Psychon Bull Rev (2016) 23:865–870
DOI 10.3758/s13423-015-0950-0

BRIEF REPORT

A continuous mapping between space and valence with left- and right-handers

Sébastien Freddi[1] · Thibaut Brouillet[1] · Joël Cretenet[1] · Loïc P. Heurley[1] · Vincent Dru[1]

Published online: 1 October 2015

Abstract In this research, we examined whether emotional valence could correspond to a continuous lateral bias in space, according to a mental metaphor that establishes the mapping between a concrete domain (space) and an abstract one (valence). Because acting with one's dominant hand is associated with fluency and positive valence (the bodily specificity hypothesis, or BSH), we asked strong right- and left-handers to perform two spatial location tasks using emotional faces with seven levels of valence. We hypothesized and showed through two studies that, according to the BSH, extreme valenced stimuli (as compared to moderate and weak ones) would be located more at the extremity of a horizontal line, according to the correspondences between handedness and the different valences of the stimuli. This research establishes that spatial and continuous mapping of emotions was obtained while controlling for motivational direction.

Keywords Body specificity hypothesis · Fluency · Handedness · Space · Valence

Mental metaphors associate a source domain continuum, which is typically more concrete and can be experienced directly through perceptive and bodily cues, with a target domain continuum, which is more abstract and can only be experienced through thinking (Casasanto, 2008; Lakoff & Johnson, 1980). Casasanto (2009) suggested that one kind of mental metaphor might operate as an implicit mapping between a concrete source domain, such as lateral space (i.e., left vs. right), with a more abstract target domain, such as valence (i.e., badness vs. goodness). If the space–valence mapping might be considered a mental metaphor, then the relationship between space and valence should be continuous (Casasanto, 2009).

However, the mental metaphor of spatial mapping of valence might also be considered to be categorical. One argument is that, when you look at your hands acting within lateral space, they could be considered categorical—that is, each hand is "categorized" as your left or right hand. So, anything on the side of the dominant hand is good, and anything on the side of the nondominant hand is bad, with no difference in the spatial mappings of *degrees* of goodness and badness within each side. This would mean that different levels of valence, either positive or negative, might be equally associated with the different sides of the dominant and nondominant hands.

Although the space–valence mapping might be considered continuous (as a mental metaphor; Casasanto & Gijssels, 2015), both space and valence have been examined as categorical cues in most previous studies. For example, Casasanto (2009) showed that when right- and left-handed participants were invited to locate valenced stimuli in space, right- and left-handers placed positive stimuli on the side of their dominant hand. Likewise, negative stimuli were placed on the nondominant side. In sum, right- and left-handers tended to associate emotional concepts to space in different ways because these concepts activated the dominant or the nondominant side of their bodies (Casasanto, 2009; Casasanto & Jasmin, 2010). Casasanto (2009, 2014) predicted this pattern of results on the basis of the body specificity hypothesis (BSH), according to which people with different kinds of bodies, who interact with the environment is different ways, think differently as a consequence. Several authors have explained these results in terms of a motor fluency, which stipulates that right- and left-handers implicitly associate positive valence

✉ Vincent Dru
dru@u-paris10.fr; druvincent@wanadoo.fr

1 U.F.R. STAPS, Université Paris Ouest, Nanterre La Défense, France

with the side of space on which they usually act more fluently (Casasanto & Chrysikou, 2011; de la Vega, de Filippis, Lachmair, Dudschig, & Kaup, 2012; Kong, 2013; Milhau, Brouillet, & Brouillet, 2013, 2015). In these different experiments, participants judged stimuli presented on their right or their left, or responded using the right or left hand.

Therefore, it has remained an open question whether the space–valence mapping is categorical or continuous, since clear evidence has been established for mappings between source and target continua such as space and time (Casasanto, & Boroditsky, 2008), space and pitch (Dolscheid, Shayan, Majid, & Casasanto, 2013), and space and numbers (Winter, Marghetis, & Matlock, 2015). In the present study, we addressed this question by asking participants to view faces that vary continuously in valence and to arrange them along a spatial continuum. So, the purpose of this research was twofold, and hence involved two different studies. In the first study, we aimed to establish a continuous mapping between space and valence, according to the BSH. In the second, we set out to examine the spatial mapping of valence when the motivational direction associated with the stimuli was controlled.

We predicted that left-handers would place extremely positive stimuli on the extreme left side of the line, as compared to moderate and weakly positive ones, whereas this pattern would be reversed for negative stimuli. In contrast, right-handers would place extremely positive stimuli on the extreme right side of the line, as compared to moderate and weakly positive ones, and this pattern would be reversed for negative stimuli. In Study 1 we investigated this hypothesis with frowning and smiling faces, whereas in Study 2 we used emotional faces associated with the motivational direction of approach (from angry to happy faces; Carver & Harmon-Jones, 2009).

Study 1

Method

Participants A total of 49 student volunteers (for statistical power considerations, see below) studying sport sciences in an urban French University participated in the experiment (20 males, 29 females; mean age = 25.98 years, $SD = 1.87$). They were first recruited at the university after verbally stating whether they were really left- or right-handers. Second, handedness was assessed through a six-item questionnaire (Porac & Cohen, 1981), and participants who had at least five consistent responses in the right or left direction were included in the study (26 right- and 23 left-handers). Participants were selected for being strongly right- or left-handed, rather than ambidextrous.

Experimental design and procedure The participants had to centrally face a 44-cm VGA computer screen on which different faces were projected, such as frowny and smiling faces (Fig. 1a, taken from Andrews & Whitney, 1976; see also Dru & Cretenet, 2008). After a 5-s presentation, participants had to draw a circle corresponding to that facial expression on one page of a booklet containing a continuous line (18 cm long), with its center placed in front of the participant. The instructions were to draw each expression at any location on the line that they chose, on one page for each stimulus.

The experiment had a 2 (Handedness: left vs. right) × 7 (Faces: extremely negative, moderately negative, weakly negative, neutral, weakly positive, moderately positive, extremely positive) design, with only the last factor being manipulated within subjects. A power analysis (conducted via the G*Power software; Faul, Erdfelder, Lang, & Buchner, 2007), which assumed a medium effect size of 0.25 for the analysis of variance (ANOVA) in our experimental design, indicated that a total of 26 participants (13 per condition) would be required in order to have 95% power of detecting a significant effect at a p value of .05.

Materials and measures Each of the seven faces was presented three times in a random order, for a total of 21 trials. We measured the distance between the center of the line and the center of the drawn circle. Negative values represented a circle located on the left side of the line, whereas positive values represented a circle located on the right side. The scores were averaged for each participant and for each level of valence

Results and discussion

The ANOVA did not reveal any main effect, either of handedness or of the faces ($F < 1$). However, as we expected, the ANOVA revealed that the interaction between these factors was significant [$F(6, 282) = 20.22$, $MSE = 501.97$, $p < .001$, $\eta_p^2 = .30$; see the top of Fig. 2].

More precisely, for left-handers, the faces were located in a continuous way from the left side, which was associated with the positive faces, to the right side, which was associated with the negative faces ($M_{ExtNeg} = +4.18$ cm, $SD = 1.35$; $M_{ModNeg} = +3.77$ cm, $SD = 1.12$; $M_{WkNeg} = +3.06$ cm, $SD = 0.73$; $M_{Neut} = –0.40$ cm, $SD = 0.33$; $M_{WkPos} = –2.42$ cm, $SD = 1.13$; $M_{ModPos} = –3.11$ cm, $SD = 1.30$; $M_{ExtPos} = –3.71$ cm, $SD = 0.70$). The t tests (with Bonferroni-adjusted ps < .05) showed significant differences for all pairs except the difference between the extremely and moderately negative faces.

For the right-handers, the mapping was also continuous, but the left side was associated with the negative faces and the right side with the positive faces ($M_{ExtNeg} = –3.39$, $SD = 0.89$; $M_{ModNeg} = –3.38$, $SD = 1.27$; $M_{WkNeg} = –2.32$, $SD = 1.15$; $M_{Neut} = +0.09$, $SD = 0.43$; $M_{WkPos} = +1.34$, $SD = 0.45$; $M_{ModPos} = +2.45$, $SD = 0.96$; $M_{ExtPos} = +4.31$, $SD = 1.35$).

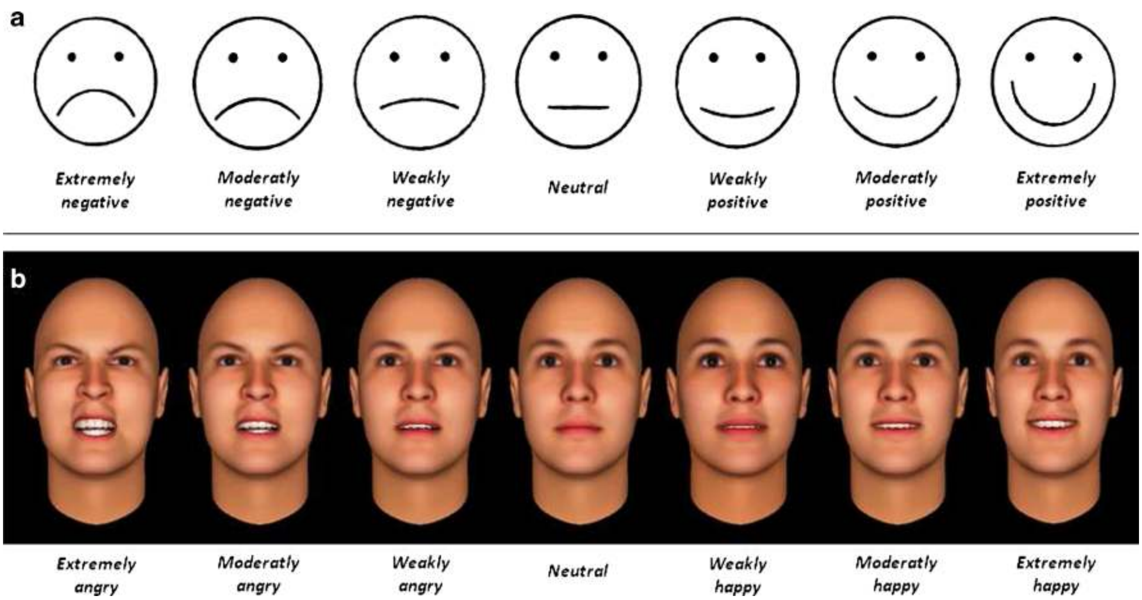

Fig. 1 Faces projected in Study 1 (**a**) and Study 2 (**b**)

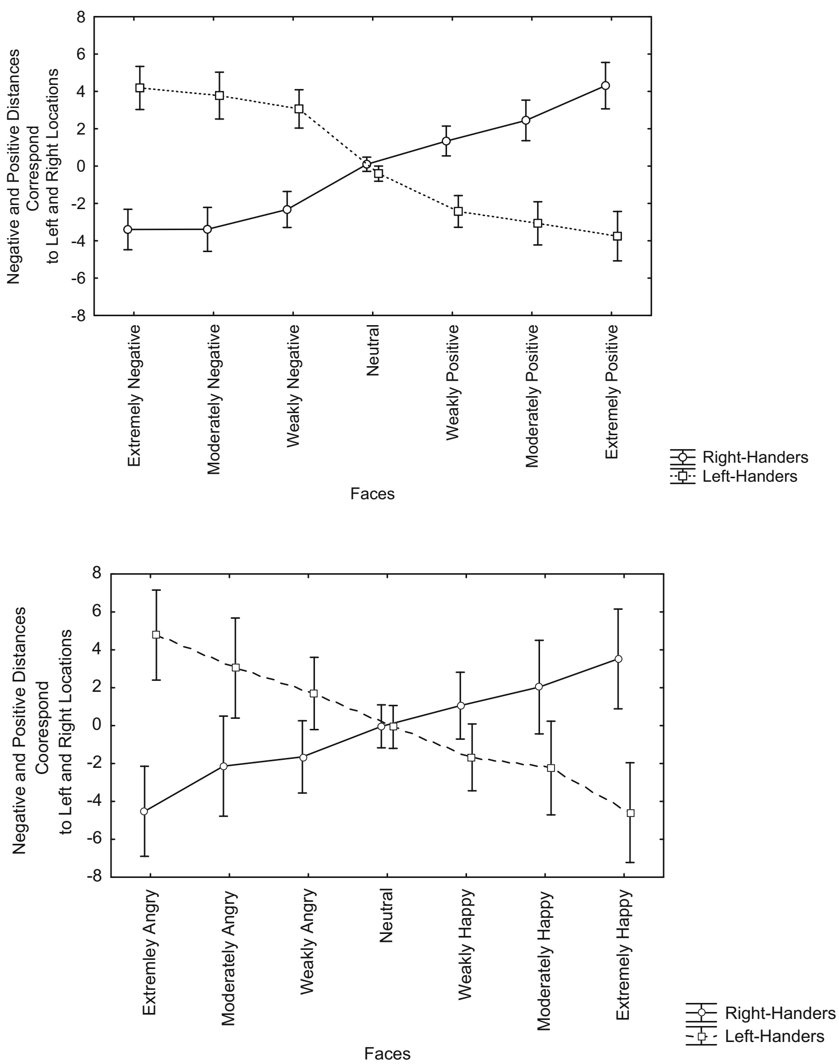

Fig. 2 Interaction between handedness and faces on the spatial locations in Study 1 (top) and Study 2 (bottom, *Bar* represent Standard Errors in the two Studies

Post-hoc t tests (with Bonferroni-adjusted ps < .05) also showed significant differences for all pairs, except again between the extremely and moderately negative faces.

First, this result replicated the results of Casasanto (2009): The association between valence and space was modulated by the handedness of the participants, in support of the BSH. Second, and more importantly, these results also indicated continuous mappings between space and valence for both the left- and right-handers. However, the main problem of this first study was that the faces used might have confounded valence with motivational direction. Indeed, the happy faces were both positive and approach stimuli, whereas the sad faces were both negative and avoiding stimuli. Therefore, in the second study we exactly replicated Study 1, with emotional faces varying at the valence level but not at the level of motivational direction. We therefore used faces evolving from an angry to a happy expression, because both reflect an approach motivation (Carver & Harmon-Jones, 2009).

Study 2

Method

Participants A total of 36 student volunteers studying sport sciences in an urban French university participated in this new experiment (20 males, 16 females; mean age = 25.98 years, SD = 1.87). They were recruited in a manner similar to that in Study 1.

Experimental design, procedure, materials, and stimuli The procedure was similar to that of the first study, except for the faces. We still used six emotional faces and a neutral one, but they ranged from angry to happy faces, with three different levels (weak, moderate, and extreme). These faces were generated by the FaceGen software (www.facegen.com). The faces were morphed by changing the rating scales of the two corresponding emotions (0% was a neutral face, 33% was the weak expression in either an angry or a happy direction, 66% was the moderate level, and 100% was the extreme level; see Fig. 1b).

Results

As in Study 1, the ANOVA did not reveal any significant main effect, either of handedness or of the faces ($F < 1$). Also as in Study 1, the ANOVA revealed the predicted interaction between the handedness and the faces [$F(6, 204) = 18.62$, MSE = 322.35, $p < .001$, $\eta_p^2 = .35$; see the bottom of Fig. 2].

Again, for left-handers, the faces were located from the left side, which was associated with the positive (i.e., happy) faces, to the right side, which was associated with the negative (i.e., angry) faces, depending on the emotional level (M_{ExtAng} = +4.77 cm, SD = 1.23; M_{ModAng} = +3.03 cm, SD = 1.19; M_{WkAng} = +1.70 cm, SD = 0.87; M_{Neut} = –0.06 cm, SD = 0.56; M_{WkHap} = –1.67 cm, SD = 0.98; M_{ModHap} = –2.23 cm, SD = 1.17; M_{ExtHap} = –4.58 cm, SD = 0.70). The t tests (with Bonferroni-adjusted ps < .05) showed significant differences for all pairs except the difference between the weakly and moderately happy faces.

Conversely, for the right-handers, the mapping was also continuous, but the left side was associated with the negative (i.e., angry) faces, and the right side with the positive (i.e., happy) faces (M_{ExtAng} = –4.51, SD = 1.09; M_{ModAng} = –2.13, SD = 1.39; M_{WkAng} = –1.64, SD = 0.99; M_{Neut} = –0.03, SD = 0.55; M_{WkHap} = +1.05, SD = 0.73; M_{ModHap} = +2.03, SD = 1.25; M_{ExtHap} = +3.52, SD = 1.61). Post-hoc t tests (with Bonferroni-adjusted ps < .05) showed significant differences for all pairs except for the difference between the moderately and weakly angry faces.

General discussion

The aim of this article was to examine the possibility of a continuous mapping between space and valence. The mental metaphor that implicitly associates space (the concrete source domain) with valence (the abstract target domain) might not be simply categorical. In both of our studies, we found that right- and left-handers located positive and negative stimuli with stronger lateral biases when the stimuli were more extreme in valence than with the moderate and weak stimuli. The more extreme was the stimulus, the more it was located at its corresponding place, according to the BSH proposed by Casasanto (2009). This result was obtained not only with frowning and smiling faces, but also with emotional faces, which helped to vary valence while controlling for the associated motivational direction.

This research might be related to the results provided by Brunyé, Gardony, Mahoney, and Taylor (2012). They asked whether the effect of handedness on the space–valence mapping is continuous. For example, they first asked participants to learn about various map locations (with the use of the Google Map tool) associated with negative, neutral, and positive events. In the second phase, participants had to recall these locations by clicking with the mouse on the map where the events took place. A measure of the distance and the direction between the learned location and the remembered one was recorded. The results showed that different degrees of left- or right-handedness were associated with the extent to which the positive stimuli were directed, respectively, to the left or the right side (and vice versa for negative stimuli). Space, which is associated with valence, varied continuously as function of continuous handedness.

Nevertheless, the results from Brunyé et al. (2012) only partially support the continuous claim, because their results do not guarantee that the valence itself is represented in a continuous way. Indeed, it is possible to assume that only the "strength" of handedness influenced the way in which participants associated the valence categories (positive vs. negative) with the space. The handedness of the participants might have influenced, in a continuous way, the mapping between space as a continuous factor and valence as a categorical factor. So, if valence is also coded continuously along a horizontal metric line, then we could also assume that strong left- and right-handers (as a categorical variable) would have placed affective stimuli differently because of their levels of valence. Although Brunyé et al. considered that handedness (the concrete source domain of the metaphor) might help to code space continuously with valence, we suggest that valence (the abstract target domain) itself is also continuous, in order to provide continuous responses in lateral space.

Coupling this result with the present research helps us to consider that the mental metaphor of the spatial mapping of valence might be developed in a continuous direction, either with the concrete source domain (i.e., handedness with space involved) or with the abstract target one (i.e., valence). One promising line of future research would be to examine how the source (i.e., handedness) and the target (i.e., valence) domains might interact when they are considered together in a continuous way, in order to fully investigate the mental metaphor of the left–right mapping of valence.

It is noteworthy that these results are not opposed to previous results reporting a categorical mapping between space and valence (e.g., Casasanto, 2009). We assume that experimental designs usually manipulate space and valence in a categorical way, in order to examine whether the space–valence mapping might be considered a mental metaphor; they did not focus precisely on a possible examination of this metaphor as continuous. However, these results might also be easily derived from an underlying continuous spatial mapping of valence. In addition, we would highlight the relevance of our results according to the current literature about the conceptual metaphor theory. Recently, a growing body of results has supported the idea that the left–right axis is a relevant spatial reference in order to metaphorically understand continuous abstract concepts. Indeed, mapping between such an axis and concepts such as numbers, time, and even politics is now strongly supported (Casasanto & Boroditsky, 2008; Dehaene, Bossini, & Giraux, 1993; Oppenheimer & Trail, 2010; Ren, Nicholls, Ma, & Chen, 2011; for recent reviews, see Bonn & Cantlon, 2012; Dijkstra, Eerland, Zijlmans, & Post, 2014; Winter et al., 2015). Together with our present results regarding the concept of valence, we assume the possibility that humans could have a kind of general tendency to represent continuous abstract concepts via the metaphor of a left–right continuum.

References

Andrews, F. M., & Whitney, S. B. (1976). *Social indicators of well-being*. New York, NY: Plenum.

Bonn, C. D., & Cantlon, J. F. (2012). The origins and structure of quantitative concepts. *Cognitive Neuropsychology, 29,* 149–173. doi:10.1080/02643294.2012.707122

Brunyé, T. T., Gardony, A., Mahoney, C. R., & Taylor, H. A. (2012). Body-specific representations of spatial location. *Cognition, 123,* 229–239.

Carver, C. S., & Harmon-Jones, E. (2009). Anger is an approach-related affect: Evidence and implications. *Psychological Bulletin, 135,* 183–204. doi:10.1037/a0013965

Casasanto, D. (2008). Similarity and proximity: When does close in space mean close in mind? *Memory & Cognition, 36,* 1047–1056. doi:10.3758/MC.36.6.1047

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. (2014). Body relativity. In L. Shapiro (Ed.), *Routledge handbook of embodied cognition* (pp. 108–117). New York, NY: Routledge.

Casasanto, D., & Boroditsky, L. (2008). Time in the mind: Using space to think about time. *Cognition, 106,* 579–593. doi:10.1016/j.cognition.2007.03.004

Casasanto, D., & Chrysikou, E. G. (2011). When left is "right": Motor fluency shapes abstract concepts. *Psychological Science, 22,* 419–422. doi:10.1177/0956797611401755

Casasanto, D., & Gijssels, T. (2015). What makes a metaphor an embodied metaphor? *Linguistics Vanguard*. Advance online publication. doi:10.1515/lingvan-2014-1015

Casasanto, D., & Jasmin, K. (2010). Good and bad in the hands of politicians: Spontaneous gestures during positive and negative speech. *PLoS ONE, 5,* e11805. doi:10.1371/journal.pone.0011805

Dehaene, S., Bossini, S., & Giraux, P. (1993). The mental representation of parity and number magnitude. *Journal of Experimental Psychology General, 122,* 371–396. doi:10.1037/0096-3445.122.3.371

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. doi:10.1037/a0024979

Dijkstra, K., Eerland, A., Zijlmans, J., & Post, L. S. (2014). Embodied cognition, abstract concepts, and the benefits of new technology for implicit body manipulation. *Frontiers in Psychology, 5*(757), 1–8. doi:10.3389/fpsyg.2014.00757

Dolscheid, S., Shayan, S., Majid, A., & Casasanto, D. (2013). The thickness of musical pitch: Psychophysical evidence for linguistic relativity. *Psychological Science, 24,* 613–621.

Dru, V., & Cretenet, J. (2008). Influence of unilateral motor behaviors on the judgment of valenced stimuli. *Cortex, 44,* 717–727.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39,* 175–191. doi:10.3758/BF03193146

Kong, F. (2013). Space–valence associations depend on handedness: Evidence from a bimanual output task. *Psychological Research, 77,* 773–779.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by.* Chicago, IL: University of Chicago Press.

Milhau, A., Brouillet, T., & Brouillet, D. (2013). Biases in evaluation of neutral words due to motor compatibility effect. *Acta Psychologica, 144,* 243–249.

Milhau, A., Brouillet, T., & Brouillet, D. (2015). Valence-space compatibility effects depend on situated motor fluency in both right- and left-handers. *Quarterly Journal of Experimental Psychology, 68,* 887–899. doi:10.1080/17470218.2014.967256

Oppenheimer, D. M., & Trail, T. E. (2010). Why leaning to the left makes you lean to the left: Effect of spatial orientation on political attitudes. *Social Cognition, 28,* 651–661.

Porac, C., & Cohen, S. (1981). *Lateral preferences and human behavior*. New York, NY: Springer.

Ren, P., Nicholls, M. E. R., Ma, Y.-Y., & Chen, L. (2011). Size matters: Non-numerical magnitude affects the spatial coding of response. *PLoS ONE, 6*, e23553. doi:10.1371/journal.pone.0023553

Winter, B., Marghetis, T., & Matlock, T. (2015). Of magnitudes and metaphors: Explaining cognitive interactions between space, time, and number. *Cortex, 64,* 209–224. doi:10.1016/j.cortex.2014.10.015