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Emotion regulation through execution, observation, and imagery of emotional movements

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ABSTRACT

According to Damasio's somatic marker hypothesis, emotions are generated by conveying the current state of the body to the brain through interoceptive and proprioceptive afferent input. The resulting brain activation patterns represent unconscious emotions and correlate with subjective feelings. This proposition implies a corollary that the deliberate control of motor behavior could regulate feelings. We tested this possibility, hypothesizing that engaging in movements associated with a certain emotion would enhance that emotion and/or the corresponding valence. Furthermore, because motor imagery and observation are thought to activate the same mirror-neuron network engaged during motor execution, they might also activate the same emotional processing circuits, leading to similar emotional effects. Therefore, we measured the effects of motor execution, motor imagery and observation of whole-body dynamic expressions of emotions (happiness, sadness, fear) on affective state. All three tasks enhanced the corresponding affective state, indicating their potential to regulate emotions.

1. Introduction

Watching Charlie Chaplin acting in silent movies, we can easily comprehend his emotions based on his body language. Most people consider body language as the external manifestation of internal emotions through posture and movements. However, it has been suggested that the reversed process, i.e., that postures and movements can affect emotional state, is also true. This concept is based on Darwin's ideas and the James-Lange theory, which at their extreme, propose that bodily responses to stimuli are necessary for emotional experience, and feelings are not the causes of autonomic system activation and emotional behavior, but rather are the consequence of these. Thus, we feel angry because we strike and afraid because we tremble, and not that we strike or tremble because we are angry or fearful (James, 1884).

In recent years, this theory has been re-formulated in neurophysiological terms by Antonio Damasio. According to Damasio, the current state of the body is conveyed to the brain through the processes of proprioception (afferent input representing muscle length and joint angle) and interoception (afferent input representing the physiological (e.g., thermal, metabolic) status of all body tissues), which create in the brain unique neural activation patterns. These neural activation patterns represent unconscious emotions that guide behavior and influence decisions, and they correlate with the conscious feelings of those emotions (Damasio, 1999; Damasio et al., 2000). The uncovering of neuronal underpinnings of interoception (Craig, 2002; Critchley, 2005) and the identification of anterior insular cortex as the brain region in which representation of internal bodily states becomes available to conscious awareness (Craig, 2009), provide plausible neurocircuits in support of this proposition. One important implication of Damasio's proposition is the potential to regulate one's feelings through deliberate control of motor behavior and its consequent proprioception and interoception (Riskind, 1984). Thus, by engaging in movements that are associated with a certain emotion, one should be able to generate or enhance that emotion and its corresponding feelings. Could we really get happier by skipping like a kid or sense fear when shrinking and retreating?

The effects of facial expression on corresponding affective state have been widely studied (for review see McIntosh, 1996) and smiling is now used in dialectical behavioral therapy as a behavioral intervention for mood regulation. Evidence suggesting that the effects of facial expressions on affective states are attained through proprioception come from studies suggesting that changes in proprioceptive feedback from facial expressions following botulinum toxin treatment may weaken emotional experience (Davis, Senghas, Brandt, & Ochsner, 2010) and attenuate neural activation

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in the amygdala (Hennenlotter et al., 2009). Surprisingly, although progressive muscle relaxation is widely used for tension reduction (and has scientific support: Vancampfort et al., 2011) and dance has been used for centuries to intensify joy in social settings, evidence for the impact of emotional bodily posture and movements on affective state is scarce. A handful of studies have shown that isometric arm flexion (associated with approach, e.g., bringing food towards one's mouth) and arm extension (associated with rejection) affect evaluative cognitive processing, causing subjects, for example, to rate neutral novel stimuli more positively during arm flexion than during arm extension (Cacioppo, Priester, & Berntson, 1993). A few other studies have shown that assuming certain postures (e.g., upright, slumped, expansive) immediately induce corresponding feelings (pride, sadness, power, respectively) (Carney, Cuddy, & Yap, 2010; Duclos, Laird, Schneider, & Sexter, 1989; Riskind & Gotay, 1982; Stepper & Strack, 1993), and that inhibition of specific facial and motor behaviors reduce the corresponding feelings (Duclos & Laird, 2001). Moreover, holding for 2 min a posture that expresses power not only increased feelings of power, but also resulted in physiological responses: reduced cortisol and increased testosterone (Carney et al., 2010), and combining facial expressions with matching expressive bodily postures resulted in corresponding feelings which lasted several minutes after stopping these behaviors (Schnall & Laird, 2003), and were stronger than engaging in either the facial expressions or postures alone (Flack, Laird, & Cavallaro, 1999).

We live in a dynamic world, where people's behavior is constantly modified to adjust to continuous changes in the environment. Thus, it is possible that engaging in whole-body *dynamic movements* which are associated with specific emotions (emotional movements) might have stronger effects on affective state than *static postures*, as it is more closely related to the ecological context in which emotion is experienced. Moreover, because brain response to unchanging stimuli diminishes over time due to neuronal adaptation, the consistently changing proprioceptive input from dynamic movements might create a stronger effect than the constant, unchanged proprioceptive input from a static posture. Indeed, perception of dynamic compared to static whole-body expressions of anger resulted in better recognition and stronger and more widespread emotion-specific brain activation (Pichon, de Gelder, & Grezes, 2008). Yet, to date, only one study has investigated the effects of whole-body emotional *movements* upon affective state (Duclos & Laird, 2001), and it was limited to movements designed to elicit only negative emotions. The first aim of our study was to examine the effects of engaging in emotional *movements* upon affective state, in particular, happy movements. We hypothesized that emotional movements would enhance corresponding affective state. We were especially interested to test whether happy movements could enhance positive feelings, because such novel finding might serve as a basis for developing a new, specific-movement based, emotion-regulation intervention for mood enhancement. Additional aims were to explore whether observation and imagery of emotional movements could also influence affective state.

It is now well established that observation of movements activates the same neural network that is active during execution of those same movements (i.e., the mirror neuron network). This mechanism of shared representations for perception and action of body and facial movements was proposed as the basis for action recognition (Rizzolatti, Fogassi, & Gallese, 2001), emotion recognition, and empathy (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003; Gallese, Keysers, & Rizzolatti, 2004). Both animal (Raos, Evangeliou, & Savaki, 2007) and human (Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006) studies have suggested that movement observation simulates in the brain the neural motor commands used to initiate execution of the same movement. It has also been suggested that neural motor commands for a given movement generate in the brain an internal representation of the expected proprioceptive feedback from that movement (Christensen et al., 2010; Raos et al., 2007; Sommer & Wurtz, 2008), and that emotions such as disgust or pain can be induced not only by afferent input from the body, but also by brain simulation of that afferent input (Bastiaansen, Thioux, & Keysers, 2009). Thus, it is very likely that simulation of the expected proprioceptive input from an emotional movement can induce the corresponding emotion during observation of such movement, similar to its induction by real proprioceptive input during motor execution. Support for this idea comes from both monkey (Raos et al., 2007) and human (Gazzola & Keysers, 2009) studies that found regions in the somatosensory cortex which were activated during both the execution and observation of the same action. Other studies found that observing movements which express different emotions generated differential brain activation patterns in emotional processing regions (Peelen, Atkinson, Andersson, & Vuilleumier, 2007; Pichon, de Gelder, & Grèzes, 2009). In addition, observing emotional facial expressions caused subjects to experience the same emotions expressed by the stimuli (Lundqvist & Dimberg, 1995), with more intense expressions producing more intense feelings (Wild, Erb, & Bartels, 2001). Thus, we hypothesized that not only motor execution, but also observation of emotional movements would induce their corresponding feelings. Such emotion regulation effects of motor observation might be useful when actual motor execution is not feasible, and motor imagery could have a similar emotional response.

Several studies have shown that kinesthetic motor imagery (i.e., imagining oneself doing a movement) results in activation of motor circuits similar to their activation during motor execution (Decety & Grèzes, 2006), and that brain activation underlying motor execution and motor imagery differ primarily in inhibition processes that suppress motor output during imagery (Lotze et al., 1999). Motor imagery has been shown to elicit autonomic responses and sensory experience that are directly associated with the imagined movements (Decety, Jeannerod, Durozard, & Baverel, 1993; Naito et al., 2002), and Schwoebel et al. have suggested that motor imagery involves generation of the expected proprioceptive input from the imagined movement (Schwoebel, Boronat, & Branch Coslett, 2002). Moreover, Kim et al. found that imagery of emotional facial expressions elicited activation in the amygdala (Kim et al., 2007). We therefore hypothesized that similar to observation, imagery of emotional movements would also enhance the corresponding affective state.

In this study we measured the effects of motor execution, observation, and kinesthetic motor imagery of happy, sad, fearful, and emotionally neutral movements on affective state, in order to explore their potential for therapeutic application. We hypothesized that all three modalities of whole-body emotional movements will enhance corresponding affective state.

2. Materials and methods

2.1. Participants

Twenty-nine participants were recruited for the study. After giving informed consent, participants were screened using the Movement Imagery Questionnaire-Revised Scale (MIQ-RS) (Gregg, Hall, & Butler, 2007) and the Expression Manipulation Procedure (Duclos & Laird, 2001). The MIQ-RS assesses the ability and ease of motor imagery. Only subjects who scored >70, indicating adequate motor imagery ability, continued their participation in the study. The Expression Manipulation Procedure determines the extent to which people are focused on, and are emotionally