Haptic Recognition of Emotions in Raised-Line Drawings by Congenitally Blind and Sighted Adults

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Abstract—15 sighted and 15 congenitally blind adults were to classify raised-line pictures of emotional faces through haptics. Whereas accuracy did not vary significantly between the two groups, the blind adults were faster at the task.

Index Terms—Psychology, human information processing, perception.

1 INTRODUCTION

FACE perception is orientation specific. We recognize upright faces better than inverted (upside-down) faces. This phenomenon, which is known as the “face-inversion effect,” was first demonstrated by Yin [1] and later documented as important in both the perception of facial identity (e.g., [2], [3]) and facial expression of emotions (e.g., [4], [5], [6]). Inverting faces disrupts configural but not featural information. Thereby, the occurrence of the face-inversion effect suggests that face is processed as a global configuration rather than as a set of independent features (e.g., nose, eyes).

This hypothesized “configural process” of the face may, however, incorporate several mechanisms, as suggested by Maurer et al. [7]. The term may refer to holistic processing (features are perceived as a unique Gestalt), sensitivity to first- and/or second-order relational information (relative position of features, fine spatial information), or any combination of these. A variety of tasks and techniques (including morphing together halves of different faces, blurring or scrambling facial features) may serve to distinguish between these various forms of configural processing.

Interestingly, a recent body of research has shown that a face-inversion effect was not restricted to the visual modality but could occur also in the haptic modality for both face identity (e.g., [8], [9], [10], [11]; for a review, see [12]) and facial expression of emotions [13]. In contrast, Kilgour and Lederman [11] used a haptic version of the inversion paradigm with three-dimensional (3D) clay face masks. Sighted (blindfolded) subjects haptically explored pairs of 3D face masks and had to decide whether stimuli in a pair were similar or different. A significant inversion effect was found for faces, but not for nonface (control) objects, which suggests that the haptic processing of upright 3D face masks was configuration based. Using two-dimensional (2D) raised-line drawings of basic facial emotions, Lederman et al. [13] asked sighted (blindfolded) adults to classify the emotional expression in upright, inverted, and scrambled pictures of faces. Accuracy was impaired when the pictures were inverted or scrambled compared to a condition where the pictures were in an upright canonical orientation. The authors concluded that sighted adults “haptically processed the global configuration of features in the universal expressions of emotion depicted in the upright 2D displays” [13], p. 36.

Visual and haptic perception of facial identity and facial expression of emotions are similar in a number of ways, one of which seems to be the global configural processing of facial information. However, whereas a holistic processing of drawings of emotional faces may be achieved effortlessly and rapidly with visual perception, the same process may require more time and cognitive effort through the haptic system. In the haptic modality, individuals must retrieve facial information sequentially and integrate it over time. Moreover, they must convert the sequentially processed haptic inputs into a corresponding visual model, which they must then interpret using the visual system ([11], see also [14]).

We designed the present study with two main aims. First, we tested whether blindfolded sighted adults show a haptic-face-inversion effect with 2D pictures of basic emotional faces, as recently demonstrated by Lederman et al. [13]. Second, we tested whether a haptic-face-inversion effect generalizes to people who have never had visual experience with facial expression of basic emotions, namely, totally congenitally blind adults. A question of interest is whether congenitally blind subjects can understand 2D raised-line pictures of facial expression of emotions, and if so, whether they can integrate information serially gathered from tactile pictures of emotional faces into a holistic representation.

From a theoretical point of view, testing totally congenitally blind adults offers a unique opportunity to assess the role of visual experience and visual imagery in the haptic processing of raised-line drawings. One view suggests that the lack of visual imagery and experience limits the possibility to read emotional expression in tactile pictures of the human face [14]. However, this view is not shared by all [15], [16], [17], and there is experimental evidence to suggest that at least some tactile pictures might be understood without recourse to visual imagery [18]. From a more applied perspective, the usefulness of tactile pictures of emotional faces for blind individuals has been questioned but is to date not yet established (see [19], [20], [16], [13]).

Following the example of Lederman et al. [13], we used a classification task in which totally congenitally blind and blindfolded sighted adults were given a list of six possible basic emotions [21] and were asked to identify the emotion depicted in each raised-line drawing. We tested whether inverted stimuli resulted in a decrease of recognition accuracy and/or increase in reaction time in sighted adults compared to a condition where upright stimuli were used. We also compared performance of the sighted group to that of the congenitally totally blind participants in order to determine whether noticeable differences emerged between the two groups. In line with the view that visual imagery and experience mediate the processing of tactile pictures [14], we predict that totally congenitally blind adults should perform worse than the sighted group in the classification task. In addition, we predict that blindfolded sighted adults, but not totally congenitally blind adults, would demonstrate a face-inversion effect under the haptic modality. Sighted participants should be able to consider the global configuration of facial features in the raised-line drawings (see [13]). By contrast, blind subjects should be restrained to process local features only in raised-line drawings without internally representing the figure as a whole. As a result, only performance of the sighted group should be impaired when the raised-line drawings are reversed (disruption of the global configuration, but not of local features).
2 Method

2.1 Participants

A sample of 30 French adults took part in the study. They were divided into two groups according to their visual status: totally congenitally blind group (n = 15; seven women, eight men; mean age 41 years, SD = 13, range 22-56), and sighted group (n = 15; seven women, eight men; mean age 41 years, SD = 14, range 20-56). Participants from the totally congenitally blind group were all blind at birth (they had no perception of object shapes or position, and little or no light perception). They were all Braille readers. None of them suffered from a known neurological dysfunction in association with their visual impairment. Etiology of blindness included congenital cataract (5), retrolental fibroplasia (4), retinitis pigmentosa (2), retinoblastoma (2), glaucoma (1), and optic atrophy (1). The sighted participants were matched for age and gender with the congenitally blind subjects. Familiarity with raised-line drawings was assessed using a 3-point scale (1, very unfamiliar; 2, quite familiar; 3, very familiar). The blind participants were quite familiar with raised-line drawings (mean = 1.86), whereas the sighted participants had never had experience with raised-line drawings prior to the experiment (mean = 1).

2.2 Materials

Photographs of 12 emotional faces were taken from the Facial Action Coding System database [22]. Half of the photographs represented faces of a female actor and half represented faces of a male actor. Each actor displayed facial expressions of six basic emotions: happiness, sadness, fear, surprise, disgust, and anger. We traced by hand the outlines of the primary facial features (eyes, eyebrows, nose, mouth, external contour of the face, and hair), and we converted the resulting line pictures into raised-line drawings using a heat-sensitive (Swell) paper. Each raised-line drawing (line: 0.5 mm high and 0.3 mm wide) falls within a 21 × 29 cm paper. The stimuli were very similar in size (mean = 13.5 × 18.25 cm). Fig. 1 presents the raised-line drawings in upright orientation for the female and male actors. A pretest with five additional sighted adults demonstrated a 90 percent interrater agreement for visual identification of facial emotions in the upright raised-line drawings.

2.3 Procedure

The study was carried out on an individual basis. Sighted participants were blindfolded during the task (they were wearing a sleeping mask). The session started with a familiarization phase during which participants had to explore freely with their hands a series of six practice emotional drawings (both upright and inverted positions). They had to identify the emotion depicted in each drawing among a list of six possible emotions (happiness, sadness, anger, surprise, fear, and disgust). There was no constraint on exploratory mode; participants could either use one hand (dominant or nondominant) or both hands to explore a raised-line picture. Response feedback was given for each practice trial. When a participant provided an incorrect answer, the experimenter indicated the correct emotion and invited the participant to explore the picture once again.

In the following (test) phase, each participant was presented with a series of 24 emotional raised-line drawings, divided into two blocks of 12 tactile pictures each (one block per actor). Order of presentation of the two blocks was counterbalanced across participants of each group. For each block, the 12 emotional pictures (6 emotions × 2 orientations) were presented in a different random order for each participant. Participants were informed that they would be presented with two blocks of 12 emotional raised-line pictures, some of which were inverted. Each raised-line drawing was placed flat on the table and fixed with UHU patafix, so that the participants were prevented from turning the pictures. They had to complete the classification task as accurately and quickly as possible. The experimenter recalled the list of six possible emotions to the participants. The participants were informed that the list could be given again whenever necessary. In fact, none of them asked for it. No feedback was given during the classification task regardless of response accuracy. Participants were timed from the moment they first touched a drawing until they gave their responses. Measures of both accuracy and response time were recorded.

3 Results

Preliminary analyses revealed that neither accuracy nor response time varied significantly according to order of presentation of the two blocks of pictures, or actor. Data were, therefore, collapsed across these two factors in all subsequent analyses. We set an alpha level of 0.05 for all statistical analyses.

3.1 Accuracy

Accuracy was indexed by the number of correct responses (max 12), and submitted to a 2 × 2 mixed analysis of variance with Group (2: congenitally blind, blindfolded sighted) as a between-subject factor, and Picture Orientation (2: upright, inverted) as a within-subject factor. Parametric tests were used because the accuracy distribution did not significantly deviate from normality (Shapiro-Wilk test, p > 0.05).

The results (see Fig. 2) showed that accuracy was well above chance level for both the congenitally blind and sighted groups. The congenitally blind participants had a mean of 5.26 correct responses (43.8 percent), and the sighted participants had a mean of 6.56 correct responses (54.6 percent). The two groups did not differ significantly in their mean number of correct responses to the classification task, $F(1, 28) = 2.32, p > 0.05$. Upright pictures were not classified better than inverted pictures, as revealed by a nonsignificant effect of orientation, $F(1, 28) = 0.05, p > 0.05$. The interaction effect (group by orientation) was not significant either, $F(1, 28) = 0.98, p > 0.05$. Hence, no face-inversion effect was observed on accuracy, regardless of visual group status. Similar conclusions were drawn when nonparametric tests were used.
Second, it aimed to test whether congenitally blind adults would show a face-inversion effect (see [13]) with 2D raised-line pictures of emotional faces. The present study was twofold. First, it aimed to test whether sighted blindfolded adults would show a face-inversion effect as a between-subject factor, and Picture Orientation (2: upright, inverted) as a within-subject factor.

The results (see Fig. 3) showed that the congenitally blind participants had lower response times (mean = 22 s, SD = 4) than the sighted participants (mean = 37 s, SD = 4). The two groups differed significantly in their mean response time, F(1, 28) = 7.39, p < 0.01. Upright pictures were not classified faster than inverted pictures, as revealed by a nonsignificant effect of orientation, F(1, 28) = 0.57, p > 0.05. There was no significant interaction effect, F(1, 28) = 0.89, p > 0.05. Hence, no face-inversion effect was observed for response time, regardless of visual group status. Similar conclusions were drawn using nonparametric tests.

3.2 Response Time

Response times per picture varied between 10 and 83 s. Results were transformed into log scores, so that the distribution of log measures did not deviate from normality (Shapiro-Wilk test, p > 0.05). Log measures were submitted to a 2 x 2 mixed analysis of variance with Group (2: congenitally blind, blindfolded sighted) as a between-subject factor, and Picture Orientation (2: upright, inverted) as a within-subject factor.

The intermatrices correlation between the congenitally blind and sighted groups was high (Pearson r = 0.89, p < 0.05). There was no significant interaction effect, F(1, 28) = 0.89, p > 0.05. Hence, no face-inversion effect was observed for response time, regardless of visual group status.

3.3 Stimulus-Response Confusion Matrices

We tabulated the stimulus-response confusion matrices for each group separately. Preliminary analyses revealed significant correlations between matrix for upright and matrix for inverted pictures within each group (congenitally blind group: Pearson r = 0.80, r² = 0.64; sighted group: Pearson r = 0.90, r² = 0.81, p < 0.05). Response times were, therefore, summed across upright and inverted pictures. Table 1 presents the resulting matrices obtained for the congenitally blind and sighted groups.

The intermatrices correlation between the congenitally blind and the sighted groups was high (Pearson r = 0.84, r² = 0.70, p < 0.05). However, this correlation was almost fully determined by the high values on the diagonals. The intermatrices correlation remained high when the Pearson correlation was computed on the correct responses only (diagonal cells) (Pearson r = 0.78, r² = 0.60, p < 0.05). By contrast, the correlation failed to reach significance when the Pearson correlation was computed on the incorrect responses only (off-diagonal cells) (Pearson r = 0.29, p > 0.05).

The results in Table 1 show that in both groups, happiness, sadness, surprise, and disgust were classified more easily than anger and fear. Between-group differences emerged with respect to confusion errors. In both the congenitally blind and the sighted participants, noteworthy confusions were fear with sadness, and anger with surprise. However, in the sighted group, fear was also confused with disgust. In the sighted group, disgust was sometimes mistaken for sadness, whereas in the congenitally blind group, disgust was confused with happiness.

4 Discussion

The present study was twofold. First, it aimed to test whether sighted blindfolded adults would show a face-inversion effect (see [13]) with 2D raised-line pictures of emotional faces. Second, it aimed to test whether congenitally blind adults would reach a similar level of performance as the sighted participants, and show a face-inversion effect with 2D raised-line pictures, despite the absence of visual experience with facial expression of basic emotions.

4.1 Summary of the Results

The study shows that there is no face-inversion effect in both sighted and congenitally blind adults who were asked to classify upright and inverted pictures of emotional faces in the haptic modality. In both groups of participants, neither accuracy nor response time varied as a function of picture orientation. However, despite a lack of between-group difference in accuracy, the study revealed that the congenitally blind participants were faster than the sighted adults to classify the pictures according to the emotion depicted. There were also high correlations between the blind and sighted participants’ classification of stimuli, mostly for the correct responses.

4.2 No Face-Inversion Effect in the Sighted Group

Unexpectedly, our study does not support Lederman et al.’s [13] observation of a haptic-face-inversion effect in sighted adults. Nevertheless, the accuracy levels found for the haptic classification of upright pictures (56 percent of correct responses) are very similar to those reported by Lederman et al. [13] (54 percent). In [13], accuracy decreased by 11 percent when the raised-line pictures were inverted. No such decrease in accuracy was found here (53 percent of correct responses for inverted pictures).

Failure to observe a haptic-face-inversion effect found by Lederman et al. [13] could be due to the following differences between the studies:

1. Stimuli: Our stimuli include much more facial information than those used by Lederman et al. [13], notably hair, pupils, and wrinkles. This may have eased the classification
The raised-line pictures when presented in an inverted orientation. Indeed, adding more facial information to the stimuli may add to the featural identifiers and may bias processing to local facial features mainly (not the global configuration). As a result, our participants may not be much impaired when the global configuration was disrupted (inverted stimuli).

2. Blocks of stimuli: In our study, upright and inverted pictures were presented together in a given block. By contrast in [13], upright and inverted pictures were presented in two separate blocks. This subtle difference in the manner of ordering pictures may have contributed to diverging output in the results.

3. Sample size: A smaller sample size was used in the present study (n = 15) than in [13] (n = 32 in the haptic condition). Perhaps, a larger sample size would have revealed positive findings.

4. Mean chronological age: Our sighted participants were older (41 years old) than those observed by Lederman et al. [13] (21 years old). It is possible that age affects our ability to deal with raised-line pictures and facial expressions of emotions. We would suggest that, with increasing age and working memory limitations, adults may be more inclined to process only parts or local features of raised-line drawings to deal with identification tasks. This may explain why our older adults were little sensitive to a disruption of configural information in the raised-line stimuli. Further research should aim to extend the present results by using a larger sample of sighted subjects and by incorporating age as a factor in the design.

4.3 Classification Ability in the Congenitally Blind Group

Our study shows that there was no difference between sighted and congenitally blind adults’ ability to classify facial expression of emotions in raised-line pictures. However, we noted that the blind participants were faster to complete the classification task. This difference may be directly related to the higher degree of experience blind adults have with the processing of 2D tactile information (e.g., Braille reading and raised-line pictures exploration). Specifically, the blind participants were likely to use more efficient exploratory movements to encode the raised-line pictures than the sighted adults (see [23], [24]). It is also possible that the blind participants were faster because they were more confident with the task and therefore did not recheck as much as the sighted subjects did. In a follow-up study, it would be useful to assess this possibility by asking participants to rate their confidence level with the task, following the example of Lederman et al. [13].

The blind participant’s ability to classify raised-line pictures of emotional faces is noteworthy because none of these participants had experience with such material prior to the study. It could be inferred that congenitally blind subjects can make sense of simple raised-line pictures of emotional faces, because the shape and location of the features fit with the tactile and proprioceptive knowledge blind subjects have of their own facial expression of basic emotions. An alternative explanation could be that blind subjects succeeded at the task due to learning about the arbitrary correspondences between pictures and verbal labels during the first (practice) phase of the study.

4.4 Conclusion and Future Directions

Our study is the first study to ask blind adults to classify simple raised-line pictures of facial expression of emotions. We found that blind adults can classify such pictures with a success level comparable to that of sighted adults, a finding which strongly suggests that these pictures are intelligible to congenitally totally blind subjects. Our study adds to previous works showing that some tactile pictures might be understood without recourse to visual imagery and experience (e.g., [15], [16], [17], [25], and [18]). Whether blind adults come to identify the emotion depicted in the raised-line drawing by processing local features only (e.g., shape of the mouth) as our findings tend to suggest (no face-inversion effect), or by building a more holistic representation of what is depicted remains an open question for future research.

One way to address this issue is to ask participants to define the most salient features on which they focused in order to identify the emotion depicted in the raised-line drawings (see [13] for a similar technique). A complementary way to address the issue relies on a precise examination of the sequential hand movements that are involved in raised-line pictures exploration. A recent study with sighted adults [26] showed that several exploratory behaviors are engaged when participants have to identify raised-line pictures of common objects (e.g., dynamic exploration with two hands, exploration with a single finger). Some exploratory behaviors are likely to involve a more complete scanning of the picture than others, and may result in a more complete or more accurate mental representation of the raised-line stimulus. Further investigations into these exploratory behaviors and into their relations with recognition performance would help us to understand how blind and sighted adults come to mentally represent information from raised-line pictures.

To quote Lederman and Klaztky [27], “hand movements can serve as 'windows' through which it is possible to learn about the underlying representation of objects in memory and the processes by which such representations are derived and utilized” (p. 342). Raised-line pictures are special objects of our world, and the way they are scanned by hands may inform about how these pictures are encoded and stored as mental representations.

4.5 Applications

Simple raised-line pictures of emotional faces may be a useful material for educative or communicative purposes. These pictures may enhance emotion understanding and emotion communication in blind individuals, including blind children and blind adults.

For educative purpose, raised-line pictures of facial expression of basic emotions may be combined with Braille text to illustrate the emotions of a character in a story. The blind children may benefit from a combination of raised-line pictures and Braille text to acquire a more complete understanding of human basic emotions, including prototypical situations that elicit basic emotions, and their expression in the human face. Using a story with picture matching task, it would be interesting to assess whether emotion understanding follows the same developmental sequence in blind and sighted children [28].

For communicative purpose, tactile pictures of facial expression of emotions may be turned into iconic versions to be used in conventional e-mail and chat (see [13]). Blind adults may benefit from the availability of a series of so-called emoticons (e.g., smiley) to enrich their electronic communication with other individuals, using and making sense of emotional graphic symbols. The intelligibility of haptic emoticons for blind adults could be investigated using recent human-computer technology, namely, force-feedback or vibrotactile mice [29].

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REFERENCES


