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Emotion biases voluntary vertical action only with visible cues

Kyoshiro Sasaki [a,b,*], Yuki Yamada [a], Kayo Miura [a]

[a] Kyushu University, Japan
[b] Japan Society for the Promotion of Science, Japan

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ABSTRACT

Emotional information influences our bodily experiences according to the space–valence metaphor (positive/negative is up/down). In the present study, we examined whether visible and invisible emotional stimuli could also modulate voluntary action. After observing an emotional image (e.g., positive, neutral, or negative), participants used a joystick to arbitrarily position a dot stimulus in a display. The emotional image was either masked (masked condition) or not (unmasked condition) via a continuous flash suppression technique, i.e., dynamic interocular masking. We found that in the unmasked condition, the placed position of the dot was significantly higher after observing the positive image compared with the negative image, but this difference was not present in the masked condition. Our findings suggest that conscious emotional information is necessary for activating sensorimotor representations of vertical directions, and voluntary action is performed based on these activations.

1. Introduction

A baseball player assumes a victory pose (raising his fist over his head in triumph) after he/she hits a home run. A woman jumps for joy because she receives an unexpected gift from her sweetheart. Conversely, a boy's shoulders will sink when he learns that his close friend has to transfer to another school. These examples illustrate how emotion is reflected in the movement of our bodies. In particular, positive and negative emotions are associated with upward and downward actions, respectively.

Previous studies have established a relationship between emotion and vertical position. For example, when positive or negative words are presented at the top or bottom of a display, respectively, participants evaluate the valence of words more quickly than when the words are presented in the opposite position (Meier & Robinson, 2004). Casasanto (2009) demonstrated that participants tended to position objects representing positive abstract concepts closer to the top of a piece of paper. Moreover, the word “up” is evaluated more positively than the word “down” (Marmolejo-Ramos, Elosúa, Yamada, Hamm, & Noguchi, 2013). All of these phenomena are based on the space–valence metaphor, which is an associative link between representations of emotional valence and vertical position.

There are two classical models of the origin of the metaphor (Slepian, 2015; Slepian & Ambady, 2014): Conceptual Metaphor Theory (CMT; Lakoff & Johnson, 1980) and the Perceptual Symbol System (PSS; e.g., Barsalou, 1999). In CMT, metaphor is regarded as the function that renders abstract concepts concrete. That is, we understand abstract concepts by translating them into well-understood concrete experiences. According to Lee and Schwarz (2012), although CMT tends to be misinterpreted as assuming only the effect of sensorimotor experience on conceptual processing because of the one-way mapping, a bi-directional effect (i.e., sensorimotor experience and conceptual processing influencing each other) could be assumed owing to the dynamic online interaction between sensorimotor experiences and psychological states. On the other hand, the PSS assumes that the mental representations of abstract concepts comprise multimodal sensory experiences associated bi-directionally with such concepts, and metaphors stem from these associations. Thus, an important premise of the PSS is that sensorimotor experience and conceptual activation are closely correlated. Together, these theories suggest that sensorimotor experience and abstract concepts associate bi-directionally and this association is shaped by the dynamic online interaction or co-occurrence of sensorimotor experiences and abstract concepts[1].

* Corresponding author at: Graduate School of Human-Environment Studies, Kyushu University, 6-19-1 Hakozaki, Higashi-ku, Fukuoka 812-8581, Japan.
E-mail address: k-ssk@kyudai.jp (K. Sasaki).

[1] A series of Slepian's studies (Slepian, 2015; Slepian & Ambady, 2014) assumed that CMT predicts that there is only unidirectional effect (i.e., sensorimotor processing influences conceptual processing), and that the PSS predicts a bi-directional effect (i.e., sensorimotor processing and conceptual processing influence each other). In this context, these studies proposed the Simulated Sensorimotor Metaphor model (Slepian, 2015; Slepian & Ambady, 2014), which resembles a combination of CMT and PSS. The Simulated Sensorimotor Metaphor model also assumes a bi-directional effect, although the model assumes that sensorimotor states are bi-directionally associated abstract concepts by learning embodied metaphors. Thus, conceptual processing influences sensorimotor processing via the association between sensorimotor experience and abstract concepts, which are less likely to co-occur (e.g., the association between smell and suspicion; Lee & Schwarz, 2012).

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In line with these theories, previous researches have indicated that bodily experience and motor action influence emotional processing according to the space–valence metaphor. For instance, one study showed that an upright posture induced more positive emotions compared to a slouched posture (Stepper & Strack, 1993). Another study revealed that positive or negative memories were more likely to be recalled while participants moved their arm upward or downward, respectively (Casasanto & Dijkstra, 2010). Similar findings of biased recall have been shown for illusory self-motion (Seno, Kawabe, Ito, & Sunaga, 2013): Positive memories were more frequently recollected during upward vection compared with downward vection. Seno et al. found that participants reported feeling more positive emotions after experiencing upward vection compared with downward vection and concluded that this recollection bias stemmed from the mood-congruency effect (Blaney, 1986; Bower, 1981). These studies indicate that upward (downward) bodily experiences induce positive (negative) emotions.

There are also several studies revealing that emotional processing can also modulate sensorimotor experience. Sasaki and colleagues demonstrated that positive sounds (e.g., a baby's laugh) promoted upward vection and inhibited downward vection (Sasaki, Seno, Yamada, & Miura, 2012). The authors concluded that this phenomenon was due to the association between the 'upward' direction of self-motion and the positive emotions induced by the semantic meanings of sounds. Moreover, another study reported that positive words were placed by participations at a higher position on a display compared to negative words (Marmolejo-Ramos et al., 2013), even though movements were made using a mouse and thus words were moved vertically by manipulating the mouse backward and forward. Additionally, saccade trajectories tend to deviate upward when participants view words with a positive valence (Gozli, Chow, Chasteen, & Pratt, 2013). Recently, Dudschig and colleagues demonstrated that emotional words affected the motor responses when the participants were required to evaluate the emotional valence of words (Dudschig, de la Vega, & Kaup, 2015). In Experiments 1 and 2 of their study, participants observed an emotional word with their fingers pressing a key on the middle of the keyboard. Then, participants were asked to press a key on the top or bottom of the keyboard as soon as possible depending on the color of the words. For example, when the font color was orange or blue, the participants released the middle key and pressed either the top or bottom key, respectively (i.e., they performed upward or downward arm movements). The results showed that emotional words modulated motor action in accordance with the space–valence metaphor: When the emotional valence of the word was positive, upward movements were faster, and when the emotional valence of the word was negative, downward movements were faster. In these studies, emotional stimuli were presented during a task (Dudschig et al., 2015; Marmolejo-Ramos et al., 2013; Sasaki et al., 2012) or a rapid response was required immediately after emotional stimuli disappeared (Gozli et al., 2013). In contrast to such online processing, the present study examined whether emotional information could influence motor action when emotional stimuli were absent during the task and when rapid motor responses were not required (i.e., offline processing[2]).

In the present study, we examined the effect of emotional information on voluntary action. We employed a novel and simple cursor-positioning task, which is similar to the word-allocation task (Marmolejo-Ramos et al., 2013) and the word-priming task (Ansorge, Khalid, & König, 2013). In our task, participants were asked to observe an emotional image and then move a neutral object (a dot cursor) to an arbitrary position on a display using a joystick fixed on a vertical surface. Fixing the joystick on the vertical surface enabled us to directly examine the effect of emotional information on voluntary vertical actions, unlike Marmolejo-Ramos et al. Moreover, by using the neutral object during the task, we could completely eliminate the ongoing effect of emotional information during the task, and thus this is adequate for investigating the effect of emotional information on subsequent sensorimotor experience. If emotional information influences subsequent action in offline processing, then the dot cursor would be placed more in the upper or lower areas of the display after viewing positive or negative images, respectively. On the other hand, if emotional information does not influence motor action in offline processing, the placed position of the dot cursor will not significantly differ according to emotional valence.

There are some advantages of using the cursor-positioning task and visual images as emotional stimuli. We could rule out the possibility that the effect of emotional information on sensorimotor experience reflects concrete lexical association. Previous studies have repeatedly shown that emotional words influence sensorimotor experience (Brookshire, Ivry, & Casasanto, 2010; Dudschig et al., 2015; Gozli, Chasteen, & Pratt, 2012; Gozli et al., 2013; Marmolejo-Ramos et al., 2013; Meier & Robinson, 2004; Santiago, Ouellet, Román, & Valenzuela, 2012; Weger, Meier, Robinson, & Inhoff, 2007; Xie, Huang, Wang, & Liu, 2015) or word classification (Ansorge et al., 2013). However, when linguistic stimuli are used as in these previous studies, it is not clear which of linguistic and non-linguistic association between vertical space and emotional valence is involved with tasks (see Lynott & Coventry, 2014). Using emotional images and the cursor-positioning task could solve this problem. Moreover, most of the previous studies measured reaction time until completing a task (Brookshire et al., 2010; Dudschig et al., 2015; Gozli et al., 2012; Meier & Robinson, 2004; Santiago et al., 2012; Weger et al., 2007; Ansorge et al., 2013) and reaction time reflects processing fluency and efficiency. On the other hand, we examined the effect of emotional images on the bias of manual localization. Because participants moved the cursor by the joystick fixed on vertical surface, we could directly test the effect of emotional information on vertical and voluntary action.

We also examined whether invisible emotional images could modulate motor action. Although a previous study examined whether the emotional valence of an invisible word affected subsequent classification of spatial words (Ansorge et al., 2013), their results might reflect concrete lexical association between vertical space and emotional valence. Thus, the present study examined this issue with non-linguistic stimuli. By addressing this issue, we hoped to identify the stage of mental processing that contributes to the space-valence metaphor. To eliminate emotional information from awareness, we adopted a continuous flash suppression technique (Tsuchiya & Koch, 2005) in which an image stimulus presented to one eye is interocularly masked by a dynamic random pattern continuously presented to the other eye. If unconscious emotional information influences motor action according to the space–valence metaphor, then we would expect to observe emotional-valence modulation of the cursor positioning for both unmasked and masked emotional images.

2. Experiment 1

2.1. Methods

2.1.1. Ethics statement

The ethics committees of Kyushu University approved the protocol of the present study. The experiment was conducted according to the guidelines established by the Helsinki Declaration. We obtained written informed consent from all participants.

2.1.2. Participants

Sixteen right-handed volunteers participated in the experiment. All were unaware of the purpose of the experiment and reported normal vision and motor function.