Advanced Review

Embodied emotion: the influence of manipulated facial and bodily states on emotive responses

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A growing body of evidence suggests that certain facial expressions and postures are associated with emotional and motivational responses. This review discusses behavioral, neuroscientific, and cognitive research connecting these bodily movements with emotive responses. General bodily feedback theories of emotion have suggested that manipulated facial expressions and postures influence emotive reactions to stimuli as well as physiological responses such as heart rate, skin conductance, and the temperature of blood entering the brain. More recent evidence suggests that manipulated bodily states influence prefrontal cortical activation and amygdala activation. Even further evidence has suggested that manipulated bodily states influence cognitive processes, such as the speed at which individuals read emotional content, the speed at which they classify information as emotional, and the extent to which they determine emotional information as threatening. Bodily feedback theories may also suggest clinical applications. Bodily feedback theories of emotion therefore have generated research showing that bodily expressions play a pivotal role in our emotive experiences.

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INTRODUCTION

We smile from ear-to-ear when we are reunited with an old friend; we are urged to run forward and embrace them. Our bodies' slump and our heads hang low when we are depressed; our ability to move forward is inhibited by our closed posture. Over the last century, researchers have investigated the relationship between outward expressions and emotive states, with some even suggesting that our bodily expressions alter emotive responses rather than simply being a consequence of the emotive state.

The purpose of this article is to review theories and research concerned with the idea that bodily expressions and feedback influence emotive states. These theories can be referred to as bodily feedback theories of emotion. To begin with, we discuss some of the original theoretical ideas leading to bodily feedback theories of emotion. Thereafter, we discuss some of the original behavioral research associated with these theories. Next, we discuss research linking bodily feedback theories with psychophysiological responses. Following this section, we explain more modern research associating bodily feedback theories with the study of subcortical brain regions. Next, we review research associating bodily feedback with cortical brain activity. Thereafter, we review research linking manipulated bodily states to cognitive processes. Finally, we discuss clinical applications of bodily feedback research. Based on this literature, we conclude that manipulated bodily states influence (1) emotive behavior, (2) multiple psychophysiological processes related to emotion and motivation, and (3) associated cognitive processes.

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ORIGINS OF BODILY FEEDBACK THEORIES

Darwin[1] was one of the first to notice that outward bodily displays are tightly connected with emotional experiences. His first law of emotive expression—serviceable actions become habitual in association with certain states of the mind (Ref 1, p. 3)—suggests that physical bodily movements and emotive states, as a result of habitual use, can become interconnected to the point where an emotional state can result in an outward expression just as readily as an outward expression can result in or intensify an emotional state (Ref 1, p. 34). Darwin, however, was not speaking simply about facial expressions of emotion. He realized that the whole body was involved in the experience of emotion. In instances of distress, e.g., he noted the 'violent and frantic movements' of the organism (Ref 1, p. 176). In instances of anger, he noted how 'the body is commonly held erect ready for instant action' (Ref 1, p. 236). When considering shyness or embarrassment, he noted the blushing of the neck, wrists, and any visible portion of the body (Ref 1, p. 314).

Darwin was also aware of the relationship between emotive expressions and the nervous system. He believed bidirectionality existed between these two components, stemming from his third law of emotive expression, the principle of the direct action of the excited nervous system on the body (Ref 1, p. 3). Due to the bidirectionality between expressive behavior and the nervous system, a manipulated bodily state, regardless of an emotive eliciting stimulus, may provide peripheral feedback that influences physiological processes related to emotion.

EARLY BODILY FEEDBACK RESEARCH

Laird[2] was one of the first experimentalists to consider that manipulating facial muscles could influence emotional states. He drew heavily from James'[3] conclusion that emotive states are the consequence of bodily states—we smile and, consequently, we realize that we are happy. Self-perception theorists, similarly, theorized that acting as though one feels a certain way will lead to that subjective feeling.[4] Laird[2] developed a method to test the effects of manipulated facial expressions on emotional states. In this experiment, emotional facial expressions were manipulated by telling participants that electrodes placed on their faces were intended to study, 'the activity of facial muscles under various conditions during perception' (Ref 2, p. 477). Participants were never informed that the research was interested in emotional expressions and responses collected at the end of the experiment revealed that the vast majority of participants did not surmise that the experiment was about emotional expressions. Instructions were provided to participants to move individual muscles (e.g., contract the electrodes between the eyebrows … contract them by pulling them down and together—anger) to create emotional facial expressions without their awareness. In this first experiment, participants were shown pictures of Klu Klux Klan members or pictures of smiling children while creating either happy or angry emotional expressions. Participants completed a mood evaluation questionnaire following each picture type trial. Results indicated that aggression self-reports where higher for angry as compared to happy expressions during KKK pictures. Elation, surgency, and social affiliation self-reports were higher for happy as compared to angry expressions during smiling children pictures (Ref 2, p. 479). A second experiment yielded similar results with pictures of cartoons, which were rated as more humorous while participants maintained smiling as compared to frowning facial expressions (Ref 2, p. 483).

Some researchers interpreted Laird's[2] results with skepticism. Some scientists suggested that demand characteristics may have caused the results[5] even though Laird's[2] methods had included several features to effectively handle this issue. Did the participants in these previous experiments simply become aware that they were being asked to smile and, consequently, did they realize that they were being intentionally placed in a happy emotional state?

To address these questions, researchers have used other methods to manipulate facial expressions. These manipulations were designed to make participants less aware of the emotional quality of the manipulation and less aware of the actual configuration of the emotional facial expression itself. An experiment by Strack et al.[6] manipulated participants' facial expressions by having the participants hold a pen in their mouths. Smiles were facilitated by having participants hold the pen with their teeth. In contrast, smiles were inhibited by having participants hold the pen with their jutted lips. Smiling facilitation versus inhibition led to more humorous reactions to cartoons. These results suggest that subtle inductions of emotional facial expressions influence emotive responses. Demand characteristics, therefore, may not explain why emotional facial expressions influence emotional feelings.

Thus far, the facial feedback research considered stems from the necessity hypothesis, the notion that manipulated facial expressions will influence reactions to affective stimuli.[7] Researchers have also considered the sufficiency hypothesis, the notion that simply forming an emotional expression with unobtrusive means leads to a subjective reaction, regardless of an emotional stimulus (Ref 7, p. 251). Furthermore, recall that Darwin's[2] original theorizing was concerned with far more than facial expressions. Researchers, as a result, have also considered the influence of whole body manipulations on subjective states without an emotion eliciting stimulus. Duclos et al.[8] tested these ideas with multiple emotional manipulations: fear, anger, disgust, and sadness. The first of their experiments tested facial expressions covertly manipulated with instructions from the experimenter. The cover story concerned 'brain lateralization.' After forming each facial expression for 6 seconds, participants filled out a questionnaire assessing their emotional state. Fear ratings were significantly higher in the fear as compared to the other conditions. Sadness rating also followed this pattern. Anger/disgust ratings were higher in the anger/disgust conditions as compared to the other conditions, but did not differ from one another (Ref 8, p. 102).

A second experiment tested manipulated bodily postures. Participants were instructed to form fear, sadness, and anger postures (e.g., clench your fists tightly and lean your upper body forward—anger) via instructions in an experiment ostensibly about brain activity. Participants maintained these postures for 15 seconds and then recorded their self-reported emotional states. Some participants did not respond to the postures as anticipated. During the debriefing, some believed that the sad posture, e.g., was intended to express a relaxed state. Upon removing such subjects, results were in line with predictions; anger reports were highest in the anger posture and so forth for the remaining two postures.

Based on similar theorizing, researchers have also considered that manipulated bodily states may have peripheral feedback on motivational behaviors, specifically persistence. For example, Riskind and Gotay[9] created two postures hypothesized to influence motivation. Stemming from prior accounts of the physical expression of depression, the 'depressed' posture in this experiment had participants' torsos bent forward at the waist, their chests and necks dropped downward, and their heads and necks pushed forward and down so that participants were stooped and hunched over (Ref 9, p. 277–278). A second posture similar to the physical expression of pride[10] had participants' shoulders pushed from the spine, the spine straightened so that the back was erect and upright, and the shoulders raised slightly and pulled back so that the chest was posed in a full expansive position. The participants' heads were raised slightly at the chin so that they looked forward and slightly upward (Ref 9, p. 278). Participants assumed one of the two postures for 8 min. They were informed that the purpose was to collect physiological data for a 'bio-feedback task.'

Afterward, participants resumed a normal posture and participated in a second unrelated study on 'spatial thinking.' In fact, the two experiments were connected and the second task was a measure of motivational persistence. This task involved the completion of several geometric puzzles.[11] Some of these puzzles were in fact unsolvable, and persistence was measured as the number of attempts participants made at solving them. Results revealed that participants placed in the stooped posture, compared to the upright-expansive posture, persisted less (made less attempts) at the unsolvable puzzles. These findings suggested that postural manipulations can influence motivational behaviors. Interestingly, however, these postures did not influence self-reported emotional states. Researchers have reasoned that there may be special circumstances wherein postures do not provide peripheral feedback on subjective emotional states (Ref 8, p. 104). Also, the lack of effects of self-reported emotions may simply be the result of the insensitivity of the measure.

These early experiments[3,4,8] provided initial support for the notion that manipulated bodily states can influence subjective emotive experiences. Importantly, however, the results of all of these experiments were interpreted with a cognitive mechanism (e.g., individuals who perceive themselves to be smiling infer that they are probably happy). Stemming from Darwin's[1] original theorizing, however, researchers have also considered that the physical action of facial muscle movements may elicit physiological changes that bring about subjective reactions.[12] That is, a physiological rather than a strictly cognitive mechanism may also contribute to bodily feedback.

Physiological Research

Initial attempts to specify a physiological mechanism for bodily feedback effects were embroiled in controversy. James[3] suggested the possibility that skeletal muscles may contribute to feedback effects. Other researchers, namely Cannon[13], attacked this idea by citing animal research wherein visceral and organic aspects of an animal were destroyed but, nevertheless, emotional displays continued to be present in the animal.[a] Other researchers, however, considered that aspects of the viscera may at least contribute to a positive versus negative affective valence quality of emotional experiences as a result of affective facial muscle movements.[15] The problem, however, was that none of these researchers clearly defined what that physiological mechanism might be.[16]

Zajonc et al.[17] seized the opportunity to propose a neural mechanism for the emotional effects of affective muscle movements. In particular, they noticed that downward contraction of the corrugator supercilii muscle (furrowing of the brow) is often associated with negative facial expressions (e.g., fear, anger, and disgust). Upward contraction of the zygomatic major muscle (smiling action of the cheeks) is often associated with positive facial expressions. These researchers found evidence that furrowing of the brow reduces air-intake into the nasal cavity, raising the temperature of blood entering the brain. This temperature change, furthermore, was associated with negative affective feelings. In addition, these researchers found evidence that upward movement of the zygomatic muscle improved nose breathing and air-intake into the nasal cavity, lowering the temperature of blood entering the brain. This temperature change was associated with positive affective feelings. Several other experiments replicated these effects utilizing different manipulations of blood brain cooling (e.g., gently pumping cool air into the nose to reduce temperature).

These results renewed interested in physiological mechanisms of bodily feedback on subjective feelings. However, this past work only examined a positive-negative valence. Other researchers[18] considered the possibility that physiological activity might be specific to manipulated emotional expressions. One reason Levenson et al.[18] indicated that past work might have failed to find this association was due to the limited nature of physiological measures used to study affective facial muscle movements. In their research, participants' facial muscles were manipulated by instructions from the experimenters. 'No emotion was mentioned by name, and subjects were not asked to feel or think anything; subjects were asked only to contract facial muscles' (Ref 18, p. 366). A myriad of physiological measures were recorded simultaneously while participants made emotional facial expressions [e.g., heart rate, skin conductance (SCR), finger temperature, and fore-arm muscle tension]. Participants' self-reported emotions were also recorded, and confirmed facial feedback effects. Results indicated that anger, fear, and disgust expressions caused unique patterns of physiological responses in the autonomic measures collected (for a review, see Ref 19).

Taken together, these past behavioral and physiological experiments indicated that manipulated facial expressions and postures influence emotive states and measures of physiological activity. More recent research has expanded these ideas to test other psychophysiological measures and metrics, and this research has furthered our understanding of the complexity between outward affective bodily movements and subjective emotive reactions and behaviors.

MODERN INVESTIGATIONS OF BODILY FEEDBACK THEORIES

Researchers have compared physiological measures while participants imitate versus simply view other individuals' facial expressions.[20] Given that viewing negative stimuli can elicit autonomic changes, these researchers questioned if affective facial muscle movements during the viewing of negative stimuli might enhance these effects. In one experiment, researchers recorded facial electromyography (EMG), SCR, and pupil dilation. Results revealed that imitating versus passively viewing angry facial expressions increased activity across all of these physiological measures. These researchers speculated that the amygdala, a brain region involved in the generation and expression of emotion,[21] may play a mechanistic role in these effects.

Researchers, as it happens, have attempted to directly measure the amygdala during facial mimicry versus nonmimicry.[22] In one experiment, participants were volunteers who had either received or who had not received botulinum toxin-A (BTX) injection into their corrugator supercilii muscles. This muscle activates during frowning or forming negative emotional facial expressions such as anger or disgust. In this experiment, participants were shown angry facial expressions in a functional magnetic resonance imaging (fMRI) scanner that recorded subcortical brain activity. Results indicated that, indeed, participants who were less able to imitate angry facial expressions due to BTX injections displayed less amygdala activity as compared to participants who had not received injections.

In addition, Hennlotter (2009) found that attenuation of amygdala activity during imitation of angry facial expressions was associated with less functional connectivity between this brain region and the dorsal pons of the brain stem. This pontine cluster receives prominent projections from the amygdala, and has been associated with homeostatic regulation and autonomic arousal.[23] Thus, this research supports prior research[18] demonstrating that imitated, as well as directly manipulated, facial expressions may influence ANS activity.

Taken together, this research supports the notion that manipulated facial expressions can influence autonomic and subcortical brain activity related to the experience of emotion. Importantly, however, the relationship between manipulated bodily states and physiological processes is complex. While subcortical brain regions may constitute the basis for emotional expression, these signals may become repeated cortically and interconnected to higher order cognitive processes.[24] We review the effects on cortical brain activity next.

PREFRONTAL CORTICAL ACTIVITY AND EMBODIMENT

Other research has relied on electroencephalography (EEG) to study the role of manipulated bodily states on emotive responses. Lateralized EEG activity over the prefrontal cortex has been associated with the motivational direction of emotions.[25] This research has demonstrated that relative right frontal cortical activity is associated with withdrawal-oriented emotions, such as fear and disgust.[26,27] More recently, relative right frontal activity has been positively associated with the incorporation of another individual's suffering and empathic concerns.[28] Relative left frontal activity, however, has been associated with approach-oriented emotions, such as joy[26] and anger.[29] More recently, relative left frontal activity has been positively associated with sexual arousal toward evocative stimuli.[30] Engagement with sexual stimuli, furthermore, has been associated with approach motivation.[31]

EEG asymmetry is often examined by taking right minus left homologues of prefrontal EEG sites (e.g., F4, midfrontal right, minus F3, and midfrontal left) on the surface of the scalp. This difference score metric is consistent with past studies suggesting a reciprocal relationship between the frontal hemispheres in relationship to motivational and emotional variables.[32] In the EEG asymmetry research, alpha power derived from the EEG is the variable most commonly used. Alpha power is inversely related to regional brain activity, as revealed in research using behavioral tasks and other neuroimaging methods.[33,34] Given that researchers take right minus left prefrontal sites, a more positive value in the EEG frontal asymmetry index indicates greater relative left prefrontal cortical activity. There are believed to be multiple neural generators of this EEG frontal asymmetry metric, such the orbitofrontal[35] and dorsolateral prefrontal cortex.[36]

Facial Expressions

Emotive facial expressions have been shown to influence frontal EEG asymmetry. An early study[37] demonstrated this relationship by studying Duchenne (genuine) and less genuine smiles. Duchenne smiles are thought to involve upward movement of the zygomatic major and movement of the orbicularis oculi muscles (wrinkling of the eye). Less genuine smiles are thought to only involve zygomatic movement (Ref 1, p. 199). Ekman and Davidson[37] found that manipulated Duchenne smiles, compared to less genuine smiles, were associated with greater relative left frontal cortical activity.

Coan, Allen, and Harmon-Jones[38] examined other emotive facial expressions in relation to relative left frontal cortical activity. Given that anger and joy may be associated with higher approach motivation, these researchers hypothesized that manipulated anger and joy facial expressions may be associated with greater relative left frontal cortical activity. Disgust and fear manipulated expressions were hypothesized to be associated with less relative left frontal activity. In this experiment, participants were asked to form facial expressions with auditory instructions from the experimenter (e.g., raise your upper eyelid). Results from this experiment were in line with the above predictions.

More recent research has compared facial expressions within the same affective valence (positive) but differing in approach motivational intensity.[39] This research compared determination (positive high approach) and satisfaction (positive low approach) manipulated facial expressions. Neutral facial expressions were included as a control. In this experiment, facial expressions were not manipulated covertly. Participants in the determination condition, e.g., were instructed as follows, 'Express determination as clearly as you can. Try to make a determination expression so that absolutely anyone would be able to recognize the emotion you are communicating.' These instructions were taken from previous research linking determination with high approach positive states.[40] The explicit instructions were intended to prevent determination participants from simply making anger facial expressions, which look similar to determination expressions (e.g., both involve furrowing of the brow). EEG was recorded while participants formed these facial expressions. Consistent with hypotheses, determination expressions caused greater relative left frontal cortical activity as compared to the satisfaction and neutral expressions.

Within the same experiment, participants next completed the motivational persistence measure taken from Glass and Singer[11] and used in prior research with bodily manipulations.[9] Participants continued to make facial expressions while working on unsolvable puzzles. Persistence on unsolvable puzzles was analyzed as the average of total attempts and total time working on these puzzles. Results indicated that facial expressions did not influence persistence. One may question this finding given prior research.[9] This lack of a different between conditions, however, may simply have resulted due to methodological differences between the two studies. Even though this persistence measure did not show evidence of differences between conditions, significant correlations occurred between relative left frontal activity caused by facial expressions and total persistence. Specifically, a positive correlation was found for participants in the determination condition; that is, greater relative left frontal cortical activity was associated with more behavioral persistence. No correlation was found for participants in the satisfaction condition. Surprisingly, a negative correlation was found for participants in the neutral condition. Future research is needed to assess whether this unexpected correlation will replicate.

Whole Body Postures

Some fMRI evidence has suggested relative left frontal cortical activity is associated with approach oriented responses.[41] Other evidence, however, has not.[42] One difference between fMRI studies and EEG studies that may account for these inconsistencies is the physical posture participants must adopt while in an fMRI scanner—a supine body position. EEG studies, contrastingly, often test participants while they are sitting upright. An initial study tested if postural manipulations influenced frontal EEG asymmetry while participants were in a simple posture during an EEG recording.[43] Participants in this experiment sat in a recliner and either leaned forward, sat upright, or reclined fully. These postures were hypothesized to embody high, medium, and low approach motivation, respectively. EEG was recorded for 1 min while participants were in their randomly assigned whole body posture. Results indicated a linear trend effect. Leaning caused greater relative left frontal cortical activity than reclining, and the upright condition fell between these two conditions.

A second study tested whether these postures influenced relative left frontal cortical activity to affective stimuli.[44] In this experiment, only the two extremes (i.e., leaning high approach and reclining low approach) in postural manipulations were used. Participants maintained these postures while they viewed affective stimuli found to influence motivational responses.[45] High approach stimuli depicted delicious dessert pictures (pretesting indicated that participants in this experiment enjoyed dessert items). Neutral pictures depicted different types of rocks. Results indicated an interaction. In the high approach leaning posture, dessert pictures elicited greater relative left frontal cortical activity than did rock pictures. In the low approach reclining posture, however, this difference did not emerge.

Together, these results suggest that manipulated bodily states influence cortical brain activity.[b] The prefrontal cortex, however, is involved in far more than motivational responses. It is also heavily involved in cognitive processes.[48] We examine the effects of manipulated bodily states on cognitive processes next.

COGNITIVE EFFECTS OF MANIPULATED BODILY STATES

Other theories of embodied emotion/cognition suggest that embodied resources play a pivotal role in higher order cognitive processes related to emotion.[49] 'For example, when we retell the story of our most embarrassing moment, we also reproduce a trace of that state of embarrassment' (Ref 49, p. 215). In this instance, the individual may blush, look downward and away (Ref 1, p. 320) while telling this story. The interesting notion is that this physical activity may, in some cases, enable the individual to better recall the embarrassing instance.

Memory

Some initial research tested whether manipulated postures and facial expressions influenced participants' recall of emotional autobiographical memories.[50] In one experiment, manipulated bodily states were not covert, so that participants could freely express their emotions in a natural manner. Participants formed happy, anger, and sadness postures together with facial expressions for 4-min blocks. There were five blocks, each separated by 2-min breaks. Thereafter, participants were given a neutral word (e.g., tree) and asked to recall a memory associated with that word. Results indicated typical bodily feedback effects for self-reported emotive states. More importantly, participants in the happy condition, e.g., recalled more happy memories than participants in the angry condition. This research suggested that bodily manipulations can influence cognitive processes related to memory.

Comprehension of Emotional Material

Research has also demonstrated that bodily manipulations influence individuals' ability to determine the emotional content of information, and that individual differences in awareness of bodily cues contribute to these effects.[51] In one experiment, participants were administered an individual difference measure to determine their sensitivity to their bodily cues. This test involved field dependence and independence. Field dependent individual rely more on contextual cues than field independent individuals, who rely more on bodily cues to interpret stimuli. In a Rod-and-Frame task,[52] participants are placed in dark room with two objects. The first, an illuminated frame, contains an illuminated bar (line) that can be turned 360 degrees. The goal of the task is to turn the bar completely vertical. Field-dependent individuals are thought to rely on the contextual cue, the frame, to make these adjustments. Field-independent individuals are thought to rely on cues from their own bodily. Field dependence is measured by the number of degrees that the participants' perception deviates from the true vertical.

Thereafter, bodily states were covertly manipulated with an elaborate cover story. Participants formed fear, happiness, and anger facial expressions together with postures detailed by instructions from the experimenter. Participants maintained these postures while working on a sentence task. In this task, participants were shown metaphors that related to the fear, anger, and happiness conditions (e.g., he flew off the handle—anger). Other metaphors, however, were neutral in emotional content (e.g., she glanced at him). Several unintelligible sentences were also created (e.g., she him snapped at). The participants' task was to quickly identify whether a sentence was intelligible or unintelligible. Results for the metaphor task were mixed. Fear bodily manipulations led to faster reactions to all types of emotional metaphors. These effects were also more pronounced for participants more sensitive to their own bodily cues. These researchers concluded that fear can promote vigilance, thus, it can cause participants to focus their attention toward emotional tasks.

Other research has demonstrated that bodily manipulations can produce emotion specific effects for the processing of emotional material. Havas et al.[53] tested participants' reading speed of angry, sad, and happy emotional paragraphs (e.g., a sentences from the anger condition: reeling from a fight you slam the car door). Participants read these paragraphs initially with no manipulation, to determine baseline ability. Thereafter, participants voluntarily received BTX injections into their corrugator supercilii muscles. After injections, participants were slower at reading anger and sad paragraphs. There was no change in their ability to read happy paragraphs. Given that the corrugator supercilii muscle is involved in the generation of anger and sad emotional expressions, these researchers concluded that the ability to freely express emotional facial expressions can influence the processing of emotional language.

More recent research has demonstrated that manipulated bodily states influence how participants interpret ambiguous information.[54] In one experiment, facial expressions were manipulated with the 'golf tee' method. This method places golf tees (with adhesive collars) to participants' brows. In order to create frowning expressions covertly, participants were asked to move the golf tees closer together, contracting the corrugator supercilii muscles. In the neutral condition, they were simply asked to keep the tees as still as possible. Participants maintained these facial expressions during a homonym spelling task. This task presented spoken words over headphones. Participants were asked to write down the words they heard. Homonyms were ambiguous and could be interpreted as threat or neutral words (e.g., dye/-die). Others, however, were ambiguous positive words (e.g., peace/piece). Results indicated that participants in the frowning condition completed more ambiguous homonyms as threat words relative to participants in the neutral expression condition. No significant differences were found for ambiguous homonyms that could be completed as positive words. A second experiment extended these results to the interpretation of bodily consequences from ambiguous situations.

Facial Recognition

Facial recognition has also been extensively studied in the embodiment literature. Some research suggests that our mimicry of another individual's emotional facial expression allows us to comprehend the emotional significance of that facial expression, through our own simulation of that individual's emotional state.[c] Research, e.g., has demonstrated that inhibiting affective facial muscle movements impairs our ability to recognize emotional facial expressions. In one experiment, participants viewed happy, sad, fearful, and disgusted facial expressions.[57] To inhibit affective facial muscle movement, participants chewed gum or bit down while viewing these expressions. Biting down greatly inhibits the ability to smile and chewing gum interferes with maintaining an emotional expression. After each presentation of an emotional facial expression, participants, in a forced-choice paradigm, indicated the emotion they believed was displayed. Consistent with an embodied simulation perspective, biting down and chewing gum relative to a control condition interfered with participants' identifications of emotional expressions.

Researchers have also investigated the neural mechanisms that may be responsible for these types of effects. In particular, researchers have investigated the somatosensory cortex, a brain region associated with the integration of sensory signals related to representations of the body, with an emphasis on facial characteristics. In one experiment,[58] repetitive transcranial magnetic stimulation (rTMS) was employed, which can electrically inhibit cortical activity in a targeted brain region. Participants viewed emotional facial expressions while receiving rTMS over the right somatosensory cortex or they did not receive rTMS. Participants either attempted to identify the emotional content of the expression, or whether the expression shown previously matched the currently displayed facial expression (i.e., nonaffective task). Results indicated that rTMS relative to the control condition interfered with participants' ability to recognize the emotional content of facial expressions, but not their ability to match expressions with one another.

Cognitive Scope

Evidence has also suggested that bodily manipulations associated with motivational responses influence conceptual attention.[59] In one experiment, narrowing/broadening of conceptual attention was measured using a cognitive categorization task used in past research.[60] Participants completed these tasks in the high, medium, and low whole-body approach motivational postures described above.[43] Participant also smiled in each posture to distinguish them as positive. While in these postures, participants completed the cognitive categorization task, which involved rating the extent to which weakly associated exemplars (camel) of a particular category (vehicle) fit within that category. Results indicated that participants in the high approach condition categorized more narrowly, indicating that the (medium and weak) exemplars fit the category less well. Contrastingly, participants in the low approach positive condition categorized more broadly, indicating that the exemplars fit the category better. These results were replicated in a second experiment, adding further support to the notion that manipulated bodily states can influence higher order cognitive processes.

Rationalizations

Postural manipulations have also been show to influence processes related to cognitive dissonance, a broad theory which explains how individuals rationalize their behavior/decisions.[61,62] It proposes that individuals attempt to remain consistent in their thoughts, behaviors and attitudes. Inconsistencies (dissonance), however, can arise. Under these circumstances, individuals are motivated to reduce this uncomfortable state between conflicting cognitions (Ref 61, p. 3). A classic example is a smoker who continues to smoke despite knowing it has negative health consequences. The individual can (1) stop smoking, or, (2) produce consonant cognitions that help reduce the dissonance. For example, the smoker might conclude that he enjoys smoking so much that it is worth the health risks (Ref 61, p. 2).

The action based model of dissonance, furthermore, assumes that many cognitions automatically activate action tendencies.[62] In this model, inconsistent 'cognitions' cause dissonance because of the inconsistency between potential actions.[63] The dissonance then motivates the organism to subjectively value one action tendency over the other, which allows the organism to behave effectively. This process of dissonance reduction is often an approach-motivated process which translates a behavioral commitment, or intention, into effective action.

Several paradigms have been constructed to measure dissonance reduction. Effort justification paradigms,[64] e.g., have participants' complete difficult tasks which cause dissonance. Such tasks cause dissonance because engaging in effortful activity is inconsistent with the cognition that one would not want to expend such effort. In order to reduce this dissonance, the individual may enhance the value of any rewards associated with the task. A classic example is hazing. Given that approach motivation leads to dissonance reduction, under heightened approach, an individual should come to enjoy difficult task rewards (vs easy task rewards) even more as a means of dissonance reduction. Under lower approach, however, this 'effort justification' effect should be decreased.

In the free-choice paradigm,[65] dissonance is examined following difficult decisions. When individuals must decide between equally attractive options, such as slightly enjoyable tasks, they are placed in a state of dissonance because the positive aspects of the rejected option and the negative aspects of the chosen option are inconsistent with the decision. After the individuals make the decision, they may spread apart their evaluation of the decision alternatives. That is, prior to the decision, the to-be-chosen and to-be-rejected alternatives are evaluated similarly, but after the decision, the chosen alternative is evaluated more positively than the rejected alternative. Given that approach motivation leads to dissonance reduction, under heightened approach, an individual should have even more spreading of alternatives for a difficult decision (vs an easy one) as a means of dissonance reduction. Under low approach motivation, however, this 'spreading of alternatives' should be decreased.

Recently, the approach motivational effect of upright versus reclining postures has been tested with an effort justification paradigm.[66] In this experiment, participants completed easy or difficult Stroop[67] tasks while in upright or reclining postures. Afterward, they rated stimuli found to be affectively neutral, which were pictures of rocks. These stimuli were supposedly a reward for their Stroop task performance. Results indicated a typical effort justification effect when participants were sitting upright. That is, rock pictures following the difficult task versus the easy task were rated as more likable. This pattern, however, did not emerge when participants were in the reclining posture. Reclining participants, in fact, rated the rock pictures as more likable following the easy Stroop task relative to the difficult tasks.

A second experiment used a free-choice paradigm to attempt to conceptually replicate this effect in a different dissonance paradigm. In this experiment, participants were told they could choose the task they completed in the experiment. They were presented with seven different task descriptions, such as a color naming task or a reaction time task. In reality, each description described a Stroop task. Participants rated how much they wished to complete each task. Thereafter, they reclined or kept the chair upright throughout the rest of the experiment. Following a short delay, participants, depending on condition, were presented with a difficult or easy decision. In the difficult condition, they decided between two options they had initially rated as somewhat positive and equally attractive. In the easy condition, they chose between an option initially rated as far more attractive than the other presented option. After a second short delay, participants saw and rated all seven descriptions a second time. In the higher approach upright condition, a typical spreading of alternative effect emerged. That is, participants spread apart their evaluations of the chosen and rejected decision alternatives more in the difficult decision condition than in the easy decision condition. In the reclining posture, however, significant spreading of alternatives did not occur for the difficult decision.

CLINCAL APPLICATIONS OF BODILY FEEDBACK THEORIES

Given that prior research has consistently indicated that manipulated facial expressions influence emotive states, researchers have attempted to amplify these effects to help individuals suffering from emotional disorders, such as major depressive disorder (MDD).[68] Researchers have employed functional electric stimulation (FES) to facial muscles, reasoning that FES possesses many clinical applications. For example, electrically stimulating paralyzed or weakened muscles during injury can help individuals regain some control over them.[69] In a similar fashion, individuals with MDD may have an impaired ability to smile and, consequently, may not experience as much positive affect as a result of smiling. In particular, MDD participants may have a marked impairment in genuine or Duchenne smiling.

Zariffa et al.[68] trained participants to form Duchenne smiles with instructions from the experimenter. Smiling instructions were intended to be covert, and no mention of emotional expressions was elucidated. Next, FES was applied to participants' facial muscles for 25 min in the experimental condition. Control participants did not receive electric stimulation. Afterward, participants filled out questionnaires assessing their emotions states. Results were mixed. No significant differences were found for primary positive outcome self-report measures (e.g., happy), but differences were found for secondary measures (e.g., determined). These results were interpreted to suggest that amplifying facial expressions with electrical stimulation may, in some cases, amplify self-reported emotional reactions.

Relatedly, researchers have also considered the role of facial expressions in well-being. For example, Kraft and Pressman[70] studied facial expressions in relation to physiological measures of well-being, relative to more commonly used measures (e.g., self-report indices). These researchers considered the role of manipulated facial expressions in response to cardiovascular stress (average heart rate). This research utilized the facial expression manipulation designed by Strack et al.[6] Kraft and Pressman[70] modified the procedure, however, to incorporate a Duchenne smile condition, a standard smile condition, or a neutral expression condition. In addition, half the participants in this experiment were instructed to smile, whereas the other half adhered to the more common covert manipulation. Participants formed these smiles while performing a cold pressor task wherein the participants' hand was submerged in ice cold water for 1 min. Results revealed that participants in the

Duchenne smile condition had lower overall heart rate relative to participants in the other two conditions. The aware smiling conditions did produce a slight advantage in heart rate recovery relative to the nonaware conditions, but the comparison was nonsignificant. These results were interpreted to suggest that smiling, with or without awareness, can help alleviate stress responses.

Finally, researchers have investigated facial feedback effects in individuals with autism. An experiment had participants with autism spectrum disorders (ASD) and matched controls watch video clips of individuals displaying happy emotional facial expressions.[71] Participants were left to automatically mimic these expressions, intentionally mimic these expressions with instructions from the experimenter, or attempt to not mimic expressions. After each video clip, participants rated their self-reported emotional states. Results indicated that matched controls experienced greater positive emotions while automatically and intentionally mimicking facial expressions relative to inhibiting mimicry. Mimicry, however, did not enhanced positive emotions for the ASD group. These results suggest that individuals with ASD have impaired bodily feedback responses. Most importantly, these results suggest treatment options for individuals with ASD, such as detailed therapies to condition individuals with ASD to mimic emotional expressions while in corresponding feeling states.[49]

CONCLUSIONS

Stemming from Darwin's[1] original theorizing, the research reviewed suggests that bodily manipulations have the ability to influence a diverse spectrum of emotional and motivational responses as measured with self-reports, physiological responses, and cognitive responses. Because these bodily manipulations have been shown to influence a diverse range of physiological processes, the possibly of one primary physiological mechanism is unlikely. Research in these areas continues to develop, and suggests possibilities for psychological treatments and a better understanding of human behavior.

NOTES

[a] While visceral dissection studies have proven inconclusive for the effect of physiological mechanisms on emotive expressions, brain dissection studies in living animals have indicated quite different results. An ingenious experiment by Dower[14] studied wild monkeys placed in captivity. These monkeys would display aggressive behavior (e.g., fang flashing) to any onlooker. Dower sectioned the forebrain commissures, including the optic chiasm. He also ablated the amygdala on one side of the monkeys' medial temporal lobe. Thereafter, each eye could convey visual information only to the ipsilateral hemisphere, and only one eye could convey visual information to an intact amygdala. When the eye that could convey information to the intact amygdala was covered, the monkeys became quite placid—their aggressive bodily displays were eliminated when onlookers were present. When the eye was uncovered, however, the aggressive displays returned.

[b] Importantly, some studies employing whole body manipulations and examining physiological processes have failed to replicate past results. For example, some research has suggested that expansive postures with open limbs (powerful appearing postures) relative to contractive postures with closed limbs (less powerful postures) are associated with increased testosterone and lower salivary cortisol levels.[46] An intended replication study with a much larger sample (reducing the likelihood of false positive results) failed to reproduce this pattern of results, however.[47] Identifying and determining the subtle differences between experiments that may contribute to replication failures is an important element to consider in embodiment research, therefore. The axiom that strong claims should be avoided until converging evidence suggests a comprehensive picture is, likewise, imperative.

[c] The notion that simulating an act, a context, or an interoceptive state underlies much of cognition is also relevant to this literature. It is important, however, not to haphazardly mix theories of grounded cognition[55] with theories of bodily feedback. Bodily feedback research helps address one aspect of grounded cognitive theories, and even then cognitions may act independently of physical bodily states. For example, an individual may grasp the intention of an action through extensive experience with that action, and bodily simulation in these circumstances may not need to occur.[49] Researchers who employ bodily manipulations, nevertheless, must often consider the context in which bodily states occur.[56]

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