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Spatializing emotion: A mapping of valence or magnitude?

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Abstract

People implicitly associate different emotions with different locations in left-right space. Which dimensions of emotion do they spatialize? Across many studies people spatialize *emotional valence*, mapping positive emotions onto their dominant side of space and negative emotions onto their non-dominant side. Yet, other results suggest a contradictory mapping of *emotional intensity* (a.k.a., emotional magnitude), according to which people associate more intense emotions with the right and less intense emotions with the left, regardless of valence. To resolve this apparent contradiction, we first tested whether people implicitly spatialize whichever dimension of emotion they attend to. Results showed the predicted valence mapping, but no intensity mapping. We then tested an alternative explanation of findings previously interpreted as showing an intensity mapping; these data may reflect a left-right mapping of spatial magnitude, not emotion. People implicitly spatialize emotional valence, but there is no clear evidence for an implicit lateral mapping of emotional intensity.

Keywords: conceptual metaphor theory; emotion; magnitude; mental metaphor; valence

Introduction

People implicitly associate different emotions with different locations in left-right space, mapping points along an imaginary continuum of emotions onto an imaginary lateral spatial axis. Which dimensions of emotion do people spatialize? In this study we explore two contrasting mappings between space and emotion that have been proposed, a Valence Mapping and an Intensity Mapping, and suggest a resolution to the apparent contradiction between them.

According to many studies, people implicitly spatialize emotional valence, mapping positive-valence emotions onto their dominant side of space and negative-valence emotions onto their non-dominant side. Right-handers, therefore, tend to associate positive emotions (e.g., happiness) with the right, and negative emotions (e.g., anger) with the left (Casasanto, 2014, for review). This "Valence Mapping" appears to be shaped by the physical experiences we have with our hands: right-handers come to associate "positive" with the side of space on which they can usually act more fluently with their dominant hand, and "negative" with the side on which they act more clumsily, with the non-dominant hand (Casasanto & Chrysikou, 2011; see also Oppenheimer, 2008).

This body-based Valence Mapping has been observed across a variety of populations: in children as well as adults (Casasanto & Henetz, 2012), in members of Western and non-Western cultures (de la Fuente, et al., 2015), and in both neurotypicals and patients with compromised motor systems (Casasanto & Chrysikou, 2011). A "good is right" mapping has also been found using a variety of methods, ranging from questionnaires and diagram tasks (Casasanto, 2009) to memory tasks (Brunyé, Gardony, Mahoney, 2012), motor training tasks (Casasanto & Chrysikou, 2011), and analyses of spontaneous gestures (Casasanto & Jasmin, 2010).

Of particular interest for the present study, the Valence Mapping also produces space-valence congruity effects in reaction time (RT) tasks. Across multiple experiments, right- and left-handers were faster to classify centrally-presented words as positive when responding with their dominant hand, and faster to classify words as negative when responding with their non-dominant hand (de la Vega et al., 2012; de la Vega, et al., 2013; Kong, 2013). A similar pattern was found when people judged positive and negative emotional faces (Kong, 2013). In sum, these results provide strong and generalizable evidence for an implicit left-right Valence Mapping.

Is valence the only dimension of emotion that people implicitly spatialize on the lateral axis? According to one study, people spatialize emotional intensity (which the authors refer to as "emotional magnitude"), associating less intense emotion with the left and more intense emotion with the right (Holmes & Lourenco, 2011; hence H&L). Participants responded to photographs of emotional faces that varied in both valence (e.g., happy vs. angry) and intensity (e.g. happy vs. extremely happy). As indexed by their RTs, participants appeared to associate less intense emotions with the left and more intense emotions with the right – regardless of whether the emotional valence was positive or negative (H&L, Experiment 2).

These data of H&L's are consistent with their proposal that people implicitly associate emotional intensity with left-right space: an "Intensity Mapping." However, these data conflict with the Valence Mapping. Whereas an Intensity Mapping predicts that very negative emotions (e.g. extremely angry) should be associated with the *right* (because they are more intense), the Valence Mapping predicts that these negative emotions should be associated with the *left*, in right-handers, (because they have negative valence).

Here we conducted three experiments to resolve this apparent contradiction. In Experiments 1 and 2, we explored the possibility that people have *both* a Valence Mapping and an Intensity Mapping available in long-term memory, and spatialize emotion according to whichever dimension of emotion is more salient in context (broadly consistent with suggestions of H&L's). To preview our results, we found evidence for the Valence Mapping but no evidence of an

Intensity Mapping. Therefore, in Experiment 3, we tested an alternative explanation for H&L's findings based on the *spatial magnitude* (as opposed to the *emotional magnitude*) of a salient feature of their stimuli.

Experiment 1: Do people spatialize whichever dimension of emotion they attend to?

In Experiment 1, we tested whether orienting participants toward either valence or intensity would cause them to show the corresponding spatial mapping. Participants responded to emotional words and judged them according to either their valence or their intensity, by pressing buttons on the left or right of a keyboard.

Method

Participants Thirty-two right-handed adults from the University of Chicago community who spoke fluent English participated in the main experiment for payment or course credit. Half were randomly assigned to make speeded valence judgments (n=16) and the other half to make speeded intensity judgments (n=16). Twenty-four other participants from the same community completed a questionnaire used to measure normative judgments of the stimulus words' meanings.

Materials Four emotional words were selected, on the basis of a previous experiment in French speakers (Carbé & Gevers, 2013), which varied in their valence and intensity: "horrible" (very negative), "bad" (negative), "good" (positive) and "perfect" (very positive).

In order to quantify differences among these words we asked a group of participants (N=24) who did not participate in the main experiment to rate the four words on intensity and valence. For this norming task, the words appeared in a vertical column along the midline of a printed page. Each participant judged the emotional valence of the words on a scale from -5 (most negative) to 5 (most positive) and, on another page, the emotional intensity of the words on a scale from 0 (least intense) to 10 (most intense). They wrote their ratings on a horizontal line to the right of each word, all using their right hand. The position of the words on the page and the order of valence and intensity judgments was counterbalanced across participants.

Procedure In both the valence and intensity tasks, the four stimulus words appeared one at a time in black text in the center of a computer screen. Participants in the valence task judged whether each word connoted a "positive emotion" or "negative emotion." Participants in the intensity task judged whether each word connoted a "more intense emotion" or "less intense emotion." Participants were instructed to respond as quickly and accurately as possible by pressing one of two keys (the "z" and the "?" keys on the English-US QWERTY keyboard) using the index finger of each hand. If no response was given, trials automatically ended after two seconds. In one block of trials, participants pressed the key on the left to indicate a negative/less intense emotion and the key on the right to indicate a positive/more intense emotion. In a second block, this mapping was reversed, and the order of blocks was counterbalanced across participants. Participants performed 8 practice trials at the start of each block, after which the four stimulus words were presented in random order 24 times each, composing a total of 192 critical trials per participant over two blocks.

After testing, participants were debriefed to determine whether they were aware of the experimental hypothesis, and they then completed a language history questionnaire and the Edinburgh Handedness Inventory (EHI; Oldfield, 1971).

Results & Discussion

Ratings of emotional word stimuli Mean valence ratings ranged from "horrible" (-4.48 +/- .15) to "bad" (-1.89 +/- .43), "good" (2.20 +/- .33), and "perfect" (3.91 +/- .44). Mean intensity ratings ranged from "good," (4.21 +/- .44), the least intense, to "bad" (5.04 +/- .42), "perfect" (7.92 +/- .64), and "horrible" (8.21 +/- .49).

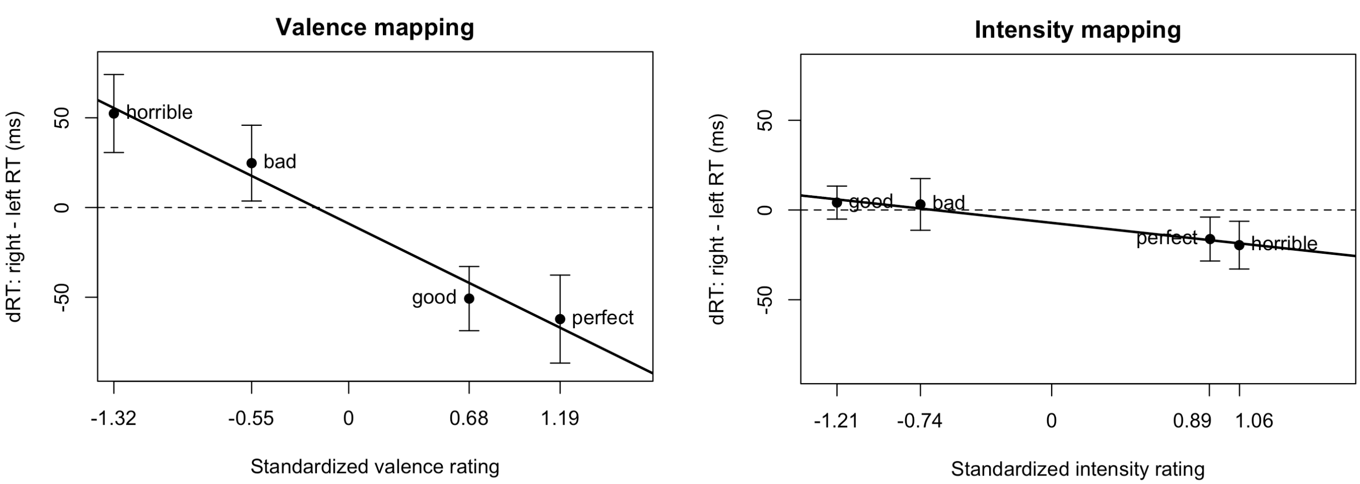

Figure 1. Results of Experiment 1. Left: Significant Valence Mapping in the valence task. Right: Non-significant Intensity Mapping in the intensity task. Error bars show the standard error of the mean.

Accuracy Four subjects failed to follow instructions and were replaced. The error rate was higher in the valence task (5.6%) than in the intensity task (4.3%; $\chi^2(1)=6.08$, p=.01). Inaccurate trials were excluded from the RT analyses.

RTs: Valence Judgments RTs greater than 2.5 standard deviations from subject means were removed, (2.69% of accurate responses). To evaluate whether participants implicitly spatialized the four words according to their valence, we adopted the technique typically used to evaluate the SNARC effect (e.g. Fias, Brysbaert, Geypens & d'Ydewalle, 1996), like H&L. For each participant and word, we calculated the RT difference between hands (dRT=right - left hand RT) and regressed these dRTs over the mean valence rating of each word. The slope of the resulting regression line provides a continuous index of each participant's Valence Mapping. On average, participants in the valence task associated the negatively valenced words with left space and the positively valenced words with right space, as indexed by the negative slope (M=-14.59 ms/unit valence; t(15)=-2.49, p=.02; Figure 1, left), demonstrating a clear Valence Mapping.

RTs: Intensity Judgments RTs greater than 2.5 standard deviations from subject means were removed (2.52% of accurate responses). Analogous to our analysis of the Valence Mapping, we regressed participants' dRTs over the mean intensity rating of each word. Although the relationship between intensity and dRT showed a slight trend in the direction predicted by an Intensity Mapping, this trend did not approach significance (M=-6.13 ms/unit intensity; t(15)=-1.03, p=.32; Figure 1, right). Participants did not show an Intensity Mapping, even though the task required them to make explicit judgments of emotional intensity.

RTs: Comparison of Valence and Intensity Effects To test the difference between the significant Valence Mapping observed in the valence task and the nonsignificant Intensity Mapping observed in the intensity task, we used a linear mixed-effects regression. RTs were predicted by response hand, standardized valence and intensity ratings, and task, with random slopes and intercepts for participants. The 3-way interaction between response hand, ratings, and task was marginally significant ($\chi^2(1)=2.93$, p=.09).

Experiment 2: A second test of Valence and Intensity Mappings

In Experiment 1, we predicted that if a Valence Mapping and an Intensity Mapping are both available to participants in long-term memory, then participants would (i.) implicitly spatialize valence when making speeded valence judgments (consistent with de la Vega, et al., 2012; de la Vega et al., 2013; Kong, 2013), and (ii.) implicitly spatialize emotional intensity when making speeded intensity judgments (consistent with the conclusions of Holmes & Lourenco, 2011). Only the first prediction was upheld. The goal of Experiment 2 was to test the same predictions with greater power, generalizability, and sensitivity.

To increase power, we doubled the number of participants and octupled the number of items; increasing the sample of items from 4 to 32 also increased the generalizability of the results. To increase sensitivity, we collected word ratings from each participant, after the RT task, and predicted dRTs on the basis of these subject-specific word ratings.

Method

Participants Sixty-four right-handed adults from the University of Chicago community participated for payment or course credit. Half were randomly assigned to the valence task (n=32) and the other half to the intensity task (n=32).

Materials The set of 4 emotional words from Experiment 1 was expanded to include 32 words for which valence (positive, negative) was crossed with emotional intensity (high intensity, low intensity): *beloved, brilliant, capable, courteous, determined, devastated, disliked, drowsy, ecstatic, energized, exhausted, good, gorgeous, gregarious, hated, hesitant, hideous, horrible, idiotic, ignorant, insulting, obstinate, perfect, pleased, prepared, rested, unattractive, unhappy*.

Procedure The procedure was identical to that of Experiment 1 except for the following changes. Participants performed 32 practice trials at the start of each block (one for each word), after which these words were presented in random order 5 times, composing 320 critical trials over two blocks. After this speeded RT task, participants rated the valence and intensity of each word. Words appeared on the computer screen one at a time in randomized order and participants spoke aloud their numerical ratings, on the same scales used in Experiment 1. The order of the valence rating and intensity rating tasks was counterbalanced across participants.

Results

Valence judgements Trials in which no response was given (0.55%) were removed as were RTs greater than 2.5 standard deviations from subject means (3.2% of responses).

We regressed each participant's mean dRTs over their standardized valence ratings for each word. As in Experiment 1, participants in the valence task associated the negatively valenced words with left space and the positively valenced words with right space, as indexed by a negative slope (M=-10.92 ms/unit valence; t(31)=2.60, p=.01), demonstrating a clear Valence Mapping.

Intensity judgments Trials in which no response was given were removed (1.30%) as were RTs greater than 2.5 standard deviations from subject means (2.9% of responses). We regressed each participant's mean dRTs over their standardized intensity ratings for each word. We found no systematic association between intensity and side of space (M=5.58 ms/unit intensity; t(31)=.54, p=.59). The mean slope did not differ significantly from a slope of zero, but notably its sign was *positive*, inconsistent with the predicted Intensity Mapping.

Comparison of valence and intensity effects To test the difference between the significant Valence Mapping observed in the valence task and the nonsignificant Intensity Mapping observed in the intensity task, we used a mixed-effects model with random slopes and intercepts for participants and words. The 3-way interaction between response hand, standardized word ratings, and task was significant, indicating that the Valence Mapping was reliably stronger than the Intensity Mapping ($\chi^2(1)=7.82$, p=.005).

Discussion

The results of Experiment 2 replicated the results of Experiment 1, extending them to a larger sample of participants and a larger set of words: we found a significant Valence Mapping but no significant Intensity Mapping. Experiment 2 also supports an inference that was only weakly supported in Experiment 1. Although the effect of valence on dRT was clearly significant, and the effect of intensity on dRT was clearly nonsignificant, the difference between these two effects was only marginal in Experiment 1. This between-task difference was significant in Experiment 2, indicating that the Valence Mapping was statistically stronger than the (nonsignificant) Intensity Mapping.

In summary, the results of Experiments 1 and 2 showed a highly significant Valence Mapping, consistent with previous results (Casasanto, 2014, for review). They contrast with H&L's results, however, which were interpreted as showing an Intensity Mapping. In Experiment 3, we tested a possible explanation for this apparent contradiction.

Experiment 3: Emotional or spatial magnitude?

Why did H&L find an Intensity Mapping whereas we did not? A potential answer comes from an examination of H&L's stimuli. For the two experiments in which H&L reported an Intensity Mapping (their Experiments 1 and 2), the stimuli were photographs of six actors making facial expressions that varied in their emotional intensity (what H&L called emotional magnitude): neutral, happy, very happy, extremely happy, etc. When classifying the gender of these faces using left- and right-hand response keys, participants showed a pattern of RTs that was consistent with an Intensity Mapping.

However, as acknowledged by H&L, these findings might also be "due to specific facial features that varied across the range of stimuli, rather than the magnitude of emotional expression per se" (p. 318). One such feature was the "size of the mouth; more happy faces had a larger mouth opening than less happy faces" (p. 318).

Although H&L dismiss this confound between emotional intensity and physical space, it is of concern for two reasons. First, across cultures, people tend to focus on the mouths of emotional faces, as much or more than other parts of the face such as the eyes (Jack et al., 2009; Koda & Ruttkay, 2014; cf, Blais et al., 2008), and this tendency is particularly strong in US participants (Jack, Caldara & Shyns, 2012; Yuki, Maddeux & Masuda, 2007). Second, and crucially, previous data show that people implicitly spatialize *area* along a left-to-right continuum. In one experiment, participants were faster to make speeded judgments on smaller circles with the left hand and larger circles with the right hand (Ren, Nicholls, Ma & Chen, 2011), producing a dRT effect much like H&L's.

Given that (a) people implicitly associate smaller spatial areas with the left and larger areas with the right, and (b) H&L's more intense faces appear to have larger mouths, it seems possible that the emotional magnitude effect H&L reported was, in fact, a *spatial magnitude* effect. To test this alternative explanation, here we calculated the mouth areas of the faces in H&L's stimulus set and used them in place of emotional intensity to predict dRTs in H&L's Experiment 2, the experiment that provided the strongest evidence for an Intensity Mapping. (We discuss alternative explanations for the results of H&L's Experiments 1 and 3 in the General Discussion.)

Method

H&L's Experiment 2 used 30 faces from the NimStim database (Tottenham, et al., 2009). The photographs depicted six actors making each of five emotional expressions, which H&L labeled as neutral, happy, angry, extremely happy, and extremely angry. A coder blind to the experimental hypotheses used Adobe Photoshop to select and measure the area of the mouth (including the lips) of each face.

Results and discussion

Analysis of Mouth Areas After the mouth areas were measured, measurements were averaged for each emotional expression (reported in units of 1000 pixels): Neutral (M=3.27; +/- .27); Happy (M=3.64; +/- .40); Angry (M=2.26 +/- .20); Extremely happy (M=10.53; +/- .75); Extremely angry (M=6.75 +/- .85). A first analysis confirmed that the mean mouth area varied significantly across the emotional expressions (F(1, 28)=36.3, p=.000000004; Figure 2).

A second analysis tested whether mouth area covaried with emotional intensity. For each image, the mouth area (from our measurements) was used to predict the intensity rating (i.e., "emotional magnitude" ratings, obtained from H&L). Mouth area reliably predicted emotional intensity ratings (F(1, 28)=17.9 p=.0002).

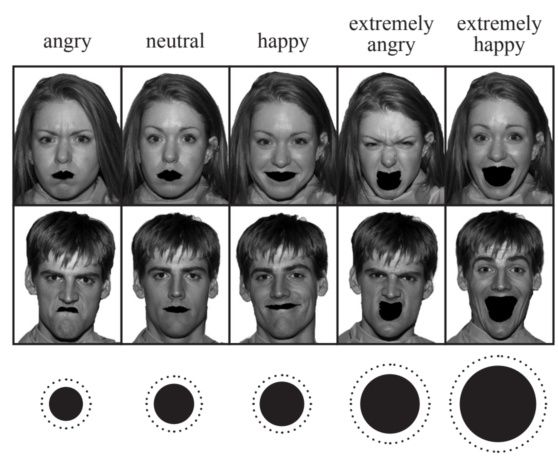

Figure 2. Top: Examples of face stimuli used in H&L Experiment 2, with measured mouth area highlighted in black. Bottom: Relative mouth area (black circles) and standard errors (dotted lines) by emotional expression.

Predicting dRT from Mouth Area The finding of a correlation between mouth area and emotional intensity confirms that spatial magnitude could, in principle, explain an Intensity Mapping. To test whether mouth area can, in fact, explain H&L's effects, we conducted a further analysis, analogous to H&L's, using mouth area instead of emotional magnitude ratings to predict dRTs. For each participant and image, dRTs (obtained from H&L) were regressed over standardized mouth area (from our measurements) to produce a spatial magnitude slope for each participant. The mean slope differed significantly from zero (M=-10.14 ms/unit area; $t(45)=2.72$, $p=.009$), suggesting an implicit mapping of spatial magnitude (i.e. mouth size) onto left-right space (a Spatial Magnitude Mapping). Moreover, when we controlled for mouth area, emotional magnitude slopes no longer differed from zero (M = -10.48 ms/unit intensity; $t(45) = 1.40$, $p = .17$); the Intensity Mapping disappeared. When we controlled for emotional magnitude, the effect of mouth area also no longer differed from zero (M = -3.31 ms/unit intensity; $t(45)=0.73$, $p=.47$).

These findings show that the effects observed in H&L's Experiment 2 can be explained by the spatial magnitude of a salient aspect of their stimuli. That is, participants may have been spatializing emotional faces either according to their relative emotional intensity or according to the relative size of their mouths; the data cannot distinguish between these two alternatives.

General Discussion

In three experiments, we investigated how people spatialize different aspects of emotion. We sought to reconcile an apparent contradiction between previous studies showing an implicit left-right mapping of emotional valence (Casasanto, 2014, for review) with the results of a study positing an implicit left-right mapping of emotional intensity (Holmes & Lourenco, 2011). In Experiments 1 and 2, we tested whether people can implicitly spatialize emotion according to either valence or intensity, depending on the context. When judging the emotional valence of words, participants reliably showed the Valence Mapping typical of right-handers. By contrast, when judging emotional intensity, participants showed no evidence of an Intensity Mapping, inconsistent with the findings of H&L. Experiment 3 provided a possible explanation for this discrepancy. In H&L's stimuli, emotional intensity was confounded with spatial magnitude: Faces expressing greater emotional intensity also had larger mouths. Mouth area reliably predicted the pattern of RTs reported by H&L, and controlling for mouth area eliminated the effect of emotional intensity. Together, these experiments (a) extend the evidence for an implicit lateral mapping of emotional valence, (b) provide no evidence for the implicit lateral mapping of emotional intensity posited by H&L, and (c) provide an alternative explanation for the RT effects that H&L interpreted as evidence for an Intensity Mapping.

Is there any evidence for an Intensity Mapping?

In light of our findings, what is the evidence that people implicitly spatialize emotional intensity on a left-right continuum? Currently, the evidence for this claim rests on a paper by H&L, whose three experiments we address in turn.

In H&L's Experiment 1, participants classified faces whose emotional expressions varied from neutral to extremely happy. As acknowledged by H&L, this experiment cannot, in principle, distinguish between a Valence Mapping and an Intensity Mapping, since both mappings make the same predictions for positive emotions.

In H&L's Experiment 2, the findings are consistent with an Intensity Mapping and inconsistent with a Valence Mapping. However, here we show that these findings are also consistent with a Spatial Magnitude Mapping, in which smaller area (i.e. mouth size) is associated with the left and larger area is associated with the right (see our Experiment 3). To the extent that participants were spatializing mouth size rather than emotional intensity or valence, the results of H&L's Experiment 2 do not bear on the spatialization of any dimension of emotion.

Although H&L interpreted the results of their third experiment as evidence of an Intensity Mapping, the data do not support this interpretation. Participants in H&L's Experiment 3 classified faces on either happiness (happy/not happy) or anger (angry/not angry). The pattern of RTs depended on the type of judgment participants made: those who judged happiness associated the angriest faces with the left and the happiest faces with the right; those who judged anger showed the opposite mapping, associating the happiest faces with the left and the angriest faces with the right.

Although H&L interpreted these two patterns as evidence of the flexibility of an "emotional magnitude line," both patterns are inconsistent with any linear mapping of emotional magnitude (i.e., intensity) onto left-right space. Whereas an Intensity Mapping predicts that people should associate the angriest and happiest faces with the same side of space, participants in H&L's Experiment 3 mapped extremely happy and extremely angry faces onto opposite sides of space. These results are, therefore, incompatible with the proposed emotional magnitude line.

Instead, these findings may be readily explained by *polarity alignment* (Proctor & Cho, 2006), also called *markedness* (Clark 1969; Dolscheid & Casasanto, 2015; Lakens, 2012; Lynott & Coventry, 2014). Like many other analog continuums in language and mind, *happiness* and *anger* are both bipolar (or marked) continuums. That is, they consist of a +polar (or unmarked) endpoint (*happy*, *angry*) and an opposing –polar (or marked) endpoint (*unhappy*, *not angry*). Lateral space is also a bipolar continuum, where *right* has +polarity and *left* has –polarity, at least for right-handers (see Huber et al., 2014).

In polarity alignment effects, participants show faster RTs when the poles of two continuums align than when they misalign (see Clark, 1969; Proctor & Cho, 2006). This is exactly the effect that H&L observed in their Experiment 3: participants responded faster when the poles of the designated emotion aligned with the poles of the lateralized response (*happy/angry: right; unhappy/not angry: left*) than when they misaligned (*happy/angry: left; unhappy/not* *angry: right*). The results of H&L's Experiment 3, therefore, provide no evidence for an Intensity Mapping, but rather show what appears to be a classic polarity alignment effect (Clark, 1969; Proctor & Cho, 2006).

In sum, none of the three experiments presented by H&L provide any clear evidence for an Intensity Mapping (although, in principle, future studies could reveal such a mapping, in some contexts). Instead, previous results may reflect emotional valence (in H&L's Experiment 1), spatial features of the stimuli (i.e., mouth size in H&L's Experiment 2), and polarity alignment (in H&L's Experiment 3).

Conclusions

In two experiments, we show that people implicitly map emotional valence onto left-right space, but we find no spatial mapping of emotional intensity. In a third experiment, we provide an alternative explanation for previous data interpreted as support for an Intensity Mapping. The idea of an Intensity Mapping was motivated by the search for a generalized magnitude system for representing multiple prothetic domains (Holmes & Lourenco, 2011). The Valence Mapping shown here provides no evidence for such a generalized magnitude system because valence is not a prothetic domain (e.g., "happy" is not *more valence* than "sad"). Rather, the present results extend the evidence for the broadly generalized tendency to spatialize our abstract concepts, whether or not they are prothetic, according to the specifics of our physical and social experiences.

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