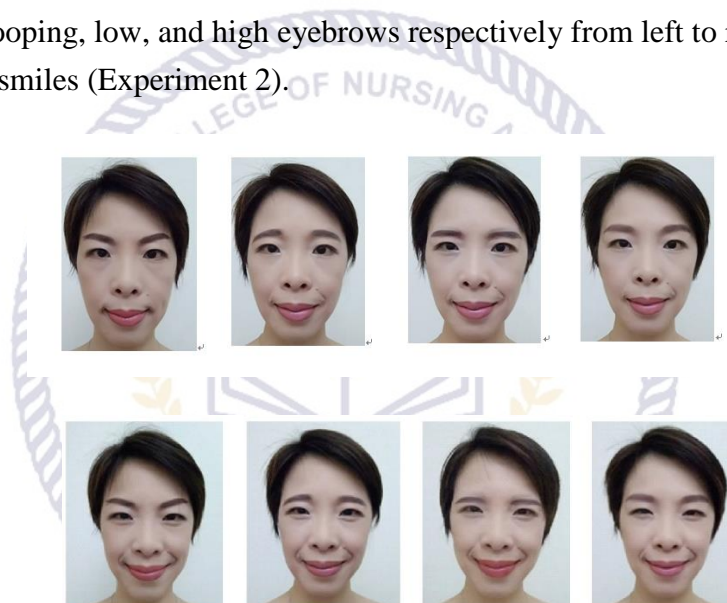


Figure 3. Raised, drooping, low, and having eyebrows respectively from left to right on faces with Duchenne smiles (Experiment 3).

Participants

The participants consisted of 31 cosmetics undergraduates and continuing education students, among which 7 were men (23%) and 24 were women (77%). They were aged 20 to 47 years, with a mean age of 23.2 years, and all had normal eyesight naturally or after vision correction.

Stimuli and Apparatus

The stimuli were the images of a Taiwanese woman with an oval face. After covering the eyebrows with eyebrow wax, four types of horizontal eyebrows—raised, drooping, high, and low—were drawn, and 12 photos were taken (Figures 1–3) with natural expressionless faces, faces with non-Duchenne smiles, and faces with Duchenne smiles. The stimulations were

performed on a computer with a 24-inch LCD display panel (View Sonic LCD). The observation height of the observers was in line with the computer screen. We tried to keep the observation distance constant at about 70 cm. All stimuli came from a single original face image, and the size of the stimuli photos was 660 pixels wide and 900 pixels high. The size of the face was about 480 pixels wide at the zygomatic level and 810 pixels high from the top of the head to the bottom of the chin.

Procedure

The details of the experiment were provided to the participants; the tasks of the experiment were conducted after each participant had signed the informed consent form. The background of the images was grayish white. After a stimulation of about 500 milliseconds, the screen turned blank. The task was to observe the facial emotions when the three faces were matched with four different types of eyebrows, i.e., raised, drooping, high, and, low. The emotion items included: happiness, sadness, disgust, surprise, anger, and fear. We instructed the participants to observe not only specific stimulating points (eyebrows and mouth), but also the whole face. The blank screen was present for at least 100 milliseconds or until the participants responded. After the responses, the screen displayed the next type of eyebrows, for a total of 12 photos. Responses were scored on a 5-point Likert scale with 5, 4, 3, 2, and 1 representing strongly agree, agree, neutral, disagree, and strongly disagree, respectively. A one-way repeated measure ANOVA was used for analysis.

Results

Results of experiment 1 (Table 1 and Figure 4) can be described as follows. F for anger = 40.23, $p < .001$, indicated a significant difference in identifying anger as an emotion after comparing the four types of eyebrows. A further post-hoc comparison was carried out for raised eyebrows ($M = 4.30$), drooping eyebrows ($M = 1.57$), low eyebrows ($M = 3.50$), and high eyebrows ($M = 2.37$), that demonstrated that raised eyebrows create a significant impression of anger compared to the other three types of eyebrows. F value for happiness was 2.14, $p > .05$, which was not significant. F for sadness = 11.65, $p < .001$, indicated a significant difference in identifying sadness as an emotion after comparing the four types of eyebrows.

Table 1. Statistics of natural faces without expression, faces with non-Duchenne smiles, and faces with Duchenne smiles.

Expression/ eyebrows	Emotional impression					
	Anger	Happiness	Sadness	Disgust	Fear	Surprise
Natural faces without expression						
1. Raised eyebrows	4.30 ± 0.84	1.77 ± 0.86	2.03 ± 1.10	3.60 ± 1.13	2.53 ± 1.31	2.77 ± 1.41
2. Drooping eyebrows	1.57 ± 0.82	1.73 ± 0.69	3.80 ± 1.30	2.70 ± 1.32	3.27 ± 1.28	2.50 ± 1.38
3. Low eyebrows	3.50 ± 1.36	1.73 ± 0.83	2.97 ± 1.35	3.57 ± 1.22	2.47 ± 1.28	2.47 ± 1.33
4. High eyebrows	2.37 ± 1.07	2.00 ± 0.83	3.10 ± 1.27	2.57 ± 1.19	2.67 ± 1.24	2.43 ± 1.28
<i>F</i>	40.23***	2.14	11.65***	6.56***	4.55**	0.56
<i>P</i>	<.001	.102	<.001	<.001	.005	.644
Post hoc	1>3>4>2		2>3, 4>1	1, 3>2, 4	2>1, 3, 4	
Faces with non-Duchenne smiles						
1. Raised eyebrows	2.60 ± 1.25	2.63 ± 1.10	2.07 ± 1.11	2.87 ± 1.33	2.37 ± 1.22	2.23 ± 1.19
2. Drooping eyebrows	1.87 ± 1.07	2.67 ± 1.12	3.43 ± 1.28	2.43 ± 1.30	2.90 ± 1.27	2.53 ± 1.22
3. Low eyebrows	1.73 ± 0.83	3.10 ± 1.09	2.37 ± 1.22	2.50 ± 1.17	2.13 ± 1.07	1.97 ± 0.93
4. High eyebrows	1.73 ± 0.87	3.63 ± 1.10	2.33 ± 1.24	2.40 ± 1.13	2.13 ± 1.04	2.20 ± 1.19
<i>F</i>	7.17***	7.46***	9.41***	1.43	5.40**	2.33
<i>P</i>	<.001	<.001	<.001	.239	.002	.080
Post hoc	1>2, 3, 4	4>1, 2, 3; 3>2	2>1, 3, 4		2>1, 3, 4	
Faces with Duchenne smiles						
1. Raised eyebrows	1.90 ± 1.18	4.07 ± 0.98	1.73 ± 0.91	2.10 ± 1.21	1.73 ± 0.94	2.17 ± 1.32
2. Drooping eyebrows	1.73 ± 0.98	3.20 ± 1.45	2.67 ± 1.27	2.17 ± 1.05	2.30 ± 1.24	2.37 ± 1.27

3. Low eyebrows	2.07 ± 1.08	3.50 ± 1.11	2.57 ± 1.41	2.53 ± 1.28	2.40 ± 1.33	2.63 ± 1.50
4. High eyebrows	1.97 ± 1.25	3.90 ± 1.27	2.23 ± 1.25	2.23 ± 1.36	2.23 ± 1.30	2.37 ± 1.33
<i>F</i>	1.23	4.20**	5.53**	0.94	3.33*	1.22
<i>P</i>	.305	.008	.002	.427	.023	.306
Post hoc		1>2, 3	2, 3, 4>1		2, 3, 4>1	

Note: Descriptive statistics of each group are presented as mean ± standard deviation
* $p < .05$, ** $p < .01$, *** $p < .001$

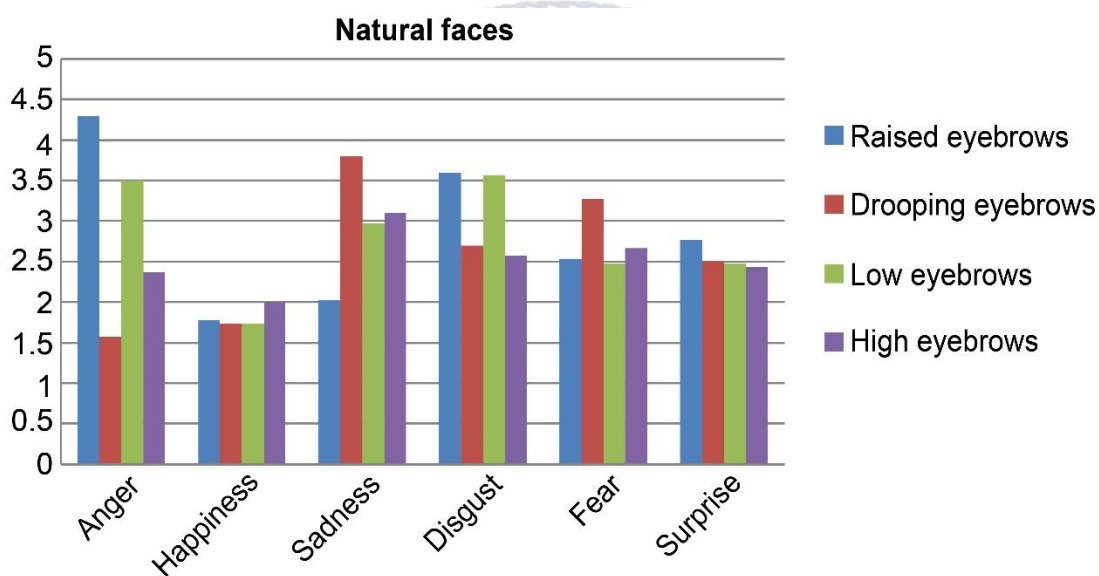


Figure 4. Emotions of eyebrows on natural faces under different conditions.

A further post-hoc comparison was carried out for raised and high eyebrows ($M = 3.10$) conditions, showing that drooping eyebrows create a significant impression of sadness compared to low eyebrows and high eyebrows. F for disgust = 6.56, $p < .001$, indicated a significant difference in identifying disgust after comparing the four types of eyebrows. A further post-hoc comparison was established for raised eyebrows ($M = 3.60$), drooping eyebrows ($M = 2.70$), low eyebrows ($M = 3.57$), and high eyebrows ($M = 2.5$), demonstrating that raised eyebrows and low eyebrows create a significant impression of disgust compared to drooping eyebrows and high eyebrows. F for fear = 4.55, $p < .01$, revealed a significant difference in identifying fear after comparing the four types of eyebrows. A further post-hoc comparison was initiated for raised eyebrows ($M = 2.53$), drooping eyebrows ($M = 3.27$), low eyebrows ($M = 2.47$), and high eyebrows ($M = 2.67$),

showing that drooping eyebrows create a significant impression of fear compared to the other three types of eyebrows. F for surprise = 0.56, $p > 0.05$, was not significant.

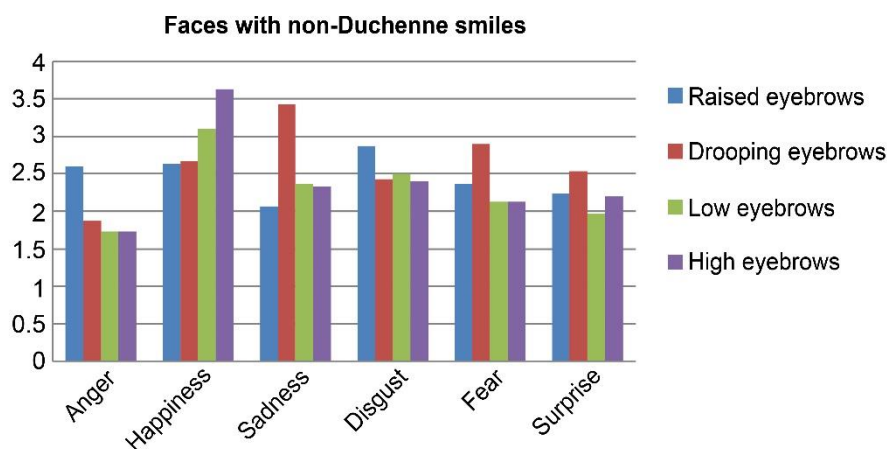


Figure 5. Emotions of eyebrows on faces with non-Duchenne smiles under different conditions.

Results of experiment 2 (Table 1 and Figure 5) are as follows. F for anger = 7.17, $p < .001$, indicates a significant difference in identifying anger after comparing the four types of eyebrows. A further post-hoc comparison was carried out for raised eyebrows ($M = 4.30$), drooping eyebrows ($M = 1.57$), low eyebrows ($M = 3.50$), and high eyebrows ($M = 2.37$), indicating that raised eyebrows create a significant impression of anger compared to drooping, low, and high eyebrows. F for happiness was 7.46, $p < .001$, demonstrated a significant difference after comparing the four types of eyebrows. A further post-hoc comparison was established for raised eyebrows ($M = 2.63$), drooping eyebrows ($M = 2.67$), low eyebrows ($M = 3.10$), and high eyebrows ($M = 3.63$), showing that high eyebrows create a significantly happy expression compared to raised, drooping, and low eyebrows. F for sadness = 9.41, $p < .001$, presented a significant difference in identification of sadness after comparing the four types of eyebrows. A further post-hoc comparison was carried out for raised eyebrows ($M = 2.07$), drooping eyebrows ($M = 3.43$), low eyebrows ($M = 2.37$), and high eyebrows ($M = 2.33$), indicating that drooping eyebrows create a significantly sad expression compared to raised, low, and high eyebrows. F for disgust = 1.43, $p > 0.05$, was not significant. F for fear = 5.40, $p < .01$, showed a significant difference in the identification of fear after comparing the four types of eyebrows. A further post-hoc comparison was established for raised eyebrows ($M = 2.37$), drooping eyebrows ($M = 2.90$), low eyebrows ($M = 2.13$), and high eyebrows ($M = 2.13$), and conveyed that drooping eyebrows create a significant impression of fear compared to raised, low, and high eyebrows. F for surprise = 2.33, $p > 0.05$, was not significant.

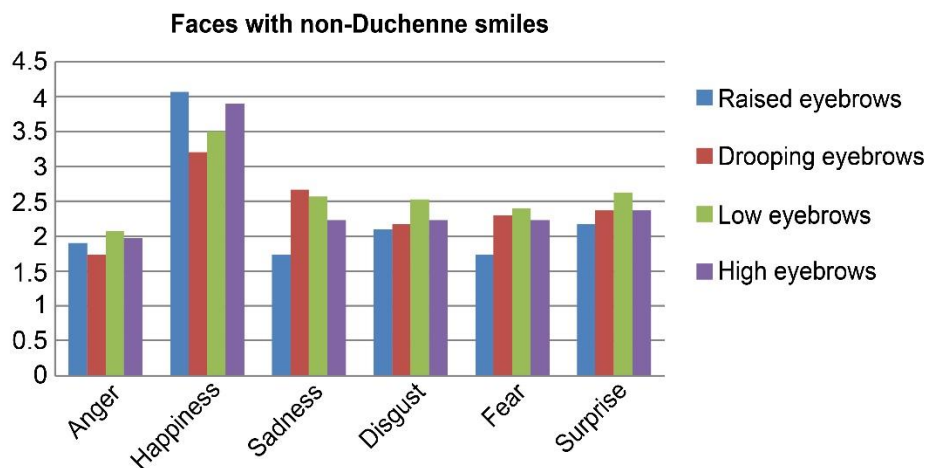


Figure 6. Emotions of eyebrows on faces with Duchenne smiles under different conditions.

Results of experiment 3 (Table 1 and Figure 6) are as follows. F for anger was 1.23, $p > .001$, which was not significant. F for happiness = 4.20, $p < .01$, indicated a significant difference after comparing the four types of eyebrows. A further post-hoc comparison was constructed for raised eyebrows ($M = 4.07$), drooping eyebrows ($M = 3.20$), low eyebrows ($M = 3.50$), and high eyebrows ($M = 3.90$), showing that raised eyebrows create a significantly happy expression compared to drooping and low eyebrows. F for sadness = 5.53, $p < .01$, displayed a significant difference after comparing the four types of eyebrows. A further post-hoc comparison for raised eyebrows ($M = 1.73$), drooping eyebrows ($M = 2.67$), low eyebrows ($M = 2.57$), and high eyebrows ($M = 2.23$), indicated that drooping, low, and high eyebrows express a significantly sad expression compared to raised eyebrows. F for disgust = 0.94, $p > 0.01$, was not significant. F for fear = 3.33, $p < .05$, showed a significant difference after comparing the four types of eyebrows. A further post-hoc comparison was initiated for raised eyebrows ($M = 1.73$), drooping eyebrows ($M = 2.30$), low eyebrows ($M = 2.40$), and high eyebrows ($M = 2.23$), that demonstrated that drooping, low, and high eyebrows showed a significant expression of fear compared to raised eyebrows. F for surprise = 1.22, $p > .001$, was not significant.

Discussion

The results of experiment 1 show that on natural faces, raised eyebrows with downward brow movement, which resemble a “V”, are associated with the impression of anger (Salgado-Montejo et al., 2017). Drooping eyebrows resembling “Λ” present the impression of sadness (Tipples et al., 2002). Drooping eyebrows also show significant responses in the impression of fear, which is consistent with raised eyebrows and a closed mouth (Ekman & Friesen, 2003). In terms of the impressions of happy and surprised emotions, the four types of eyebrows show no significant response. Eisenbarth and Alpers

(2011) revealed that participants spent more time paying attention to happy mouths than those indicating sadness and fear. It is important to discuss observed emotions based only on the movement of the mouth. On an expressionless face, the mouth is not raised, curved down, or open, which may be the factor that further affects the perception of happiness and surprise. Low eyebrows have the emotional perception of disgust (Sun, 2014). The results of experiment 2 show that raised eyebrows indicate an emotional impression of anger on faces with non-Duchenne smiles, which is consistent with the results of Öhman et al. (2001), who pointed out that raised eyebrows signal an angry face. Drooping eyebrows create a significant impression of sadness and fear. Non-Duchenne smiles do not affect the perception of sadness, unlike drooping eyebrows, which may be related to the fact that participants focused their attention on eyes during the observation (Eisenbarth & Alpers, 2011). We found that high eyebrows create a significant impression of a happy mood, which is consistent with Massaro's findings (Massaro, 2000).

Regarding the disgusted and amazed emotional impressions, in pictures displaying non-Duchenne smiles, no obvious phenomena appeared in the four eyebrow types variations. Previous research indicates that observers may spend more time paying attention to specific features (Eisenbarth & Alpers, 2011). Perhaps the observer will focus on the mouth and the characteristics of the smile, which minimizes the attention given to the eyebrows. According to the results of Figures 4 and 5, natural faces and faces with non-Duchenne smiles have similar emotions of anger, happiness, sadness, and fear based on the perception of raised, drooping, high, and low eyebrows. The four types of eyebrows present no different emotional interpretations connected to the change of mouth type (the shape of the mouth changes from a flat state to an upward curved state), thus, this difference in emotional interpretation may be related to the prominent characteristics of eyebrows. In experiment 3, we found that raised eyebrows create a perception of happiness in faces with Duchenne smiles and the smile weakens the relationship between raised eyebrows and anger. In addition, sadness and fear were observed in the drooping, low, and high eyebrows, which might be because the participants focused on the eye area. According to Figure 6, low eyebrows show significant expression of fear and surprise, which may be due to the similarity between surprised faces and fearful faces (Etkoff & Magee, 1992). In contrast, the other four types of eyebrows did not demonstrate significant perceptions of anger, disgust, and surprise, which may be the influence of the significant characteristics of faces with Duchenne smiles. In summary, by observing the expression-aware emotions, the observer may be affected by significant features and focus on specific parts. Such features directly or indirectly affect the interpretation of emotions, further affecting the above results.

Conclusion

Facial emotion perception is related to a number of features in the visual search for expression (Lo & Cheng, 2017). With the involvement of more facial muscles, the expression of emotions can be more accurately detected and processed, but this high muscular involvement can also result in faulty judgements (Calvo & Marrero, 2009). We found that raised eyebrows showed significant anger on natural expressionless faces and faces with non-Duchenne smiles. However, on faces with Duchenne smiles, none of the four types of eyebrows revealed a feeling of anger. Raised eyebrows resulted in perceptions of happiness on faces with Duchenne smiles. Surprise was not indicated through the four types of eyebrows on the three faces. Disgust was not a significant feeling based on the four types of eyebrows on faces with non-Duchenne smiles or faces with Duchenne smiles. These situations might be related to the analysis and result interpretations when lip deformations changed the shape of lips (Matthews et al., 2002), which is consistent with the hypothesis of this study. In addition, drooping eyebrows had a significant impact on the perception of both sadness and fear on the three faces. It is obvious that the prominent features of drooping eyebrows became a specific focus, which led to different interpretations of emotions (Eisenbarth & Alpers, 2011; Lo & Cheng, 2017). The results of this study confirm that eyebrows and mouths are important factors in the formation of facial expressions. They affect feelings of emotions to different degrees, and allow for different interpretations, especially in the presence of prominent features or when visual attention is focused on specific parts of the face.

The subjects involved in this study were students of cosmetics who had received cosmetic training in the beauty department. One of the limitations of this sample was the great disparity in the male to female ratio that appeared at the time of sampling, because fewer males were enrolled in the cosmetics program. Nonetheless, as the study of cosmetics helps students pay more attention to experimental tasks, facial features, and facial particularities, this study selected those who have been trained in makeup courses as participants. However, another limitation of this sample is that the participants, who do have cosmetic experience, might have differing opinions comparatively to those with no cosmetic experience. These restrictions can be suggestions for interesting future research directions.

Previous studies have analyzed facial emotions by locating eyebrows or mouth units. However, emotional interpretations seen through the face may be affected by a mental state or makeup. Therefore, observing different expression faces and eyebrows at the same time contributes to a more in depth emotional analysis. This study used a make-up method to design four eyebrows on the face and camouflage three faces for experimentation. The study design can eliminate the lack of realism in computer graphics and emulate the way eyebrows are modified in life. As the results showed, the pattern of

eyebrows and smiles affected the judgment of emotions to varying degrees, which ultimately supports the necessity of the experiments design.

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