

The perception and recognition of emotions and facial expressions

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Abstract

The perception of emotions and the recognition of facial expressions play a critical role in social interaction between humans. Faces communicate a great deal of information, including dynamic features, such as an individual's internal emotional state, and static features, such as a person's identity. Two major views have evolved from the investigation of how facial expressions are perceived and processed, the discrete category view and the dimensional theory. According to the discrete category view, basic facial expressions convey discrete and specific emotions: anger, happiness, surprise, fear, disgust, and sadness. Conversely, the dimensional view suggests that the mental representation of emotional space consists of continuous underlying dimensions in which similar emotions are clustered together while different ones are far apart. While both theories postulate that affective information is resistant to contextual influences, research on this topic has provided reasons to believe that the relationship between facial expressions and their contexts may play an important role in determining the perceived emotion. Similarly, studies looking at the right hemisphere and the fusiform face area (FFA) have led researchers to suggest that factors other than the presence of faces, such as experience and training, can also activate the FFA. This review looks at the role of facial expressions in everyday life and the two opposing theories on how facial expressions are perceived and processed in the brain. Specifically, the malleability of emotion perception and face recognition and the brain regions involved in emotion are explored.

Introduction

Emotions play a fundamental role in human interactions and experiences. Emotion (or affect) is the feelings that involve subjective evaluation, physiological processes, and cognitive beliefs [1]. Regardless of the situation in everyday life, humans endlessly attempt to decipher social and emotional cues from one another. Research into the cognitive neuroscience of human social behaviour has shown that social behaviour is tightly linked to emotions [2]. Similarly, facial expressions are a particularly important source for obtaining social and emotional information [2, 3] and are also an essential aspect of social cognition, as faces communicate a great deal of information such as an individual's internal emotional state and a person's identity [4, 5].

The importance of facial perception and recognition is exemplified in patients with prosopagnosia. Individuals with prosopagnosia are unable to recognize or differentiate among faces, although other objects in their visual modality can be correctly identified [6]. To compensate for the deficit, these patients rely on visual non-facial information such as a person's clothing, or on information in a non-visual modality, such as voice [7]. Clearly, using the above techniques to distinguish one individual from another poses a great problem for prosopagnosic patients, as much visual non-facial information and non-visual modality are not unique to one particular individual. Therefore, the ability to perceive and recognize faces is a crucial aspect of human interaction.

Subcortical brain regions involved in emotion

Subcortical regions of the brain, including the amygdala, hippocampus, hypothalamus, and regions of the cingulate cortex, enable us to react to emotional stimuli quickly. For example,

the amygdala plays a role in fear and emotional learning [8-10]. Lesions of the amygdala interfere with the processing of emotional information [6], making patients with amygdala damage unable to detect aversive emotional cues in the visual and auditory stimuli [11, 12].

The hippocampus is critical in putting emotion into context [6]. It has been suggested that the main problem with patients suffering from mental disorders is that they are unable to express their emotions appropriately [13]. Specifically, research with post-traumatic stress disorder (PTSD) patients shows the presence of hippocampal atrophy, which is thought to be due to the excessive release of glucocorticoids. This suggests that impaired functioning of the hippocampus may contribute to the emotional dysfunction seen in PTSD [14].

The hypothalamus allows for the quick processing of emotional information [15]. This region of the brain is closely connected with the amygdala and serves as an important relay station for information going into and receiving information out of the amygdala. It also mediates certain autonomic processes and endocrine reactions [6]. For instance, it helps to coordinate the physical events that prepare the organism for approach or withdrawal, also known as the "fight or flight" response.

Finally, the cingulate cortex, viewed as a part of the limbic system, is an important brain structure in a variety of cognitive functions, including emotional self-control [6]. Of particular importance in interfacing emotion and cognition are the anterior cingulate gyrus and the retrosplenial cortex. The retrosplenial cortex mediates interaction between emotional and cognitive processes [16] and lesions to the anterior cingulate cortex result in apathy, inattention, and changes in personality [17].

Cortical brain regions involved in emotion

Cortical regions of the brain, such as the prefrontal cortex, the insula [18], and the parietal lobes also play a role in emotion. They use the quick reactions to emotional stimuli made possible through the subcortical brain regions to influence more complicated aspects of our behaviour. One region of the cortical brain that is important in emotion is the prefrontal cortex, particularly the orbitofrontal prefrontal cortex (OFC) and the dorsolateral prefrontal cortex (DLPFC) [6]. The OFC plays a role in emotion regulation, reward, and punishment. Individuals with damage to the OFC have difficulty anticipating the consequences of their actions and learning from their mistakes [19, 20] and exhibit perseveration even when contingencies change [21]. The DLPFC is sensitive to the integration of cognition and emotion [22] and is involved in the goal directed behaviours that are influenced by positive and negative emotional states [13].

The parietal lobe, particularly the right parietotemporal region, plays an important role in one's ability to perceive, interpret, and recall emotionally meaningful information [6] and in appreciating the emotional significance of visual information [23, 24]. Patients with damage to this region compared to those with damage to the left hemisphere perform poorer when asked to discriminate between emotional faces or to name emotional scenes [25]. They also exhibit more difficulties matching emotional expressions [26] and grouping emotional scenes and faces [27-29].

Malleability of emotion perception and face recognition

Emotion perception, context, and adaptation.

Research into how facial expressions are perceived and processed in the brain has resulted in two major views, the *discrete category view* and the *dimensional view* [3, 30]. According to the discrete category view [31-33], basic facial expressions convey discrete and specific emotions: anger, happiness, surprise, fear, disgust, and sadness. Conversely, the dimensional view [34, 35] suggests that facial expressions convey values on the dimensions of valence (pleasant vs. unpleasant) and arousal (high vs. low). These values, obtained through the facial expressions, are consequently used to attribute a specific emotion to the facial expression.

While both theories hypothesize that affective information is resistant to contextual influences, extensive research on this topic has provided reasons to believe that the relationship between facial expressions and their contexts may play an important role in determining the perceived emotion. Although early studies on this topic have resulted in inconsistent results, with some studies demonstrating insignificant contextual effects [36, 37] and other showing strong contextual effects [38], more recent studies are demonstrating that the categorization of emotions from facial expressions can be strongly influenced by bodily and scene context.

In 2008, Aviezer and colleagues pointed out that previous studies have resulted in conflicting findings because they did not take into account the perceptual similarities among facial expressions [39], such as the strong similarity between anger and disgust [40]. In this study, they showed that bodily context influenced the facial expression that was being perceived. Specifically, affective information from facial expressions was perceived as noticeably different on different bodily contexts, hence differing from the discrete category view. Their results also contrasted with the dimensional view, as

context also changed the ratings of the valence and arousal of presented faces. Of particular importance is the finding that the above effects are dependent on the similarity between the presented facial expression (e.g., anger) and the facial expression that is typically associated with the context emotion (e.g., a body holding a knife).

Studies using an adaptation paradigm have also demonstrated the malleability of facial expressions. Adaptation paradigms allow for the further investigation of the neural representations of faces by inducing aftereffects through prolonged exposure to a stimulus [41]. In this context, adaptation to a particular facial expression has been shown to result in a shift in the category boundaries between two different expressions [42]. That is, a previously ambiguous expression was seen as the opposite expression from the adapting expression. It is believed that adaptation fatigues the neural mechanism associated with a particular stimulus and thus, there is a decrease in the responsiveness of a neural representation to a constant stimulus [43, 44].

Using an adaptation paradigm, Ellamil, Susskind, and Anderson examined the identity invariance of facial expressions. The test stimulus in this experiment consisted of four different expressions – anger, disgust, fear, and surprise, as the pairs of anger and surprise and of disgust and fear were shown to be most different from one another [39]. They found that the perception of facial expressions was reliably and noticeably biased by prolonged exposure to images of facial expressions, which was consistent with previous facial expression adaptation studies [41, 42]. This means that adapting to one facial expression moved the category boundary towards the matching prototype, and thus, required the facial expression to be more prototypical to be categorized correctly.

Lastly, situations other than environmental and bodily contexts can also influence the perception of facial emotions. Kirsh and Mounts observed a negative processing bias in the recognition of emotional expressions with violent video games [45]. Consistent with previous research [46-49], there was a reduction in the “happy face” advantage (the generally faster ability to identify happy expressions compared to angry ones) following violent video games, providing further evidence for the relationship between exposure to violent media and aggressive biases in social information processing [47, 50-55].

Face recognition, the right hemisphere, and the fusiform face area.

Studies with neurologically intact individuals and patients with hemisphere damage have shown that the right hemisphere of the brain is particularly adept at facial recognition [10, 56, 57]. The inversion effect, which is the greater difficulty in remembering inverted rather than upright stimuli, is often used in the research of face recognition.

In 1970, Yin postulated that configural information is especially important for recognizing faces [58]. In this study, participants viewed pictures of either faces or houses in the upright position and were subsequently asked to identify the items that were previously presented. When this task was completed for the second time, the pictures were presented in an inverted orientation. This manipulation allowed for the investigation of the significance of the loss of configural information (e.g., when in faces, the mouth is no longer below the nose). In this study, Yin discovered that neurologically intact individuals exhibited an inversion effect for

faces but not for houses. This suggests that configural information plays a more important role in recognizing faces and that faces are processed differently than other objects.

Further investigation into the malleability of the right hemisphere in face recognition has led researchers to the role of experience or expertise in face processing. Diamond and Carey have postulated that the inversion effect may be observed for any objects with experience [59]. According to this hypothesis, the inversion effect is observed because faces are a class of objects in which humans have much experience. Hence, with experience, a configural strategy would develop for any particular class of objects and the inversion effect would be observed as well. To test this hypothesis, they recruited college students and judges of show dogs for an experiment with a similar procedure used by Yin. The results showed that the judges of show dogs had as large an inversion effect for show dogs as for faces, allowing the researchers to conclude that expertise plays an important role in the inversion effect.

Similarly, recent neuroimaging studies have also demonstrated the role of the right hemisphere in face recognition. In one study [60], the fusiform face area (FFA) was identified individually for eleven car experts and eight bird experts by finding the brain region that exhibited a larger response to faces than other objects. The results showed that there was a greater FFA activation for cars than for other objects, including birds. Conversely, the bird experts exhibited greater FFA activation for birds than for other objects, including cars.

Moreover, activation of the FFA increases as individuals become more experienced. In a study by Gauthier and colleagues, participants were trained to become experts at recognizing novel objects known as “greebles”. When they were judged by the researchers to be experts at differentiating “greebles” from one family to another, they observed activation in the right FFA in the participants. When the inversion effect was looked at, they found that the activation of the right FFA for upright as compared to inverted “greebles” increased with training [61].

Summary

The ability to perceive and recognize emotions and facial expressions is critical, with research showing that vital information can be inferred from facial expressions [2, 3]. In social environments, emotions contribute in regulating social behaviour and communicate important information and social signals. Conflicting theories regarding how facial expressions are perceived and processed in the brain and the use of adaptation paradigms have led researchers to extensively study the malleability of emotions and facial expressions. Similarly, studies looking at the brain regions that are involved in emotions have shown that factors, such as experience and training, can also activate the FFA, suggesting that this area of the brain is not only specialized for the processing of faces. Further research into the malleability, perception, and recognition of emotions and facial expressions will allow us to elucidate the cognitive neuroscience of human social behaviour.

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