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4 **The superiority of up/down over left/right in metaphorical association with**
5 **emotion**

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13 Running Head: Anisotropy of the space-valence metaphor

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Abstract

Positive valence links to the upside and dominant side, while negative valence is associated with the downside and non-dominant side (i.e., space-valence metaphor). Previous studies indicate that the effect of the vertical-valence metaphor is more salient than that of the horizontal-valence metaphor. Furthermore, this difference in the saliency is possibly connected with whether the experimental task is related to reaction time (RT) or not. The present study empirically examined these hypotheses; we conducted both the RT and non-RT tasks (i.e., detection task and pointing task, respectively) and compared these results. We found that the effect of the vertical-valence metaphor occurred in both the RT and non-RT tasks, while the typical impact of the horizontal-valence metaphor was not found in both the tasks. Our findings suggest that the effect of the vertical-valence metaphor is salient while the impact of the horizontal-valence metaphor is not robust. Moreover, this difference in the saliency was independent of the kinds of experimental tasks.

Keywords: Emotion, Metaphor, Space, Embodied cognition, Conceptual replication

Introduction

Where are heaven and hell? No one knows, but we often say, “we go *up* to heaven and *down* to hell.” Besides, a clumsy person has two *left* feet, and an intelligent person can answer *right* to difficult problems. In these ways, positive and negative concepts are expressed with vertical and horizontal space: positive concepts are associated with the upside and dominant side, while negative concepts are associated with the downside and non-dominant side (e.g., Casasanto, 2009).

These space-valence metaphors are found not only in linguistic expressions but also in our behavior. For example, Casasanto (2009) has demonstrated that good things are positioned at the upside and dominant side, while bad things are placed at the downside and non-dominant side (i.e., Bob task). Upward and downward actions also modify emotional valences of visual images positively and negatively, respectively (Sasaki, Yamada, & Miura, 2015); a similar effect was also found for horizontal (rightward or leftward) action (Milhau, Brouillet, & Brouillet, 2013). Moreover, participants can rapidly detect a visual target at the upside and downside after observing positive and negative stimuli, respectively (e.g., Meier & Robinson, 2004). Furthermore, when participants make emotional judgments of words, responses to the judgments of the positive/negative words are more rapid with their dominant/non-dominant hand (e.g., de la Vega, De Filippis, Lachmair, Dudschig, & Kaup, 2012). Altogether, the space-valence metaphor was found in various kinds of cognitive tasks.

Is the metaphorical effect equally salient between the vertical-valence and horizontal-valence associations? Previous findings posed challenges in this respect. For example, positive and negative words were allocated at the upside and downside, respectively, while there was no significant difference for the horizontal plane (Marmolejo-Ramos, Elosúa, Yamada, Hamm, & Noguchi, 2013; Marmolejo-Ramos, Correa, Sakarkar, Ngo, Ruiz-Fernández, Butcher, & Yamada, 2017). A similar result was obtained in the case of a pointing task (Sasaki, Yamada, & Miura, 2016) and an emotional evaluation task (Sasaki et al., 2015). Additionally, we conducted a registered direct replication of the Bob task (Casasanto, 2009) for Japanese people. However, we could not obtain the original effect in right-handers, and the effect sizes of all the results were much smaller than those of the original study

(Sasaki, Yonemitsu, & Yamada, 2019). However, several studies addressing the Bob task have successfully replicated the original research (Brouillet, Milhau, & Brouillet, 2015; Casasanto & Chrysikou, 2011; Casasanto & Henetz, 2012; de la Fuente, Casasanto, Martínez-Cascales, & Santiago, 2017; de la Fuente, Casasanto, Román, & Santiago, 2015; de la Fuente, Casasanto, & Santiago, 2015; Kominsky & Casasanto, 2013) and our *p*-curve analysis (Simonsohn, Nelson, & Simmons, 2014) did not support the potentiality that publication bias and questionable research practices (QRPs) mediated in the Bob task (for the details, please see Figure 3 in Sasaki et al., 2019). We also performed *p*-curve analyses for the effects of the vertical-valence and horizontal metaphors (articles published from 2004 to 2019) and found that the *p*-curves of both of the effects were significantly right-skewed and were not flat (Figure 1); publication bias and QRPs were less likely to be involved with the reported findings of the effects of the vertical-valence and horizontal metaphors. These previous studies raise the possibility that the effect of the vertical-valence metaphor is more salient than that of the horizontal-valence metaphor independently of publication bias and QRPs. We empirically tested this issue.

How could these differences in the saliency occur? We hypothesized that the kinds of cognitive tasks used in each study would be connected with the differences in the saliency between the vertical- and horizontal-valence metaphors. This hypothesis was derived from assumptions about how each metaphor should be formed. The previous study (Casasanto, 2009) suggested that the vertical-valence metaphor may arise due to the use of metaphorical expressions in daily life (e.g., “feeling down” or “high on life”) or the experiential co-occurrence of bodily and emotional experiences (e.g., when feeling good, we are upright). In contrast, Casasanto and Chrysikou (2011) demonstrated that the horizontal metaphor stems from a difference in processing fluency between dominant and non-dominant hands. Thus, the salient effect of the horizontal metaphor might be prone to occur in the tasks connected with processing fluency; tasks use a reaction time (RT) as an index. The above studies (Marmolejo-Ramos et al., 2013, 2017; Sasaki et al., 2015, 2016, 2019), where the effect of horizontal metaphor was not found, mainly used non-RT tasks. This way, the impact of the horizontal-valence metaphor might be less salient than that of the vertical-valence metaphor.

Figure 1. *p*-curves of the effects of the vertical-valence (a) and horizontal-valence (b) metaphors.

The present study would test the above hypothesis: We compared the effect of the space-valence metaphor between the RT and non-RT tasks. We conducted a modified detection task (Figure 2a; e.g., Meier & Robinson, 2004) as the RT task, where participants had to detect a target presented around an emotional image. If the space-valence metaphor was found, the target at upside and dominant side would be detected rapidly in the case of a positive image, and vice versa. Moreover, we used a modified pointing task (Figure 2b; Sasaki, Yamada, & Miura, 2016) as the non-RT task, where the participants had to touch a position arbitrarily after observing an emotional image. When the space-valence metaphor was found, touched positions would be at the upside and right side in the case of a positive image, and vice versa. If our hypothesis was correct, the salient effect of the vertical-valence metaphor would be found in both the RT and non-RT tasks, while that of the horizontal metaphor would occur only in the RT one.

Methods

Our protocol was registered on the Open Science Framework (<https://osf.io/5d2ph>) before data collection. We carried out our research according to this protocol except for minor deviations (for details, see the Data Analysis and Footnotes sections).

Figure 2. The timeline of each trial of the RT task (a) and non-RT task (b).

106 *Participants*

107 The present study received approval from the psychological research ethics committee of the Faculty
 108 of Human-Environment Studies at Kyushu University (approval number: 2018-002). The experiment
 109 was conducted according to the guidelines laid down in the Helsinki declaration. We collected the data
 110 only from those who reported that their dominant hand was right and obtained written informed
 111 consent from all participants before the experiments. We calculated the required sample size as 24 for
 112 paired *t*-tests with G*power (Cohen's $d_z = 0.80$, $\alpha = .05$, $1 - \beta = .95$). Moreover, we fixed 1.2 times the
 113 required sample size (i.e., 28) as the maximum sample size. Hence, we collected data from 24 right-
 114 handers for the period from 12th December 2019 to 20th January 2020.

115 *Apparatus*

116 The stimuli will be presented on a 21.5-inch touch panel display (GH-LCT22B-BK, GREEN HOUSE
 117 CO., LTD.) with a refresh rate of 60 Hz and a screen resolution of 1920 × 1080 pixels. A computer
 118 controlled the stimuli presentation and data collection. MATLAB generated stimuli with the
 119 Psychtoolbox extension (Brainard, 1997; Pelli, 1997).

120 *Stimuli*

The viewing distance was about 45 cm. Stimuli consisted of a fixation mark and visual images on a gray background. The fixation mark was composed of two concentric rings (radius, 0.19, and 0.32 deg) in the RT task, while the mark was a white dot (radius, 0.32 deg). We also presented a black dot (radius, 0.19 deg) in the RT task. On the other hand, we introduced a white square frame in the non-RT task, whose side length and width of the squares were 23.84 and 0.06 deg, respectively.

We chose 40 emotional images (20 positive and 20 negative images) from International Affective Picture System (Lang, Bradley, & Cuthbert, 2005); these were also used in the previous study (Sasaki, Yamada, & Miura, 2015). The size of each image was 11.42×8.51 deg. There was a significant difference in emotional valence scores ($t(38) = 34.339, p < .001$, Cohen's $d = 10.859$), while the difference in arousal scores was not significant ($t(38) = 0.558, p = .580$, Cohen's $d = 0.176$).

Procedure

The experiment consisted of two task phases: The RT and non-RT task phases. We counterbalanced the order of the task phases across the participants.

RT task. The participants initiated each trial by pressing a spacebar. Subsequently, the fixation mark was presented for 500 ms. After the disappearance of the fixation mark, we introduced the emotional image, and the participant had to judge whether the image was pleasant or unpleasant by pressing the assigned keys. The target (i.e., the black dot) appeared 10-300 ms after emotional judgment. The target's location was 0.64 deg above, under, on the left, or on the right from the side of the emotional image. The participants were asked to rapidly detect the target by pressing the assigned keys. They performed 160 trials: twenty images, each from two emotional valences (positive and negative) and four target locations (up, down, left, and right). The trial order was randomized across the participants.

Non-RT task. The participants initiated each trial by pressing a spacebar. Then, the fixation mark was presented for 500 ms. After the disappearance of the fixation mark, the emotional image was presented for 500 ms, and the participants were asked to touch an arbitrary position within the square frame. They performed 40 trials: twenty images, each from two emotional valences (positive and negative). The trial order was randomized across the participants.

Data Analysis

In the RT task, we excluded data from trials where the RT was below 100 ms or over the mean + 3 SD, and a wrong answer was provided in the detection task and emotional judgment.¹ Then, we performed a log transformation of the RTs. Two conditions existed for each spatial plane: congruence and incongruence conditions. In the vertical plane, the congruence condition indicated that the target was presented at upside and downside in the case of the positive and negative images, respectively. In contrast, the incongruence condition indicated that the target was presented at a downside and upside in the case of the positive and negative images, respectively. In the horizontal plane, the congruence condition indicated that the target was presented at the left side and right side in the case of the negative and positive images, respectively. In comparison, the incongruence condition indicated that the target was presented at the right side and left side in the case of the negative and positive images, respectively. We calculated an average RT of each of the congruence and incongruence conditions. We performed paired *t*-tests on the log-transformed RTs between congruence and incongruence conditions separately for horizontal and vertical conditions. We planned to conduct equivalent tests (lower equivalence bounds = -0.5, upper equivalence bounds = 0.5, $\alpha = .05$; Lakens, Scheel, & Isager, 2018) for the pairs in which the *t*-tests were not significant. We computed Cohen's *dz* (i.e., $t/\sqrt{n}$; e.g., Lakens, 2013)² and its 95 % confidence intervals (95% CIs for Cohen's *dz*; Cumming & Finch, 2005; Lakens, 2013).

In the non-RT task, we used the *x*- and *y*-coordinates of the touched location (the origin was the center of the display). We excluded data from trials in which the coordinate of the touched position of the dot was outside the mean $\pm$ 3 SD. We calculated the average touched position of each of the positive and negative conditions. Positive values of the *x*- and *y*-coordinates indicated that the participants touched the upside and right side, respectively. In contrast, negative values indicated that the participants touched the downside and left side. We performed a paired *t*-test on each of *x*- and *y*-coordinates of the touched location between positive and negative conditions. We planned to conduct

Figure 3. The violin plots of the results of the experiments. The black dots indicate the mean.

equivalent tests (lower equivalence bounds = -0.5, upper equivalence bounds = 0.5, $\alpha = .05$) for the pairs in which the t -tests were not significant. We computed Cohen's d_z and its 95% CIs.

Results

Figure 3 shows the results. A total of 6.953 % of all the trials were excluded according to the criteria stated in Data Analysis in the RT task, while no data was excluded in the non-RT task. The t -tests on RTs showed that the RT of the vertical plane was significantly shorter in the congruence condition than

Figure 4. Cohen's d_z of each experiment. Error bars indicate 95% CIs.

178 in the incongruence condition ($t(23) = 3.632, p = .001$, Cohen's $d_z = 0.742$), while there was no
 179 significant difference in the RT of the horizontal plane ($t(23) = 0.155, p = .878$, Cohen's $d_z = 0.032$).
 180 Thus, we performed the equivalent test for the RT of the horizontal plane and found a significant
 181 equivalence ($t(23) = 2.294, p = .016$). We computed the 95% CI of Cohen's d_z for each plane, and
 182 those of the vertical and horizontal planes were $[0.282, 1.189]$ and $[-0.369, 0.432]$, respectively (Figure
 183 4).

184 Moreover, the t -tests on y -coordinates showed that the touch position was significantly higher
 185 in the positive condition than in the negative condition ($t(23) = 2.534, p = .019$, Cohen's $d_z = 0.517$).
 186 On the other hand, the t -tests on x -coordinates revealed that the touch position was significantly
 187 rightward in the negative condition than in the positive condition ($t(23) = 2.286, p = .032$, Cohen's d_z
 188 $= 0.467$). We computed the 95% CI of Cohen's d_z for each coordinate, and those of the x - and y -
 189 coordinates were $[0.085, 0.939]$ and $[0.040, 0.884]$, respectively (Figure 4).

Discussion

The results showed that the significant effect of the vertical-valence metaphor was found in both the RT and non-RT tasks. In contrast, there was a substantial equivalence in the RT of the horizontal plane between the congruence and incongruence conditions. Moreover, the touched position was significantly at the right side in the negative condition in comparison with the positive condition; briefly, this is an opposite tendency of the horizontal-valence metaphor. We also computed Cohen's d_z for each condition. Cohen's d_z of the RT-horizontal condition was notably smaller than those of the other conditions, although the 95% CIs overlapped among the conditions to some extent. Taken together, our findings suggest that the vertical-valence metaphor is more salient than the horizontal metaphor. However, the typical effect of the horizontal metaphor was not found. Therefore, these findings partly support our hypothesis.

How is the vertical-valence metaphor more salient than the horizontal metaphor? We hypothesized that the specific kind of task would be connected with this difference in the saliency; our data did not support this hypothesis. Our findings indicate that the effect of the horizontal-valence metaphor was not robust, unlike the vertical-valence metaphor, which is consistent with the previous studies (Marmolejo-Ramos et al., 2013, 2017; Sasaki et al., 2015, 2016, 2019). At this time, there is no apparent reason for the lack of robustness of the horizontal-valence metaphor. Perhaps, the plasticity of the sensorimotor system in the horizontal plane might be connected with this lack of robustness. A previous study of reverse vision has revealed that we can adapt to horizontally reverse vision more rapidly than vertically reverse vision (Miyauchi, Egusa, Amagase, Sekiyama, Imaruoka, & Tashiro, 2004), supporting the plasticity of the sensorimotor system in the horizontal plane. This plasticity of the sensorimotor system might disrupt the strong association between horizontal space and emotional valence (for a similar discussion, see Marmolejo-Ramos et al., 2013).

The horizontal-valence metaphor is related to a *body-specificity hypothesis* (Casasanto, 2009); people with different bodies should form different mental representations. According to the body-specificity hypothesis, right-handers can interact with physical environments more fluently on their

right side than on their left side, and this difference in fluency possibly leads to an association between emotion valences and horizontal space (i.e., horizontal-valence metaphor). On the other hand, the present study as well as the previous studies (Marmolejo-Ramos et al., 2013, 2017; Sasaki et al., 2015, 2016, 2019) did not find the typical effect of the horizontal-valence metaphor. Considering that the effect of the horizontal metaphor on our behavior is one of the significant grounds for the body-specificity hypothesis (Casasanto, 2009) and this effect does not seem to be stable, it cannot be said at this time that the body-specificity hypothesis dominantly accounts for the formation of mental representations; indeed, this hypothesis might partially be valid.

In the vertical plane of the non-RT task, the touched positions in both valences were below the center. However, the touched position was significantly higher in the positive condition than in the negative condition. Indeed, posterior tests (i.e., one-sample *t*-tests) showed that the *y*-coordinates in both valences were significantly smaller than zero ($t_s(23) > 2.583$, $ps < .017$, Cohen's $d_zs > 0.527$). Similarly, several studies have repeatedly reported the significant differences between positive and negative emotions whereas the differences from the center were inconsistent (Crawford, Margolies, Drake, & Murphy, 2006; Damjanovic & Santiago, 2016; Gozli, Chow, Chasteen, & Pratt, 2013; Lynott & Coventry, 2014; Marmolejo-Ramos et al., 2013; Meier & Robinson, 2004; Sasaki et al., 2016; Xie, Huang, Wang, & Liu, 2015). These previous and present findings support the idea that positive and negative emotions are not absolutely associated with upside and downside, respectively, but positive emotion is located relatively higher compared with negative emotion.

In the present study, although the typical effect of the horizontal-valence metaphor was not found, the opposite tendency was observed: The touched position in the negative condition was at the dominant side (i.e., right side) in comparison with that in the positive condition. The previous studies repeatedly reported that positive and negative emotions link with the dominant and non-dominant sides, respectively (Casasanto & Chrysikou, 2011; Casasanto & Henetz, 2012; de la Fuente et al., 2017; de la Fuente et al., 2015; de la Fuente et al., 2015; de la Vega et al., 2012; Kominsky & Casasanto, 2013; Milhau et al., 2013). Considering these previous studies, the obtained pattern in the present study was

unexpected. At this time, we should avoid discussing the reason for this unexpected pattern. In arriving at a definite conclusion, it is necessary to confirm how much the opposite trend in the present study is robust and to systematically compare the current experiment with the previous experiments producing the typical pattern.

The present study used the detection and pointing tasks as the RT and non-RT tasks, respectively, for Japanese people. Previous studies on the space-valence metaphor used an emotional judgment of words (e.g., de la Vega et al., 2012; Dudschig, de la Vega, & Kaup, 2015), rating task (e.g., Milhau et al., 2013; Sasaki et al., 2015), the task related to the saccade (Gozli et al., 2013), and so on. Although there was no significant effect of the horizontal-valence metaphor, its robust effect might be found in the case of the other tasks. Moreover, the effect of the horizontal-valence metaphor might be weak, in particular, in Japanese people. Several studies, where the effect of the horizontal-valence metaphor was not found, targeted Japanese people (Sasaki et al., 2015, 2016, 2019) as with the present study or were cross-cultural studies including Japan (Marmolejo-Ramos et al., 2013, 2017). The left side tended to be evaluated better than the right side (e.g., minister of the left and minister of the right) before modern times of Japan, and this remnant is sometimes found even now. These cultural backgrounds might mediate in our results. Systematic investigation addressing various tasks and cultural backgrounds should be conducted in future studies to determine the mechanism of the differences in the saliency of the space-valence metaphor.

Footnotes

¹We were remiss in not recording the exclusion rule of wrong answers to the detection task and emotional judgment in the pre-registered protocol. These rules should be suitable for measuring accuracy. Thus, we spontaneously modified the plan before data collection.

²We planned to calculate the Cohen's d in the pre-registered protocol. However, we realized that Cohen's d_z would be more appropriate for the within-participant design. Thus, we spontaneously modified the plan before data collection.

References

- Brainard, D. H. (1997). The psychophysics toolbox. *Spatial Vision*, 10, 433–436.
- Brouillet, D., Milhau, A., & Brouillet, T. (2015). When “good” is not always right: effect of the consequences of motor action on valence-space associations. *Frontiers in psychology*, 6, 237.
- Casasanto, D. (2009). Embodiment of abstract concepts: Good and bad in right- and left-handers. *Journal of Experimental Psychology: General*, 138, 351–367.
- Casasanto, D., & Chrysikou, E. G. (2011). When left is “right”. Motor fluency shapes abstract concepts. *Psychological Science*, 22, 419–422.
- Casasanto, D., & Henetz, T. (2012). Handedness shapes children’s abstract concepts. *Cognitive Science*, 36, 359–372.
- Crawford, L. E., Margolies, S. M., Drake, J. T., & Murphy, M. E. (2006). Affect biases memory of location: Evidence for the spatial representation of affect. *Cognition & Emotion*, 20, 1153–1169.
- Cumming, G., & Finch, S. (2005). Inference by eye: Confidence intervals and how to read pictures of data. *American Psychologist*, 60, 170–180.
- Damjanovic, L., & Santiago, J. (2016). Contrasting vertical and horizontal representations of affect in emotional visual search. *Psychonomic Bulletin & Review*, 23, 62–73.
- de la Fuente, J., Casasanto, D., Martínez-Cascales, J. I., & Santiago, J. (2017). Motor imagery shapes abstract concepts. *Cognitive Science*, 41, 1350–1360.
- de la Fuente, J., Casasanto, D., Román, A., & Santiago, J. (2015). Can culture influence body-specific associations between space and valence? *Cognitive Science*, 39, 821–832.
- de la Fuente, J., Casasanto, D., & Santiago, J. (2015). Observed actions affect body-specific associations between space and valence. *Acta Psychologica*, 156, 32–36.
- de la Vega, I., de Filippis, M., Lachmair, M., Dudschig, C., & Kaup, B. (2012). Emotional valence and physical space: Limits of interaction. *Journal of Experimental Psychology: Human Perception and Performance*, 38, 375–385.
- Dudschig, C., de la Vega, I., & Kaup, B. (2015). What’s up? Emotion-specific activation of vertical

- space during language processing. *Acta Psychologica*, 156, 143–155.
- Gozli, D., Chow, A., Chasteen, A., & Pratt, J. (2013). Valence and vertical space: Saccade trajectory deviations reveal metaphorical spatial activation. *Visual Cognition*, 21, 628–646.
- Kominsky, J. F., & Casasanto, D. (2013). Specific to whose body? Perspective-taking and the spatial mapping of valence. *Frontiers in Psychology*, 4, 266.
- Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for *t*-tests and ANOVAs. *Frontiers in Psychology*, 4, 1–12.
- Lakens, D., Scheel, A.M., & Isager, P.M. (2018). Equivalence testing for psychological research: A tutorial. *Advances in Methods and Practices in Psychological Science*, 1, 259–269.
- Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2005). International affective picture system (IAPS): Affective ratings of pictures and instruction manual. *Technical report A-6*. Gainesville, FL: University of Florida.
- Lynott, D., & Coventry, K. (2014). On the ups and downs of emotion: Testing between conceptual-metaphor and polarity accounts of emotional valence–spatial location interactions. *Psychonomic Bulletin & Review*, 21, 218–226.
- Marmolejo-Ramos, F., Correa, J. C., Sakarkar, G., Ngo, G., Ruiz-Fernández, S., Butcher, N., & Yamada, Y. (2017). Placing joy, surprise and sadness in space: A cross-linguistic study. *Psychological Research*, 81, 750–763.
- Marmolejo-Ramos, F., Elosúa, M. R., Yamada, Y., Hamm, N., & Noguchi, K. (2013). Appraisal of space words and allocation of emotion words in bodily space. *PLOS ONE*, 8: e81688.
- Meier, B. P., & Robinson, M. D. (2004). Why the sunny side is up: Association between affect and vertical position. *Psychological Science*, 15, 243–247.
- Milhau, A., Brouillet, T., & Brouillet, D. (2013). Biases in evaluation of neutral words due to motor compatibility effect. *Acta Psychologica*, 144, 243–249.
- Miyauchi, S., Egusa, H., Amagase, M., Sekiyama, K., Imaruoka, T., & Tashiro, T. (2004). Adaptation to left–right reversed vision rapidly activates ipsilateral visual cortex in humans. *Journal of*

- Casasanto, D. (2009). Embodiment of abstract concepts: Good and bad in right- and left-handers. *Journal of Experimental Psychology: General*, 138, 351–367.
- Casasanto, D., & Chrysikou, E. G. (2011). When left is “right”. Motor fluency shapes abstract concepts. *Psychological Science*, 22, 419–422.
- Casasanto, D., & Henetz, T. (2012). Handedness shapes children’s abstract concepts. *Cognitive Science*, 36, 359–372.
- Casasanto, D., & Jasmin, K. (2010). Good and bad in the hands of politicians: Spontaneous gestures during positive and negative speech. *PLOS ONE*, 5, e11805.
- Crawford, L. E., Margolies, S. M., Drake, J. T., & Murphy, M. E. (2006). Affect biases memory of location: Evidence for the spatial representation of affect. *Cognition & Emotion*, 20, 1153–1169.
- Damjanovic, L., & Santiago, J. (2016). Contrasting vertical and horizontal representations of affect in emotional visual search. *Psychonomic Bulletin & Review*, 23, 62–73.
- de la Fuente, J., Casasanto, D., Martínez-Cascales, J. I., & Santiago, J. (2017). Motor imagery shapes abstract concepts. *Cognitive Science*, 41, 1350–1360.
- de la Fuente, J., Casasanto, D., Román, A., & Santiago, J. (2015). Can culture influence body-specific associations between space and valence? *Cognitive Science*, 39, 821–832.
- de la Fuente, J., Casasanto, D., & Santiago, J. (2015). Observed actions affect body-specific associations between space and valence. *Acta Psychologica*, 156, 32–36.
- de la Vega, I., de Filippis, M., Lachmair, M., Dudschig, C., & Kaup, B. (2012). Emotional valence and physical space: Limits of interaction. *Journal of Experimental Psychology: Human Perception and Performance*, 38, 375–385.
- de la Vega, I., Dudschig, C., De Filippis, M., Lachmair, M., & Kaup, B. (2013). Keep your hands crossed: The valence-by-left/right interaction is related to hand, not side, in an incongruent hand–response key assignment. *Acta Psychologica*, 142, 273–277.
- de la Vega, I., Graebe, J., Härtner, L., Dudschig, C., & Kaup, B. (2015). Starting off on the right foot: strong right-footers respond faster with the right foot to positive words and with the left foot to

- negative words. *Frontiers in Psychology*, 6, 292.
- Dudschig, C., de la Vega, I., & Kaup, B. (2015). What's up? Emotion-specific activation of vertical space during language processing. *Acta Psychologica*, 156, 143–155.
- Eder, A. B., & Rothermund, K. (2008). When do motor behaviors (mis) match affective stimuli? An evaluative coding view of approach and avoidance reactions. *Journal of Experimental Psychology: General*, 137, 262–281.
- Freddi, S., Brouillet, T., Cretenet, J., Heurley, L. P., & Dru, V. (2016). A continuous mapping between space and valence with left-and right-handers. *Psychonomic Bulletin & Review*, 23, 865–870.
- Gottwald, J. M., Elsner, B., & Pollatos, O. (2015). Good is up—spatial metaphors in action observation. *Frontiers in Psychology*, 6, 1605.
- Gozli, D., Chow, A., Chasteen, A., & Pratt, J. (2013). Valence and vertical space: Saccade trajectory deviations reveal metaphorical spatial activation. *Visual Cognition*, 21, 628–646.
- Horstmann, G., & Ansorge, U. (2011). Compatibility between tones, head movements, and facial expressions. *Emotion*, 11, 975–980.
- Huang, Y., & Tse, C. S. (2015). Re-examining the automaticity and directionality of the activation of the spatial-valence" good is up" metaphoric association. *PLOS ONE*, 10, e0123371.
- Kato, T., Imaizumi, S., & Tanno, Y. (2018). Metaphorical action retrospectively but not prospectively alters emotional judgment. *Frontiers in Psychology*, 9, 1927.
- Kominsky, J. F., & Casasanto, D. (2013). Specific to whose body? Perspective-taking and the spatial mapping of valence. *Frontiers in Psychology*, 4, 266.
- Kong, F. (2013). Space–valence associations depend on handedness: Evidence from a bimanual output task. *Psychological Research*, 77, 773–779.
- Lichtenstein-Vidne, L., Gabay, S., Cohen, N., & Henik, A. (2017). Lateralisation of emotions: evidence from pupil size measurement. *Cognition and Emotion*, 31, 699–711.
- Lynott, D., & Coventry, K. (2014). On the ups and downs of emotion: Testing between conceptual-metaphor and polarity accounts of emotional valence–spatial location interactions. *Psychonomic*

- 401 *Bulletin & Review*, 21, 218–226.
- 402 Marmolejo-Ramos, F., Arshamian, A., Tirado, C., Ospina, R., & Larsson, M. (2019). The Allocation
403 of valenced percepts onto 3D space. *Frontiers in Psychology*, 10, 352.
- 404 Meier, B. P., & Robinson, M. D. (2004). Why the sunny side is up: Association between affect and
405 vertical position. *Psychological Science*, 15, 243–247.
- 406 Milhau, A., Brouillet, T., Dru, V., Coello, Y., & Brouillet, D. (2017). Valence activates motor fluency
407 simulation and biases perceptual judgment. *Psychological Research*, 81, 795–805.
- 408 Milhau, A., Brouillet, T., & Brouillet, D. (2013). Biases in evaluation of neutral words due to motor
409 compatibility effect. *Acta Psychologica*, 144, 243–249.
- 410 Pitt, B., & Casasanto, D. (2018). Spatializing emotion: No evidence for a domain - general magnitude
411 system. *Cognitive Science*, 42, 2150–2180.
- 412 Santiago, J., Ouellet, M., Román, A., & Valenzuela, J. (2012). Attentional factors in conceptual
413 congruency. *Cognitive Science*, 36, 1051–1077.
- 414 Sasaki, K., Seno, T., Yamada, Y., & Miura, K. (2012). Emotional sounds influence vertical vection.
415 *Perception*, 41, 875–877.
- 416 Sasaki, K., Yamada, Y., & Miura, K. (2015). Post-determined emotion: motor action retrospectively
417 modulates emotional valence of visual images. *Proceedings of the Royal Society B: Biological*
418 *Sciences*, 282: 20140690.
- 419 Sasaki, K., Yamada, Y., & Miura, K. (2016). Emotion biases voluntary vertical action only with visible
420 cues. *Acta Psychologica*, 163, 97–106.
- 421 Sasaki, K., Yonemitsu, F., & Yamada, Y. (2019). Goodness of the side of the dominant hand: A
422 registered direct replication of Casasanto (2009). *Japanese Psychological Review*, 63, 262–271.
423 (in Japanese)
- 424 Seno, T., Kawabe, T., Ito, H., & Sunaga, S. (2013). Vection modulates emotional valence of
425 autobiographical episodic memories. *Cognition*, 126, 115–120.
- 426 Song, X., Chen, J., & Proctor, R. W. (2017). Role of hand dominance in mapping preferences for

emotional-valence words to keypress responses. *Acta Psychologica*, 180, 33–39.

Torres, S. C., Fernández, S. R., Lachmair, M., & Gerjets, P. (2020). Coding valence in touchscreen interactions: hand dominance and lateral movement influence valence appraisals of emotional pictures. *Psychological Research*, 84, 23–31.

Weger, U. W., Meier, B. P., Robinson, M. D., & Inhoff, A. W. (2007). Things are sounding up: Affective influences on auditory tone perception. *Psychonomic Bulletin & Review*, 14, 517–521.

Xie, J., Huang, Y., Wang, R., & Liu, W. (2015). Affective valence facilitates spatial detection on vertical axis: shorter time strengthens effect. *Frontiers in Psychology*, 6, 277.

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Data availability

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All the data have been uploaded at <https://osf.io/m4eqa>

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Author contribution (CRediT style)

444
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446 Investigation, Methodology, Writing - Original Draft, and Writing – Review & Editing
447 Kyoshiro Sasaki: Conceptualization, Data curation, Formal analysis, Funding acquisition,
448 Methodology, Project administration, Resources, Software, Visualization, Writing - Original
449 Draft, and Writing – Review & Editing
450 Yuki Yamada: Conceptualization, Funding acquisition, Methodology, Resources, Supervision, Writing
451 - Original Draft, and Writing – Review & Editing