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Facial expressions of emotion: A cognitive neuroscience perspective

Kristine Erickson[a] and Jay Schulkin[b,*]

[a] Mood and Anxiety Disorders Program, National Institutes of Mental Health, NIH, Bethesda, MD, USA
[b] Department of Physiology and Biophysics, Georgetown University, Washington DC, 20007, USA

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Abstract

Facial expressions are one example of emotional behavior that illustrate the importance of emotions to both basic survival and social interaction. Basic facial responses to stimuli such as sweet and bitter taste are important for species fitness and governed by simple rules. Even at this basic level, facial responses have communicative value to other species members. During evolution simple facial responses were extended for use in more complex nonverbal communications; the responses are labile. The perception and production of facial expressions are cognitive processes and numerous subcortical and cortical areas contribute to these operations. We suggest that no specific emotion center exists over and above cognitive systems in the brain, and that emotion should not be divorced from cognition.

1. Introduction

Our view is that the emotions, and facial expression in particular, are adaptive social and communicative tools. In some contexts emotional expressions are species-specific and reflexive, as shown by facial responses by animals and human neonates during taste reactivity tests (Grill & Norgren, 1978; Nowlis, 1977; Steiner, Glaser, Hawilo, & Berridge, 2001). Cognitive mediation is important for emotional experience, and variables such as goals and social context influence emotions (e.g., Lazarus, 1999). Facial expressions serve a communicative role, social context influences facial expression of emotion, and humans use facial expressions to interpret the intentions and goals of others. The complex topographies and social meanings of facial expressions are the result of extended use of simple rule-governed species-specific responses. In this paper, we use the example of facial expression to illustrate these points.

The paper is divided into three main sections. The first section describes the hedonic functions of facial expression and how regulatory needs can change the facial response to a stimulus in order to demonstrate that, although facial responses to certain stimuli are innate, those responses are labile and subject to modification. The second section discusses the communicative aspects of facial expression, and how social variables can influence the production of facial expressions, followed by a discussion of the ability to interpret and the propensity to infer intentions of others from facial expression and biological movement. The third section presents how neural systems are implicated in emotional behavior and facial perception. The ability to communicate and interpret emotion and intentions through facial expression require the complex interaction of cognitive systems.

2. Species-specific, rule-governed properties of facial gustatory responses

The gustatory system is a model system of simple rule-governed species-specific affective facial responses. Salty and bitter tastes typically elicit aversive reactions from animals that are observable in oral-facial responses, while sweet tastes elicit positive facial responses. Facial responses to sweet and bitter tastes are also expressed by infants and adults of primate species, including the chimpanzee, gorilla, orangutan, and various Old and New World monkeys (Steiner et al.,

* Corresponding author. Fax: 1-202-863-4994.
E-mail address: jschulkin@acog.org (J. Schulkin).

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2001). Positive responses are characterized by lateral tongue protrusions, while bitter quinine elicits an opening of the mouth, depression of the jaw, and extension of the tongue within the mouth. These facial responses are quite similar to those observed in human neonates, who produce observable facial responses to gustatory stimuli (Bergamasco & Beraldo, 1990; Steiner, 1979; Steiner et al., 2001). The front part of the tongue is sensitive to sweet tastes while the back of the tongue is more sensitive to bitter tastes (Nowlis, 1977), enhancing either acceptance or rejection of food, respectively. As in many non-human primates, bitter stimuli elicit facial expressions of disgust in neonates, while sweet stimuli elicit expressions of satisfaction often accompanied by a slight smile. The facial reactions are produced along with other characteristic approach or avoidance behaviors in animals capable of complex actions, and the clusters of behaviors suggest motivational states.

A change in regulatory state results in a change in approach behavior and facial display suggesting enjoyment or disgust, depending on the valence of the situation. For example, when the stomach of a rat is loaded through a catheter prior to presenting a sweet taste to the oral cavity, the facial consummatory response shifts from a positive to negative facial display and the rat is not motivated to ingest more food (Cabanac & Lafrance, 1990). The shift in response is not permanent. Later, when the rat's stomach is not full, the positive facial response to sucrose returns. In this case, hedonic response to sweet taste depends on physiological need and maintenance of homeostasis (Stellar & Stellar, 1985). Similarly, three-day-old human infants after feeding produce facial displays of disgust when presented with the odor of formula reflecting a change in motivation to ingest this specific food (Soussignan, Schaal, & Marlier, 1999). Changes in hedonic reactions and facial displays in response to food stimuli are ubiquitous across diverse mammalian species, and the emotional responses are tied to motivation (Schulkin, 1999; Stellar & Stellar, 1985).

Taste aversion learning is another example in which the facial response and approach behaviors shift from positive to negative (Pelchat, Grill, Rozin, & Jacobs, 1983). When a sweet food source that normally elicits a pleasurable facial response is poisoned and ingested the animal becomes sick. The animal learns in one trial to avoid that sweet taste, and the animal produces aversion/rejection responses when that taste is presented in the future (Garcia, Hankins, & Rusiniak, 1974; Rozin, 1976). The aversive responses are accompanied by facial displays of disgust (Pelchat et al., 1983). These changes from approach to avoidance behaviors suggest a shift in hedonic experience that in this situation is based on learning, and the animal is no longer motivated to ingest the formally pleasurable stimuli.

An opposite shift in facial response in the rat can be observed during sodium hunger, in which the animal is deprived of sodium. Concentrated sodium solution typically elicits a negative facial and behavioral response (Berridge, Flynn, Schulkin, & Grill, 1984; Grill & Norgren, 1978). In the presence of sodium hunger, the facial response shifts towards a taste reaction seen during sweet taste experience, and the rat avidly ingests concentrated sodium or a gustatory stimuli formerly associated with sodium such as quinine (Berridge & Schulkin, 1989; Berridge et al., 1984). The change in experience of salty taste, as inferred from the observable response, is rooted in regulatory changes within the animal. Salt in the case of sodium hunger is necessary to maintain homeostasis, and the result is twofold (Schulkin, 1991). The first is motivation to ingest salt; and the second is a hedonic liking for salt (see Fig. 1).

Similarities among various species in hedonic and aversive responses to certain stimuli suggest a possible evolutionarily adaptive role for these responses. Sweet taste generally signals nutritious food, the purpose of which may be to maximize acceptance of the food. Bitter taste usually signals the food may be dangerous and hence the reaction maximizes rejection of food (Janzen, 1977; Steiner et al., 2001). Shifts in reactions to stimuli resulting from regulatory changes or learning are adaptive because they promote wellness and, therefore, survival. Additionally, conspecifics can observe these facial responses and use the information gained from the observation to modify their own behavior and decisions.

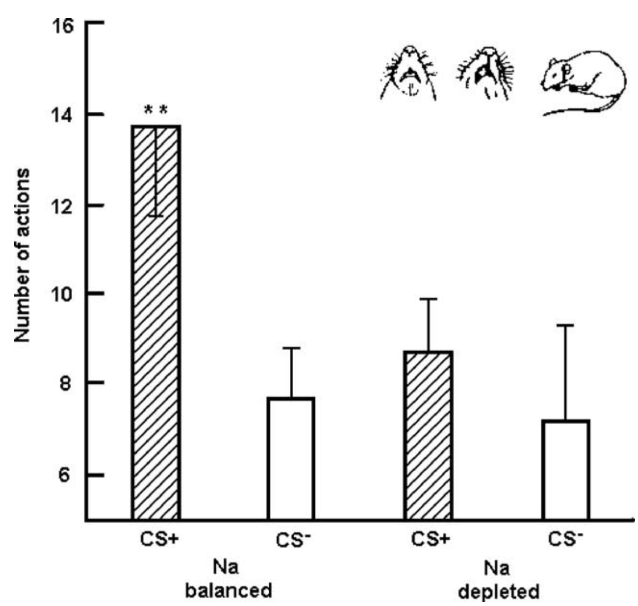

Fig. 1. Ingestive taste reactivity to conditioned tastes. Mean (SEM) number of combined ingestive actions emitted to the CS (quinine or citric acid) and CS while either sodium depleted or when sodium replete. Top right insert illustrates taste-elicited ingestive consummatory responses measured (rhythmic mouth movements, tongue protrusions, and paw licking) (from Berridge & Schulkin, 1989).