Environmental Orientation Affects Emotional Expression Identification

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Abstract

Spatial metaphors for affective valence are common in English, where up in space=happy/positive and down in space=sad/negative. Past research suggests that these metaphors have some measure of psychological reality: people are faster to respond to valenced words and faces when they are presented in metaphor-congruent regions of space. Here we explore whether the *orientation* of a stimulus – rather than its *position* – is sufficient to elicit such spatial-valence congruency effects, and, if so, which spatial reference frame(s) people use to represent this orientation. In Experiment 1, participants viewed images of happy and sad profile faces in different orientations and had to identify the emotion depicted in each face. In Experiment 2, participants completed this task while lying down on their sides, thereby disassociating environmental and egocentric reference frames. Experiment 1 revealed a metaphor-congruent interaction between emotion and orientation, while Experiment 2 revealed that this spatial-valence congruency effect was only reliable in the environmental frame of reference.

Keywords: spatial metaphor; valence, emotional expression identification; spatial reference frames

Introduction

We often talk about abstract domains like time, emotion, consciousness, health, and social status using spatial metaphors (Lakoff & Johnson, 1980). For example, we organize the concept of emotional valence around a vertical spatial dimension, where a higher spatial position connotes happiness and positivity while a lower spatial position connotes sadness and negativity. Thus we say things like "She *sank* into a *deep depression* and is feeling quite *low*, very *down* in the dumps; we need to give her a *lift, raise* her spirits, and *boost* her self-esteem until she's *flying high*." This particular mapping between space and valence may have its origins in everyday embodied experiences: sad feelings are associated with a drooping posture and drowsiness, while happy feelings are associated with a more alert and erect bearing (though it's rare to see people literally jumping with joy).

Interestingly, research has found that this association between space and valence goes beyond language: people seem to automatically activate metaphor-congruent spatial representations in the course of processing valenced stimuli (and vice versa. e.g., Brookshire, Ivry, & Casasanto, 2010; Casasanto & Dijkstra, 2010; Lynott & Coventry, 2013; Meier & Robinson, 2004).

In one study, participants were faster and more likely to retrieve positive memories while making concurrent motor movements upwards, and faster and more likely to retrieve negative memories while making concurrent motor movements downwards (Casasanto & Dijkstra, 2010). In another experiment, Meier and Robinson (2004) found that participants were faster to identify positive words like *hero* when they appeared at the top of the screen than when they appeared at the bottom of the screen, while the reverse was true for negative words like *liar*. A follow-up study revealed that simply attending to higher or lower regions of space facilitated the subsequent processing of valenced words presented centrally in a metaphor-congruent fashion. More recently, Lynott and Coventry (2013) extended these findings by using non-linguistic stimuli: in their study, participants were faster to respond to happy faces that appeared at the top of the screen compared to sad faces that appeared at the top of the screen and happy faces that appeared at the bottom of the screen. Taken together, these findings provide compelling evidence for the cognitive reality of the spatial-valence metaphorical mapping.

The present work builds on these findings by testing whether people are also sensitive to the *orientation* of valenced stimuli. That is, one way to test for spatial-valence congruency effects is to manipulate the *position* of stimuli in a display (or the direction of movement towards a particular position) – the method used by other researchers tackling this phenomenon. Another way of testing for spatial-valence congruency effects is to manipulate the *orientation* of a stimulus. In addition to presenting a face at the top of a computer screen (position), "up" can be cued by presenting an upward gazing face (orientation). Furthermore, spatial relations like *upright* and *orientation* must be defined with respect to a particular frame of reference; objects that are upright with respect to a computer screen (environmental frame of reference) would appear upside-down to a person standing on their head (egocentric frame of reference). In other words, spatial relationships are multifaceted; a fuller consideration of this nuance can help us understand how people use space to represent valence.

Across two experiments, we investigated whether the *orientation* of a stimulus – rather than its *position* in space –

would be sufficient to elicit such spatial-valence congruency effects, and, if so, which spatial reference frame people use to represent this orientation. In Experiment 1, participants viewed images of happy and sad profile faces in different orientations and had to identify the emotion depicted in each face. We expected a metaphor-congruency effect: that people would be faster (and more accurate) to respond to upward gazing happy faces and downward gazing sad faces, and slower (and less accurate) to respond to upward gazing sad faces and downward gazing happy faces. This finding would provide additional evidence that representations of valence are grounded in conceptions of space, and it would demonstrate that spatial-valence congruency effects are not limited to spatial located, but extend also to spatial orientation.

In Experiment 2, participants completed this task while lying on their right sides, thereby disassociating environmental and egocentric reference frames. In a majority of everyday experiences, environmental and egocentric reference frames are highly correlated – most of the time we see faces that are upright in the world (environmental reference frame) while we sit or stand in an upright position (egocentric reference frame). This study design allowed us to investigate whether the representation of valence is more strongly tied to the reference frame of the world (environmental) or the individual (egocentric).

Given the importance of egocentric reference frames in face perception (e.g., Rossion, 2008; Troje, 2003), one possibility is that the spatial-valence mapping will be defined with respect to the orientation of the participant. On the other hand, our experience with faces in the world, which are normally upright (even if we are tilted or on our side), may tie the spatial-valence mapping to an environmental frame of reference. Indeed, some metaphors in English seem to reference the environmental frame specifically, as when we say, "things are looking *up*." Identifying the reference frame(s) in which the spatial-valence mapping is defined can help us understand how these representations are learned and when they influence our behavior (Davidenko & Flusberg, 2012).

Experiment 1

Methods

Participants We recruited 81 participants (59 female) from the Introduction to Psychology Participant Pool at SUNY Purchase College. The average age was 19 (*SD*=1.2), and participants received course credit for their participation.

Materials & Procedure The experiment was created using PsychoPy software (Pierce, 2007) and was administered on a 21.5" iMac desktop computer. Face stimuli were drawn from the Karolinska Directed Emotional Faces Database (KDEF; Lundqvist, Flykt, & Öhman, 1998). We selected 40 profile faces from the database for use in the study: 10 male faces and 10 female faces each expressing both happiness and sadness. The images were cropped in Adobe Photoshop using the same ovular template to highlight the face and keep each picture the same size.

On every trial, a black fixation cross appeared at the center of the screen, which had a light gray background. After 500 milliseconds, one of the face images appeared at the center of the display in one of five possible orientations (0° = upright; -90º, -45º = looking downwards; 45º, 90º = looking upwards; see Figure 1). All 40 face images appeared in each of the 5 orientations, for a total of 200 trials. Half of the faces were presented facing to the left, and half were presented facing to the right (counterbalanced); the order of trials was fully randomized.

Participants were instructed to respond as quickly and as accurately as possible as soon as the face image appeared during a trial, pressing one button on the keyboard if the face was "happy" and another button if the face was "sad." Participants used the "f" and "j" keys to respond (counterbalanced across participants).

Participants were also randomly assigned to one of two stimulus duration conditions. In the *Unmasked* condition (N=40), the face image remained on the screen until participants pressed a response key. In the *Masked* condition (N=41), the face image remained on the screen for 100 milliseconds and was then replaced by a scrambled version of one of the images, created in Photoshop. This manipulation was included to test whether the effects of metaphorical spatial congruence on emotional expression identification emerge early in visual processing (i.e., within the first 100 milliseconds).

Before the main experimental task, participants completed 8 practice trials consisting of upright, front view, cartoon faces (two sad faces and two happy faces, each presented twice) to acclimate them to the task.

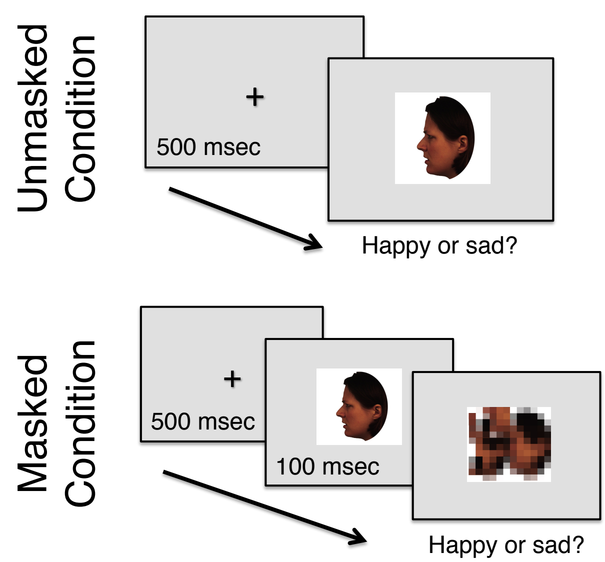

Figure 1. Schematic diagram of trial structure for both stimulus duration conditions in Experiment 1.

Results

Response times faster than 200 milliseconds and slower than five standard deviations above the overall mean RT were removed from analysis (<1% of all trials). Accuracy was very good overall (*M*=93.7%, *SD*=4.3).

Our initial analysis included only trials where participants correctly identified the emotional facial expression. Using reaction time as our dependent variable, we ran a 2 (emotion: happy vs. sad) X 5 (orientation: -90º, -45, 0º, 45º, 90º) repeated measures ANOVA with stimulus duration condition included as a between-subjects factor. Of particular relevance to our theoretical question was a predicted metaphor-congruent interaction between the emotion and orientation of the face, which was statistically significant, $F(4, 316)=5.74$, $p<0.001$, $\eta^2=.068$[1] (see Figure 2). Planned contrasts revealed that participants were faster to recognize happy faces oriented at 45º, $t[80]= 2.28$, $p=.025$, and 90º, $t[80]=3.07$, $p=.003$. There were no differences in recognition time by emotional expression at other orientations (-90º, -45º, 0º), *t*s < 1, *p*s > .3.

In addition to the predicted interaction, the model revealed a main effect of orientation, $F(4, 316)=36.88$, $p<0.001$, $\eta^2 = .317$, consistent with prior work on the effects of orientation on face perception (e.g., Davidenko & Flusberg, 2012): participants were fastest to respond to upright faces (0º) and were progressively slower to respond as the faces were rotated away from upright. No other main effects or interactions were statistically significant, *p*s > .1.

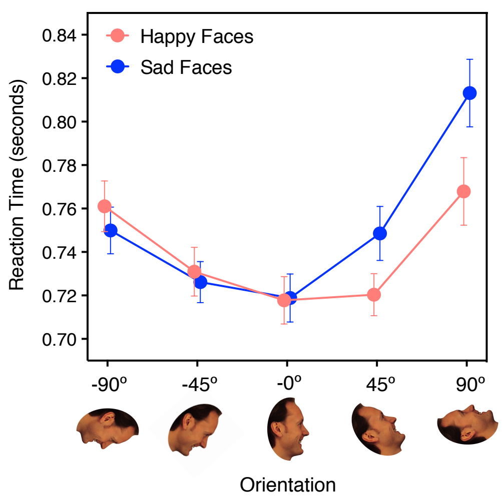

Figure 2. Mean reaction times for happy and sad faces for each stimulus orientation in Experiment 1, collapsed across stimulus duration condition. Error bars represent 95% CIs

An analysis of error trials revealed a similar pattern. Using error frequency as the dependent variable, we conducted another 2 (emotion) X 5 (orientation) repeated-measures ANOVA with condition as a between-subjects factor. Consistent with the analysis of RTs, we found that people made more errors on trials that presented downward gazing happy faces than trials that presented downward gazing sad faces, and vice versa for upward gazing faces, $F(4, 316)=4.84$, $p<0.001$, $\eta^2=.056$. Planned contrasts revealed that participants made more errors in recognizing happy faces oriented at -90º, $t[80]= 5.23$, $p<.001$, -45º, $t[80]=3.28$, $p=.002$, 0º, $t[80]=4.35$, $p<.001$, and 45º, $t[80]=2.94$, $p=.004$; there were no differences in error rates by emotional expression 90º, $t[80]=0.05$, $p=.958$.

The model also revealed differences between the *Masked* and *Unmasked* conditions. Not surprisingly, participants in the *Unmasked* condition (mean accuracy=96.4%, *SD*=2.39) made fewer errors than those in the *Masked* condition (mean accuracy=91%, *SD*=4.13), $F(1, 79)=47.76$, $p<0.001$, $\eta^2=.379$. Since the performance of participants in the *Unmasked* condition was close to ceiling, the interaction between emotion and orientation was only present for participants in the *Masked* condition (i.e., the 2-way interaction between emotion and orientation was qualified by a 3-way interaction between emotion, orientation, and condition, $F(4, 316)=3.89$, $p<0.005$, $\eta^2=.045$[2]).

In addition, this model revealed that people made more errors for happy face trials (*M*=92.4% accuracy, *SD*=5.64) than for sad face trials (*M*=95.2% accuracy, *SD*=4.59)[3], $F(1, 79)=20.1$, $p<0.001$, $\eta^2=.201$, and more errors as the faces were rotated away from upright, $F(4, 316)=13.6$, $p<0.001$, $\eta^2=.136$. As shown in Figure 3, the effect of orientation was only apparent for those in the *Masked* condition, $F(4, 316)=10.66$, $p<0.001$, $\eta^2=.104$. See Figure 3.

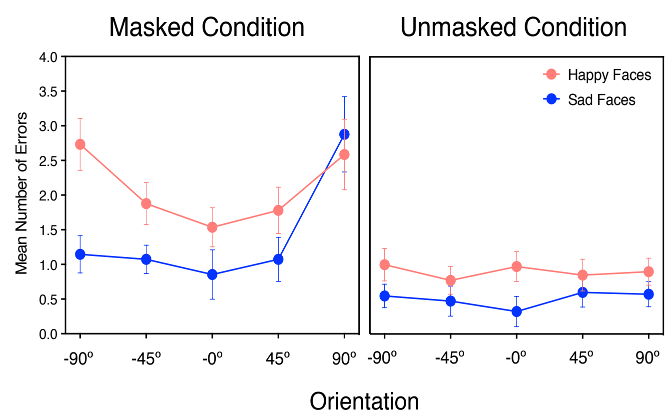

Figure 3. Mean number of errors for happy and sad faces for each stimulus orientation in each condition in Experiment 1. Error bars represent 95% CIs

[1] Though Mauchly's test indicated that the assumption of sphericity was violated in this and several of the following analyses, the *F* and *p*-values remain nearly identical under both Greenhouse-Geisser and Huynh-Feldt corrections in all cases.

[2] Results of planned contrasts do not change when focusing exclusively on data from the *Masked* condition: *t*s > 2.5, *p*s < .016 for orientations < 90º; $t = .62$, $p = .539$ at 90º.

[3] This may reflect a slight response bias in our sample to perceive sadness in others (or negativity more generally), or it may signal that our stimuli were not equally discriminable based on emotion.

Discussion

In Experiment 1, we asked whether the *orientation* of a face (i.e. where the face is *looking,* as opposed to its *position* in space) would be sufficient to elicit spatial-valence congruency effects on performance in an emotional expression identification task. The answer was a clear *yes*: participants were faster and more accurate to identify emotional expressions when the faces were oriented towards metaphor-congruent regions of space. This was true whether the stimuli were masked after 100 milliseconds or remained visible until response, suggesting that metaphorical spatial representations of valence are activated quickly and automatically when people view emotional stimuli (and vice versa; cf., Brookshire, Ivry, & Casasanto, 2010).

Interestingly, these effects seemed to be driven largely by a *decrease* in performance for sad faces facing upwards: while RTs and error rates (in the *Masked* condition) for happy faces increased symmetrically as the images were rotated upwards and downwards away from upright, RTs and error rates for sad faces dramatically increased on upward rotations (i.e., metaphor-incongruent orientations). This is somewhat surprising, as the only other published work on spatial-valence congruency effects that used happy and sad face stimuli found a response time *advantage* for happy faces positioned in metaphor-congruent regions of space (i.e., the top of the display), rather than a metaphor-incongruent decrease in performance for sad faces (Lynott & Coventry, 2013). These researchers interpreted these findings as evidence for a "polarity" account of spatial-valence congruency effects, which is an issue we return to in the general discussion (cf., Dolscheid & Casasanto, 2015).

The results of Experiment 1 cannot address one key question: which way is *up*? Spatial relations like *up*, *down*, and *orientation* must be defined with respect to a particular frame of reference. When participants are seated at a computer in a typical lab study like Experiment 1, several spatial reference frames are conflated: faces that are oriented upwards with respect to the computer screen, the room itself, and the directional pull of gravity (environmental frames) are also orientated upwards with respect to the participant (egocentric reference frames). This makes it impossible to determine which reference frame(s) participants are using to represent the orientation of the faces (and thus which reference frame is driving the observed spatial-valence congruency effects).

Fortunately, there is a simple method for disassociating environmental and egocentric reference frames: tilt your head 90º to one side. Now faces that appeared to be gazing upwards in the environment will appear to be upright or upside-down in your egocentric frame of reference (depending on which way you tilt your head). Interestingly, prior research has shown that people process faces independently in both the environmental and egocentric reference frames: Davidenko & Flusberg (2012) found that people were better at classifying and remembering images of faces that were egocentrically upright (as compared to egocentrically inverted) as well as environmentally upright (as compared to environmentally inverted), though effects in the environmental reference frame were reliably smaller. In Experiment 2, participants completed the same task as in Experiment 1 while lying down on one side.

Experiment 2

Methods

Participants We recruited 85 participants (59 female) from the Introduction to Psychology Participant Pool at SUNY Purchase. The average age was 19.2 (*SD*=2.63) and participants received course credit for their participation.

Materials & Procedure The experiment was similar in design to Experiment 1, with a few key differences:

Instead of sitting on a stool at a computer workstation, participants began the experiment by sitting upright on a futon positioned at the back of the lab room. The computer running the experimental software was positioned on a low table in front of the futon. Participants first completed the same 8 practice trials featuring front-view cartoon faces that participants completed in Experiment 1. The only difference was that they used only their left hand to make the speeded response, using the "1" and "2" keys on the keyboard (counterbalanced across participants). After the practice trials, participants were instructed to lay down on their right side with their head resting horizontally on a flat pillow facing the computer screen.

For Experiment 2 we used eight out of the ten male and eight out of the ten female profile faces that we had used in Experiment 1, each one again appearing with both a happy and sad expression[4]. On any given trial, one of the 32 individual profile images (8 males, 8 females, 2 expressions each) appeared in one of 8 possible orientations (see Table 1 and Figure 4). Participants saw each of the 32 faces in each of the 8 possible orientations, for a total of 256 trials, the order of which was randomized across participants.

Table 1. Stimulus orientations in Experiment 2

	Egocentric Orientation	Environmental Orientation
1	upright	90º
2	upside-down	90º
3	upright	-90º
4	upside-down	-90º
5	90º	upright
6	90º	upside-down
7	-90º	upright
8	-90º	upside-down

[4] This was to keep the experiment short enough to complete in a reasonable time frame, since each face appeared 8 times in Experiment 2 compared to 5 times in Experiment 1. The 4 faces we eliminated for Experiment 2 were chosen based on pilot subject ratings (1-10 scale) of how happy and sad the expressions looked. We selected the two male and two female faces that scored lowest on these ratings.

Note that when participants lay on their right side to view these images, faces that were oriented upwards or downwards in one frame of reference (i.e., rotated 90º or -90º in that frame) were always either perfectly upright or perfectly upside-down in the other frame of reference[5]. This decoupling of the environmental and egocentric reference frames allowed us to investigate independent spatial-valence congruency effects in both frames of reference.

Results & Discussion

The data from four participants were removed from analysis because the computer crashed mid-session (N=1), the participant was under 18 and could not give legal consent to participate (N=2[6]), or the participant's error rate was extremely high, representing a clear outlier (32% errors; N=1). Accuracy for the remaining 81 participants was quite good (*M*=96%, *SD*=3.14). Response times less than 200 milliseconds and greater than five standard deviations above the overall mean RT across all participants and trials were removed from analysis (<1% of all trials).

Past research suggests that there are independent effects of spatial orientation on face perception in the environmental and egocentric reference frames (Davidenko & Flusberg, 2012). Therefore, we analyzed the trial data separately for each frame, including only those trials where participants correctly identified the emotional facial expression.

Environmental Frame We first conducted a 2 (emotion: happy vs. sad) X 2 (orientation: -90º in the environment vs. 90º in the environment) repeated measures ANOVA with mean RT as the dependent variable. There was no main effect of emotion, as participants had similar reaction times to happy and sad faces, $F(1, 80)=0.75$, $p=0.39$. There was a marginal effect of orientation, as participants were slightly slower to respond to faces looking upwards in the environment (90º) compared to faces looking downwards in the environment (-90º), $F(1, 80)=3.29$, $p=0.074$. Crucially, there was a significant metaphor-congruent interaction between emotion and orientation, $F(1,80)=4.48$, $p=0.038$, $\eta^2=.053$: participants were marginally slower to respond to sad faces gazing upwards compared to happy faces gazing upwards, $t[80]=1.82$, $p=.073$, and to sad faces facing downwards, $t[80]=2.94$, $p=.004$, in the environment; there was no difference in recognition time for downward facing faces by emotional expression, $t[80]=.14$, $p=.887$; participants responded similarly fast to happy faces facing upwards and downwards in this environment, $t[80]=.36$, $p=.719$ (see Figure 4).

Egocentric Frame We repeated this analysis for trials where the faces were oriented upwards or downwards in the egocentric frame of reference. There were no main effects of emotion or orientation, nor was there an interaction between the two (all F's < 0.2, all p's > 0.7; see Figure 4).

In both the environmental, $F(1, 80)=27.93$, $p<.001$, $\eta^2=.259$, and egocentric, $F(1, 80)=6.53$, $p=.013$, $\eta^2=.075$, frames of reference, analyses of error rates revealed a main effect of emotional expression: in both frames of reference people were more accurate recognizing happy faces.

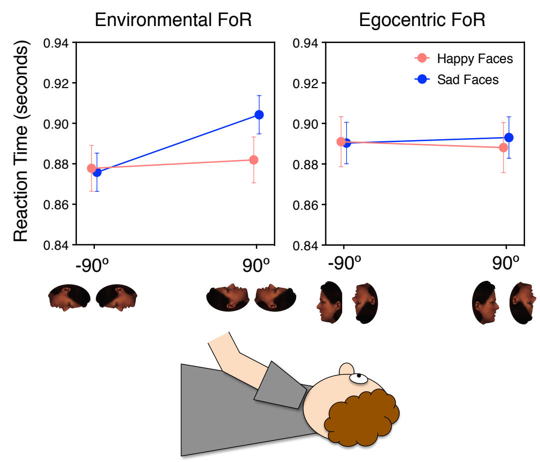

Figure 4. Mean RTs for happy and sad faces for each stimulus orientation and each frame of reference (environmental on the left) in Experiment 2. Error bars represent 95% CIs.

General Discussion

Spatial metaphors for affective valence are common in English, where *up* in space connotes happy or positive feelings ("things are looking *up*!") and *down* in space connotes sad or negative feelings ("I'm *down* in the dumps"). Past research suggests that this association is not merely a matter of language; rather, it offers a window into how people (metaphorically) represent the concept of emotional valence. For example, people are faster to respond to positive and negative words and faces when they are presented in metaphor-congruent regions of space (Lynott & Coventry, 2013; Meier & Robinson, 2004). In the present study, we explored whether the *orientation* of a stimulus – rather than its *position* in space – is sufficient to elicit such spatial-valence congruency effects, and, if so, which spatial reference frame people use to represent this orientation.

In Experiment 1, participants viewed images of happy and sad profile faces in different orientations and had to identify the emotion depicted in each face. Results revealed a significant spatial-valence congruency effect on performance: participants were faster and more accurate to respond when faces were oriented towards metaphor-

[5] As it turns out, when people tilt their head to one side, their eyes rotate several degrees in the opposite direction, a phenomenon known as Ocular Counter-Roll (OCR). At 90º rotation, this effect is very small (roughly 4º), and it does not appear to explain the effects of environmental orientation on face processing (see Davidenko & Flusberg, 2012). Because we observe an interaction between emotion and orientation in our data, OCR cannot account for our findings, since it should equally affect all faces.

[6] A valuable legal and ethical lesson for undergraduate research assistants!

congruent regions of space. In Experiment 2, participants completed the same task while lying down on their side, thereby disassociating environmental and egocentric reference frames. Results indicated that this spatial-valence congruency effect was only reliable in the environmental frame of reference, suggesting that (metaphorical) representations of the spatial dimension of emotional valence are constructed with respect to the environment.

Of course, multiple environmental reference frames were conflated in the present study design (e.g., faces that were environmentally upright were upright with respect to the computer display, the lab room, and the directional pull of gravity), so future work is required to tease apart which one(s) people are using to structure affective valence. Nonetheless, the present findings are notable in part because other research has found that effects of spatial orientation on face perception and memory are typically larger in the egocentric frame (e.g., Davidenko & Flusberg, 2012; Troje, 2003).

Also of note, in both experiments the spatial-valence congruency effects appeared to be driven by a decrease in performance for sad faces looking upwards in the environment. As mentioned in the discussion of Experiment 1, this result is somewhat surprising, as other researchers have observed similar congruency effects driven by a relative *increase* in performance for happy faces and positively valenced words that appear in higher regions of space (Lakens, 2012; Lynott & Coventry, 2013). One possibility is that differences in stimuli may account for these disparate findings: It may be that people simply respond to profile faces differently than they do to front view faces and common English words, perhaps due to the fact that judging emotions based on profile views is not a common activity.

No matter the explanation, these data may pose a challenge to some theories that have been put forth to explain spatial-valence congruency effects. In particular, the "polarity-based" perspective suggests that stimulus dimensions (including space and valence) are always anchored at a default endpoint (+pole) that is typically more frequent and unmarked linguistically (Lakens, 2012; Lynott & Coventry, 2013). In the case of valence, for example, "happy" is the default +pole (you can negate the unmarked term *happy* – *un*happy – but not the term *sad*; *un*sad is not an English word). The polarity account attributes spatial-valence congruency effects to a generic processing advantage for +polar items, and since *up* is another example of a +polar endpoint, this means that people should be fastest to respond to happy stimuli in higher regions of space (but see Dolscheid & Casasanto, 2015, for evidence against a universal polarity correspondence account of metaphor-congruency effects). In the present study, however, we do not observe this sort of processing advantage, but rather a processing *cost* for sad faces oriented towards the metaphor-incongruent upper-regions of the environment.

That being said, there is one way to interpret the present findings that would actually support the polarity account: if people are generally much worse at perceiving upward than downward gazing faces, then in fact it *would* be the case that we are seeing a processing advantage for happy faces looking upwards. However, based on other research on orientation effects in face processing and other (unpublished) findings from our lab, we do not think this is the most parsimonious explanation of the current findings. Still, more work may be required to fully rule out this possibility, and to fully explain why different performance asymmetries emerge in studies of spatial-valence congruency.

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