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The Emoji Spatial Stroop Task: Exploring the impact of vertical positioning of emoji on emotional processing

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ABSTRACT

Despite emoji often being assumed to be a form of emotional communication, the emotional affordances of these are not yet fully established. The current study employed the Emoji Spatial Stroop Task to explore whether spatial iconicity affects semantic-relatedness judgments relating to emoji stimuli. Namely, emoji stimuli were displayed in various vertical positions and valence perceptions were measured. A 3 (emoji valence; positive, negative, neutral) x 3 (vertical position; upper, lower, central) within-participants design was used to determine the impacts on valence perceptions. Valence perceptions were obtained from ratings on how positive/negative participants perceived stimuli to be on an 11-point Likert scale (−5 negative, 0 neutral and +5 positive). Findings from 157 participants revealed that, after controlling for current mood, both emoji valence and their vertical positioning impacted significantly on valence ratings. The valence × positioning interaction effect was also significant, highlighting a congruence effect whereby positive emoji in higher vertical space were rated significantly more positively than when in central or lower space, and negative emoji were rated significantly more negatively when displayed in lower vertical space compared to central or upper space. These congruence effects suggest we may embody emoji as symbolic objects to represent abstract emotional concepts.

1. Introduction

Emoji use continues to be increasingly popular within online communication (Novak et al., 2015). This has motivated researchers to understand their uses, functions and affordances within communication and self-expression (see Bai et al., 2019, for recent review). Indeed, emoji are noted to be especially useful within text-based online communication (e.g., social media posts, text messaging, emails) as a means of providing additional contextual information to exchanges, in the absence of non-verbal cues such as facial expressions (Walther et al., 2015; Walther & D'Addario, 2001). However, their use within these forms of online communication remain diverse across individuals and different online contexts (Kaye et al., 2016). Despite this, it is typically assumed that people use emoji as a means of supporting emotional communication.

Interesting, although emoji are thought to serve emotional functions in online communication (Kaye et al., 2016), empirical literature on this is unclear. This, in part, is due to the majority of research in this field focusing on emoji function from the user/sender's perspective rather than the receiver. Understanding the function(s) of emoji in communicative exchanges for both sender and receiver is critical if the study of emoji is to be more fully situated in core computer-mediated communication (CMC) theory. Of the limited research examining this from the receiver's perspective, much focuses on issues outside of emotional processing such as perceptual processing (Robus et al., 2020) and interpersonal signalling (Gesselman et al., 2019). However, two studies are directly relevant to identifying the emotional functions of these symbolic representations of emotion (i.e., Kaye, Rocabado, et al., 2021; Kaye, Rodriguez Cuadrado, et al., 2021). Findings from these studies indicate that emoji are more likely a social processing tool rather than being inherently emotional as measured by lexical decision paradigms. That is, processing advantages which may be expected for emotional stimuli such as quicker reaction times and fewer errors in lexical decision tasks to emotion-laden over neutral stimuli (Kousta et al., 2009; Larsen et al., 2008) have not been found in relation to emoji stimuli (e.g., happy and sad emoji) suggesting these are not implicitly processed as

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emotional stimuli (Kaye, Rocabado, et al., 2021; 2021b). Despite this, emoji are typically still considered to be meaningful candidates of emotion in a similar way to human faces (Fischer & Herbert, 2021).

However, this topic is still very much in its infancy, with much more to investigate. Specifically, the study of emoji could benefit from further integration with core psychological principles relating to cognitive or emotional processing, given that this is largely absent from much discussion on emoji and their position in the communication-mediated communication (CMC) field more generally. Specifically, if emoji are indeed candidates in emotional communication, it would be fruitful to more fully establish whether paradigms in cognitive psychology and emotional processing field may reveal insights into the way in which emoji are processed on a cognitive and/or emotional level. Decades of work in cognitive psychology has established numerous experimental paradigms to ascertain how cognitive-emotional processing relates to (emotional) stimuli. One classic experimental approach here is the Stroop test to explore our abilities to inhibit the cognitive interference of a specific feature of a stimulus (Scarpina & Tagini, 2017; Stroop, 1935). From a selective attentional perspective, features of a stimulus which cause semantic inference require more attentional resources, thus places a bottle-neck on processing efficiency (McMahon, 2013), typically evidenced by slower reaction times to stimuli (McMahon, 2013). "Interference" features of stimuli can refer to many properties of how stimuli are presented to participants, including the classic incongruent text colour, spatial location, auditory presentation or other intermodal features (Cohen & Martin, 1975; Shimada, 1990; White, 1969). We discuss spatial properties as a specific presentation feature later in this paper.

When using the Stroop test in relation to emotion, research has tended to focus on lexical decision or colour naming (Algom et al., 2004). Interestingly, this has found that task performance for negative emotional words is typically slower than neutral stimuli, suggesting that any effects from the emotional Stroop Test may not be best considered a Stroop effect (selective attention process) at all (Algom et al., 2004; McKenna & Sharma, 2004). This supports other assertions relating to the principles of the Stroop effect perhaps not always supporting the notion that the effect manifests from a restriction on a single, serial attentional system (MacLeod, 1991) or that (negative) stimuli may automatically receive allocation of attentional resources. Instead, there are discussions about parallel processing in which different features of stimuli presentation may be processed independently, thereby refuting the notions of feature-integration theory in explaining Stroop effects (Shimada, 1990).

To explore how spatial properties of stimuli impact on processing efficacy and effectiveness, the Spatial Stroop test has a great deal of relevance (White, 1969). The Spatial Stroop specifically tests the interference which may occur between the spatial location of where the stimulus is presented and the word or symbolic feature itself that conveys spatial information (MacLeod, 1991; Wuhr, 2007). There have been many variations on the Spatial Stroop including: font size of word stimuli (Palef & Olson, 1975), use of arrows with preposition words such as "up" and "down" in them (Shor, 1970), and whether stimuli are presented in the upper or lower visual fields (Zwaan & Yaxley, 2003). In respect of the latter, this can test whether spatial iconicity affects semantic-relatedness judgments. For example, when the word "attic" is presented in the upper visual field, evidence suggests we are more efficient at responding to this compared to when it is presented in the lower visual field, and vice versa for words such as "basement" (Zwaan & Yaxley, 2003). Indeed, the impact of spatial stimuli features has been suggested to be a key factor in cognitive performance (Lu & Proctor, 1995). These effects are perhaps best underpinned by Lakoff and Johnson's (1999) conceptual metaphor theory. This posits that abstract domains become embodied by links with concrete domains we experience in our physical world, and thus these concrete domains are a bridge between abstraction and the referent of interest. Embodiment here refers to the role played by the body when processing information (Clark, 1998), such that our cognition is influenced (or at least related) to perceptual or bodily experience. This has been observed in experimental contexts such that participants report higher levels of guilt when wearing a *heavy* backpack compared to a lighter backpack (Kouchaki et al., 2014).

The vast majority of research testing the principle of how the interpretation of stimuli can vary based on spatial location has focused on words (Mahon, 2015; Mahon & Caramazza, 2008; Thornton et al., 2013). It is suggested that recognising a word requires activation of perceptual and/or motor-related processing that may be relevant when we are actually experiencing the entity (i.e., perceptual simulation hypothesis; Barsalou, 1999; Treccani et al., 2019; for a review, see Meteyard et al., 2012). In addition to the classic work of Zwaan and Yaxley (2003) noted earlier, further supporting evidence for this is provided by Šetić and Domijan (2007) who demonstrated a congruence effect whereby words such as "bird" or "sky" had a processing advantage when presented in the upper visual field (in line with where one would typically expect to observe this referent) compared to when presented in the lower visual field. In these cases, the effect is evidenced from the fact that participants are both faster and more accurate when responding to congruent pairings of words and space, compared to incongruent pairings. Whilst this hypothesis makes intuitive sense for words and objects which would typically be physically embodied within our everyday experiences, the abstract nature of emotion raises questions about the validity of this explanation for understanding emotional processing.

When considering the issue of emotion and spatial location, scholars have argued that abstract cognition can be based on physical metaphors (Lakoff & Johnson, 1999). In this way, metaphors encourage us to think in abstract terms by linking abstract concepts such as certain emotions (e.g., happiness) to concrete sensory experiences (Meier & Robinson, 2004). In detail, happiness is considered to be higher in physical space (e.g., "I'm in *high* spirits"), while sad is lower in physical space (e.g., "I *fell* into a depression"). Empirical evidence supports this association between space and emotion whereby a processing advantage is observed when positive stimuli are is presented in the upper visual field rather than the lower visual field, with the converse pattern observed for negative stimuli (negative stimuli in lower visual space is more congruent than negative stimuli in higher space; Meier & Robinson, 2004). Indeed, this processing advantage has also been observed for emotion words associated with a stereotypical posture (e.g., happiness and joy being related to upright posture and sadness and grief related to slouched), with these words playing an automatic role in activating the corresponding vertical space (i.e., upper for happiness; lower for sadness; Dudscig et al., 2015). Similarly, gait patterns such as slower walking speed have been found to be associated with sadness and depression, suggesting physical embodiment of emotional states (Michalak et al., 2009). Overall, the existing literature suggests that processing of emotional stimuli is impacted by the spatial properties of its presentation. Given that this effect has been observed for words (e.g., "happiness" and "sadness"; Dudscig et al., 2015), it is of interest to determine whether this effect extends to other symbolic representations of emotions; specifically, emoji. If emoji are indeed processed as emotional stimuli (as is typically assumed, but barely proven), we would expect an equivalent congruence effect. That is, congruent presentations of emoji (e.g., happy emoji in upper vertical space) should support our processing of these stimuli rather than an incongruent presentation (e.g., happy emoji in lower vertical space). The same would also occur for sad emoji, with greater valence associated with their presentation in lower vertical space than higher vertical space. Given the exploratory nature of this work, we focused exclusively on explicitly asking for emotion (i.e., valence) perceptions rather than implicitly testing effects via semantic judgements as per the previous literature using word stimuli. Previous research has found that explicit rather than implicit tasks may be more likely to elicit effects (Bahn et al., 2017), and therefore may be deemed more useful in this case as exploratory work. As such, the Spatial Stroop paradigm here was not administered to garner response times, but rather to elucidate how participants explicitly rated valence of stimuli. This was achieved through the use of our Emoji Spatial Stroop Task. As such, we aim to address the following research question (RQ):

RQ1. Does the vertical positioning of emoji presentation impact upon valence perceptions?

Given the exploratory nature of this work, it is not necessarily appropriate to form directional hypotheses, but if indeed emoji are embodied as emotional stimuli, we should observe i) higher (more positive) valence ratings for positive emoji when situated in upper vertical space, and ii) lower valence ratings (more negative) for negative emoji in lower vertical space.

In addition, we note that the current emotional state of individuals is a key consideration for research in this area. Previous work has noted that positive mood, for example may improve performance on tasks such as the Stroop task (Phillips et al., 2002), and sad mood may result in longer latencies in responding to negatively-valenced words (Isaac et al., 2012). Whilst the current study did not seek to obtain response times, these findings suggest mood to be a useful variable to control. Specifically, in relation to vertical positioning, previous work suggests that when an individual is in a positive mood this can cause visual perception to be viewed upwards (Wapner et al., 1957). Conversely, when an individual's mood is negative mood, visual perception has been found to be viewed downwards (Fisher, 1964). This suggests current mood is likely to bias vertical perceptual processes and as such, is an important control variable in empirical enquiry. Therefore, we also measured current mood as covariate in our study.

2. Method

2.1. Design

We used a 3 (emoji valence: positive, negative, neutral) x 3 (vertical position: upper, lower, central) within-participants design. Therefore, emoji were presented across three conditions: 1) Congruent (i.e., positive emoji in the upper vertical space; negative emoji in the lower vertical space) 2) incongruent (e.g., positive emoji in lower vertical space; negative emoji in upper vertical space); 3) control (e.g., positive, negative and neutral emoji in the central visual space; and neutral emoji in upper and lower positions).

2.2. Participants

Prior to the research being conducted, it received full ethical approval from the Department of Psychology Research Ethics Committee at Edge Hill University. Participants were primarily recruited as an opportunity sample from this Department although an online advertisement recruited beyond this sample. The final sample ($N = 157$) had an average age of 26.89 years ($SD = 9.93$; range = 18–72 years), with a gender breakdown of 59 males, 96 females, and 2 who preferred not to say. We have performed a sensitivity analysis in our sample with G*Power 3.1 software (Faul et al., 2009). For the analysis, we used F tests with $\alpha = 0.05$, power = 0.80 and the total sample size of 157 participants as input parameters. We performed sensitivity analysis rather than post-hoc power analysis based on previous recommendations noted in the literature (Lakens, 2021; Perugini et al., 2018).

2.3. Measures and stimuli

2.3.1. Pre-test mood

Current mood was obtained at pre-test using the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). The scale consists of 20 adjectives; 10 represented positive affect (e.g., alert, excited) and 10 represented negative affect (e.g., distressed, upset). Using a 5-point Likert scale, participants indicted the degree to which the adjectives were representative of their current mood (1 = very slightly or not at all, 5 = extremely). Total scores were calculated per sub-scale and used in the subsequent analyses. Cronbach's alpha for the full scale in the current study was found to be acceptable at .74 and per subscale was also found to be highly acceptable (α = 0.85 and 0.85 for both positive and negative affect, respectively).

2.3.2. Emoji Spatial Stroop task

Positive, negative and neutral emoji (24 in total; 8 per emoji valence) were selected from the stimuli valenced by Rodrigues et al. (2018). Specifically, Rodrigues et al. (2018) asked participants to provide ratings on seven evaluative dimensions of emoji from the Unicode Emoji Chart (accessible here: http://unicode.org/emoji/charts/full-emoji-list.html). Ratings were made in respect of valence as well as other key dimensions such as arousal. For valence, these ratings varied from 1 (very negative) to 7 (very positive) from which three levels were derived (high, moderate and low). For the current study, emoji were selected from each of these levels to represent positive, neutral and negative emoji conditions respectively. Therefore, of the 24 total emoji stimuli used, there were eight emoji per emoji valence condition (see Appendix 1 for emoji stimuli).

The task was developed on Microsoft PowerPoint, with a single slide created for each trial. A vertical rectangular box was positioned in the centre of each slide (17.5 cm × 13.5 cm), with a cross placed in the central location to signify the centre. All emoji (formatted to be 3.8 cm × 3.8 cm) were positioned on the central vertical line of the rectangle, with only their vertical positioning varying. In the upper vertical space condition, emoji were placed between 0.5 and 0.7 cm below the top line of the rectangle. In the lower vertical space condition, they were placed between 0.5 and 0.7 cm above the base of the rectangle. In the control condition, they were placed in the centre. Each slide (i.e., trial) was saved as an individual PNG file and uploaded into the Qualtrics software (Qualtrics, Provo, UT). The following Open Science Framework link provides a copy of the Emoji Spatial Stroop task and individual stimuli files https://osf.io/jk8qc/?view_only=14c499529edf4acfb28b3c327af234ab. To ensure the presentation of stimuli remained equivalent across the sample, participants were requested to complete the study on a PC rather than a mobile or other device. See Fig. 1 for visual example of trial stimuli.

2.4. Procedure

Once agreeing to participate in the online research via Qualtrics, participants provided demographics (age, gender) and completed the measure of current mood (PANAS, Watson et al., 1988). Following this, participants undertook the Emoji Spatial Stroop Task, in which a series of 72 trials commenced. These trials consisted of 8 positive emoji stimuli x 3 positions (24 trials), 8 negative emoji stimuli x 3 positions (24 trials), and 8 neutral emoji stimuli x 3 positions (24 trials). A random number generator within Microsoft Excel was used to randomly order the trials. These trials were then split into three equal blocks, each containing 24 trials. The order of the blocks was randomly presented for each participant, yet the order of the trials within the specific blocks remained constant.

Within Qualtrics, trials were presented one per page. For each trial, participants were asked "How positively or negatively do you perceive this emoji to be?" Responses were provided using an 11-point horizontal Likert scale (−5 negative, 0 neutral and +5 positive). These scores were used to create a mean valence rating per experimental condition, resulting in nine mean ratings. The whole study took approximately 20 min to complete.

3. Results

Descriptive analyses were undertaken to explore valence by experimental condition (see Table 1).

The sensitivity analysis, given a sample size of 157 participants, an α = 0.05 and an expected power = 0.80, showed that we could detect values down to $f = 0.073$ ($F_{critical} = 1.95$, $df = 8, 1248$); therefore,

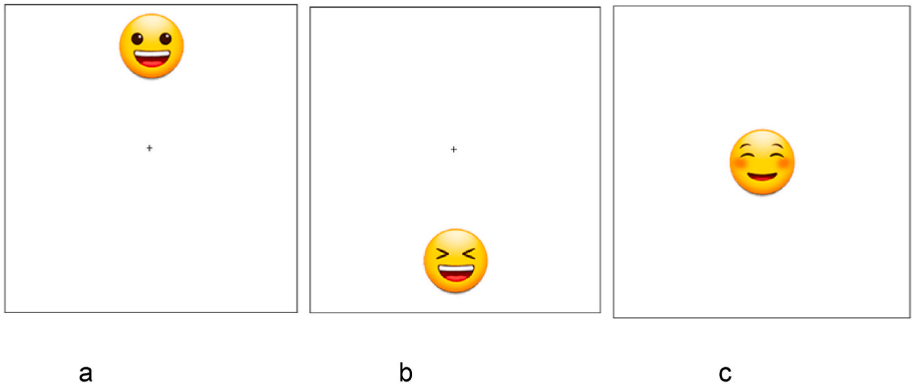


Fig. 1. Examples of a congruent (a), incongruent (b) and control (c) trials for positive emoji.

Table 1
Descriptive analysis of valence ratings between experimental conditions for positive, negative and neutral emoji.

Emoji Valence	Position in Visual Space	M	SD	Skewness	Kurtosis
Positive	Upper	3.98	1.00	−1.81	5.44
	Lower	3.20	1.27	-.86	.12
	Central	3.48	.98	-.82	.88
Negative	Upper	−2.50	1.08	.65	.26
	Lower	−3.19	1.03	.12	.24
	Central	−2.58	.83	.29	-.06
Neutral	Upper	-.33	1.29	.69	.65
	Lower	−1.14	1.12	-.68	-.05
	Central	-.74	.64	-.69	2.65

Note. Minimum and maximum mean valence scores was −5 to +5. A greater positive score indicates greater mean positive valence, and greater negative score indicating greater negative valence.

Table 2
Summary of main and interaction effects.

Condition	*df*	*F*	η_p^2	*p*
ANOVA				
Emoji valence	1.41, 220.21	2467.34	.94	<.001
Vertical position	1.07, 167.04	35.41	.19	<.001
Emoji valence * Vertical position	2.58, 402.36	9.05	06	<.001
ANCOVA (current mood as covariate)				
Emoji valence	1.42, 220.29	145.45	.48	<.001
Vertical position	1.08, 166.62	4.11	.03	.041
Emoji valence * Vertical position	2.57, 397.93	1.08	.01	.350

obtained *F* values equal to or larger the critical *F*-value is significant at the level of probability.

To examine whether emoji valence and vertical position influenced valence ratings, a 3 (emoji valence: positive, negative, neutral) x 3 (vertical condition: congruent, incongruent, control) repeated measures ANOVA was conducted. Mauchly's test indicated that the assumption of sphericity had been violated for emoji valence ($\chi2$ (2) = 83.58, $p < .001$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.71$). Assumption of sphericity was also violated for vertical position ($\chi2$ (2) = 313.66, $p < .001$), and therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.54$).

A significant main effect was found for emoji valence, *F* (1.41, 220.21) = 2467.34, $p < .001$, $\eta_p^2 = 0.94$ and vertical position *F* (1.07, 167.04) = 35.41, $p < .001$, $\eta_p^2 = 0.19$. There was also a significant interaction effect for emoji valence x vertical position, *F* (2.58, 402.36) = 9.05, $p < .001$, $\eta_p^2 = 0.06$. Planned post-hoc Bonferroni comparisons revealed that for emoji valence, the difference in ratings occurred between each of the conditions (all *ps* < .001), indicating that positive emoji (*M* = 3.55, *SE* = 0.07) were rated more positively than neutral (*M* = −0.74, *SE* = 0.06) which in turn were rated more positively than negative ones (*M* = −2.76, *SE* = 0.06). Bonferroni comparisons also revealed that for vertical positioning, the difference in ratings occurred between each of the positions (all *ps* < .001). Namely, emoji were rated more positively when in the upper visual position (*M* = 0.39, *SE* = 0.07) than the central position (*M* = 0.05, *SE* = 0.03), which in turn was greater than when presented in the lower visual position (*M* = −0.38, *SE* = 0.08). See Table 2 for a summary of the main and interaction effects.

To elucidate the effects further, simple main effects analyses were conducted. This suggested that the effect of emoji valence on valence ratings was significant in most vertical positions. That is, valence ratings of positive emoji varied significantly between all three vertical positions, whereby ratings increased linearly from lower (*M* = 3.20, *SE* = 0.10), central (*M* = 3.48, *SE* = 0.08) to upper positions (*M* = 3.98. *SE* = 0.08) (all *ps* < .001). For negative emoji, valence ratings varied significantly between lower and both central and upper vertical positions (both $p < .001$), but not between upper and central ($p = .232$). Namely, negative emoji were rated significantly more negatively in lower (*M* = −3.19, SE = 0.08) compared to both central (*M* = −2.58, *SE* = 0.06) and upper positions (*M* = −3.19, *SE* = 0.08). For neutral emoji, valence ratings varied significantly between all three vertical positions (all *ps* < .001). That is, valence ratings increased linearly from lower (*M* = −1.14, *SE* = 0.10), central (*M* = −0.74, *SE* = 0.05) to upper positions (*M* = −0.33, *SE* = 0.10) (all *ps* < .001). Further simple main effects analysis suggested that the effect of vertical positioning on valence ratings was significant for all emoji conditions. Namely, when in upper vertical positions, positive emoji were rated most positively (*M* = 3.98, *SE* = 0.08), followed by neutral (*M* = 0.33, *SE* = 0.10) and then negative emoji (*M* = −2.50, *SE* = 0.09) (all *ps* < .001). The same pattern was found when emoji were in central positions (all *ps* < .001). Namely, highest valence ratings for positive emoji (*M* = 3.48, *SE* = 0.08), followed by neutral (*M* = −0.74, *SE* = 0.05), and then negative emoji (*M* = −2.58, *SE* = 0.07). Finally, in lower vertical positions, negative emoji were rated most negatively (*M* = −3.19, *SE* = 0.08), followed by neutral (*M* = −1.14, *SE* = 0.10), and then positive emoji (*M* = 3.20, *SE* = 0.10) (all *ps* < .001). See Fig. 2 for visualisation of data for the three emoji conditions by vertical positioning.

To control for pre-test current mood, a 3 × 3 repeated measures ANCOVA was conducted which included current mood as a covariate. Mauchly's test indicated that the assumption of sphericity had been violated for emoji valence ($\chi2$ (2) = 80.54, $p < .001$), therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.71$). Assumption of sphericity was also violated for vertical position ($\chi2$ (2) = 303.40, $p < .001$), and therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.54$).

Significant main effects were still observed both for emoji valence

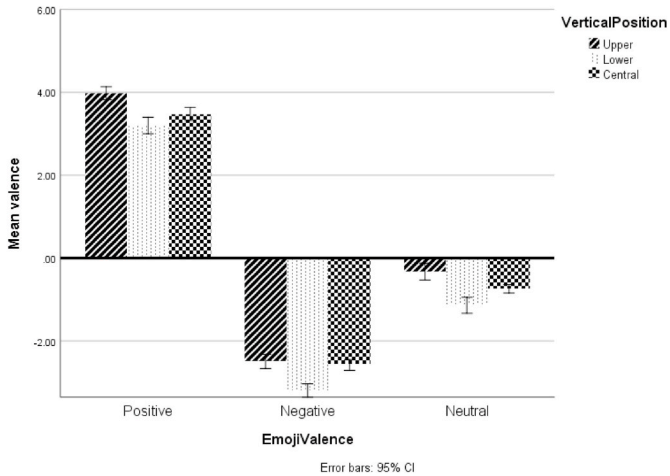


Fig. 2. Mean valence ratings for positive, negative, and neutral emoji by vertical position.

and positioning. Namely, emoji valence F (1.42, 220.29) = 145.45, $p <$ .001, $\eta_p^2 = 0.48$, and vertical position F (1.08, 166.62) = 4.11, $p < .05$, $\eta_p^2 = 0.03$. The interaction effect however was not observed with the presence of current mood as a covariate F (2.57, 397.93) = 1.08, $p =$ .350 $\eta_p^2 = 0.01$. Finally, pairwise comparisons of valence ratings between all emoji and position conditions remained significant (all $p <$ .001). No further analyses were undertaken given the main and interaction effects were not substantially different from the aforementioned ANOVA, suggesting current mood did not seem to change the nature of the effects observed.

4. Discussion

Emoji are typically assumed to be emotional (e.g., Kaye et al., 2016) yet the empirical basis for this assumption is largely under-established. As such, the current study investigated the role of spatial properties of emoji stimuli presentation on emotional processing. Specifically, we developed an Emoji Spatial Stroop Task to explore the effect of vertical positioning on valence perceptions of emoji. We studied this in relation to emoji of positive, negative and neutral valence. The main findings and implications are discussed in the following sections.

Findings revealed that, irrespective of participants' current mood, valence of emoji (i.e., positive, negative and neutral) and their vertical positioning (i.e., upper, central or lower) impacted significantly on valence ratings, with a significant interaction effect. Namely, positive emoji in upper vertical position were rated significantly more positively than when in central or lower vertical positions. Neutral emoji followed an equivalent pattern. Conversely, negative emoji were rated significantly more negatively when in lower visual space relative to central or upper positions. These vertical positioning congruence effects suggest that we embody emoji as has been shown with other emotional stimuli, such as emotional words (e.g., Dudscig et al., 2015), indicating that they may be processed emotionally. This challenges recent evidence which suggests the contrary (Kaye, Rodriguez Cuadrado, et al., 2021). Given the emoji stimuli were consistent across the current study and that of previous work, one potential explanation for these disparate findings may be variations in response format. That is, the current study utilised a self-report format whereas previous studies have used computerised "automatic" processing tasks to garner response time and accuracy data. It may be the case that emoji are processed emotionally (as evidenced by the current findings) but not at an automatic processing level as per previous findings. Indeed, previous research shows differentiation effects dependent upon the origin of emotions; that is whether they are automatically elicited (such as via an emotional Stroop) or reflective via deliberative evaluation (Imbir & Jarymowicz, 2013). However, other research suggests that even though interference effects for incongruent stimuli are noted to occur irrespective of whether measures are implicit or explicit, subjective evaluations may have some dissociation from implicit measures (Bertelietti et al., 2010). Whilst the self-report nature of our findings can still allow us to explore questions about valence evaluation, this may relate to more considered and conscious processing than equivalent work on priming and automatic processing effects (e.g., Kaye, Rodriguez Cuadrado, et al., 2021). As such this further research which utilises the Emoji Spatial Stroop task would be encouraged to apply paradigms akin to previous work on the more traditional Spatial Stroop task to allow greater comparability to the existing work. This could help determine the extent to which conscious or automatic processing of emoji occurs.

To our knowledge, this is the first study that has explored spatial properties of emoji by applying the theoretical principles of Spatial Stroop. In line with Meier and Robinson's (2004) "sunny side up" notion, the current findings go some way to suggest that this is indeed the case for evaluating valence of emoji. From a theoretical perspective, this suggests that valence associated with emoji is grounded in sensorimotor perception, as may also be the case for other emotional stimuli. In this case, we evidence that emoji may constitute concrete symbolic representations of abstract emotional concepts which until now, has remained rather a speculative notion.

We see the Emoji Spatial Stroop as a tool which could be further utilised in empirical enquiry. One research avenue could be to explore response formats associated with stimuli presentation. That is, in line with the principles of the Simon task effect, we may expect interference effects based on spatial response formats (Lu & Proctor, 1995). Additionally, interference effects have been noted to be dependent on response mode, in that when participants are responding verbally rather than by manual/motor reactions, this is more likely to prompt the expected inference effect (Hilbert et al., 2014; White, 1969). Therefore, testing the Emoji Spatial Stroop Task in line with a variety of different response formats could be an interesting empirical development.

A limitation of our work is that emoji were presented in isolation from the types of content with which they usually appear in online communication (e.g., written posts, photos). Whilst this allowed us to maintain effective experimental control, it would be useful to explore how the space × affect interaction may work when emoji are presented alongside more ecologically valid stimuli. This would help us understand a little more about how these effects may work in practice. In line with this, this raises the question about practical implications. Within online/text-based communication, the findings may suggest that emoji could bring on additional emotional "weight" if they were presented as super or sub-scripts alongside written text. That is, given that positive emoji are experienced as being more positive when in upper space, these may be especially more prominent as positive emotional cues in superscript font in written discourse (e.g., "Today has been a good day!☺"). Studies which utilise this approach to test this assertion could be very useful and if applied to practical contexts, could support people's emotional understanding in ambiguous situations. This may be especially useful when communicating in contexts with multiple audiences/receivers such as in a social media post on one's timeline, when communicative efficacy may be reduced based on the fact there is not one specific interaction partner. This may also be considered in line with other physical properties of emoji such as size, in which larger sized emoji may correspond with dimensions of dominance or arousal (Bradley & Lang, 1994). Additionally, replication work which asks participants to make dominance or arousal judgements instead of valence ratings would be an interesting future avenue here.

A further potential limitation is the possibility that completing the current mood measure at pre-test may have primed responses on the Emoji Spatial Stroop Task. Although this would not be a specific confound to some conditions and not others, it would be interesting to control for this in future studies in which measurement of current mood is counterbalanced to be measured pre-test or post-test to test this assertion. Further, we did not control for native language which we recognise may influence emotional processing of emotion-laden stimuli (Kazanas & Altarriba, 2016), although it is yet to be determined whether effect may apply to emoji.

Our findings suggest that emoji are suitable candidates as emotional stimuli and would benefit from additional work to explore more fully their embodiment potential. For example, it would be interesting to investigate other multimodal properties such as horizontal positioning given that previous findings have suggested positive emotional valence is more readily associated with one's dominant hand (de la Vega et al., 2012). For example, a right-handed individual is likely to have a greater processing advantage of positive stimuli towards their right, dominant hand compared to their left. This may also be interesting to correspond to work in numerical cognition and number lines in which negative values would typically be represented in left horizontal space and therefore this may also elicit a left-negative/right-positive bias. Previous work by Robus et al. (2020) has studied the effect of horizontal positioning based on where emoji appear in sentences although not found any significant effects but there is further work to do here. Further aural properties would be an interesting advancement. For example, aural tones which vary in pitch (high vs. low frequency) have been found to interact with the spatial processing of visual stimuli in upper vs. lower positioning (Romero-Rivas et al., 2018). Melodic "ups" (high pitch) for example appears to be encoded more efficiently when visual stimuli are presented in high positioning relative to low, suggesting a cross-modal effect (for related evidence with sound intensity see Puigcerver et al., 2020). Extending to emotional processing of emoji, presenting tones of varying pitch, with various spatial positioning of emoji stimuli could help us understand how these cross-modal properties extend to emoji. If it is the case that emoji are emotionally embodied, we may observe that these effects apply also to emoji as potentially emotional stimuli. This can help further develop the conceptual basis for answering the question; "are emoji emotional?"

5. Conclusion

This study is the first of its kind to apply theoretical principles of the Spatial Stroop to examine emoji processing. Specifically, we developed the Emoji Spatial Stroop Task which we believe is a worthy contribution in the area of emoji research, and could be a practical means for further work to be undertaken. Our findings highlight that spatial properties of emoji intersect with valence processing, highlighting they may be symbolic objects representing abstract emotional concepts. Emoji represent a popular tool in (emotional) communication, and their emotional affordances present an area of key societal interest. As such, our findings highlight how these may be embodied within our everyday online communicational experiences. Whilst it is yet to be determined whether this operates at an implicit level, our findings give rise to the claim that at least on an explicit evaluative level, emoji may be emotional.

Data availability statement

The experimental task, stimuli and datasets generated during and/or analysed during the current study are available on the Open Science Framework repository, https://osf.io/jk8qc/?view_only=14c499529edf4acfb28b3c327af234ab.

CRediT author statement

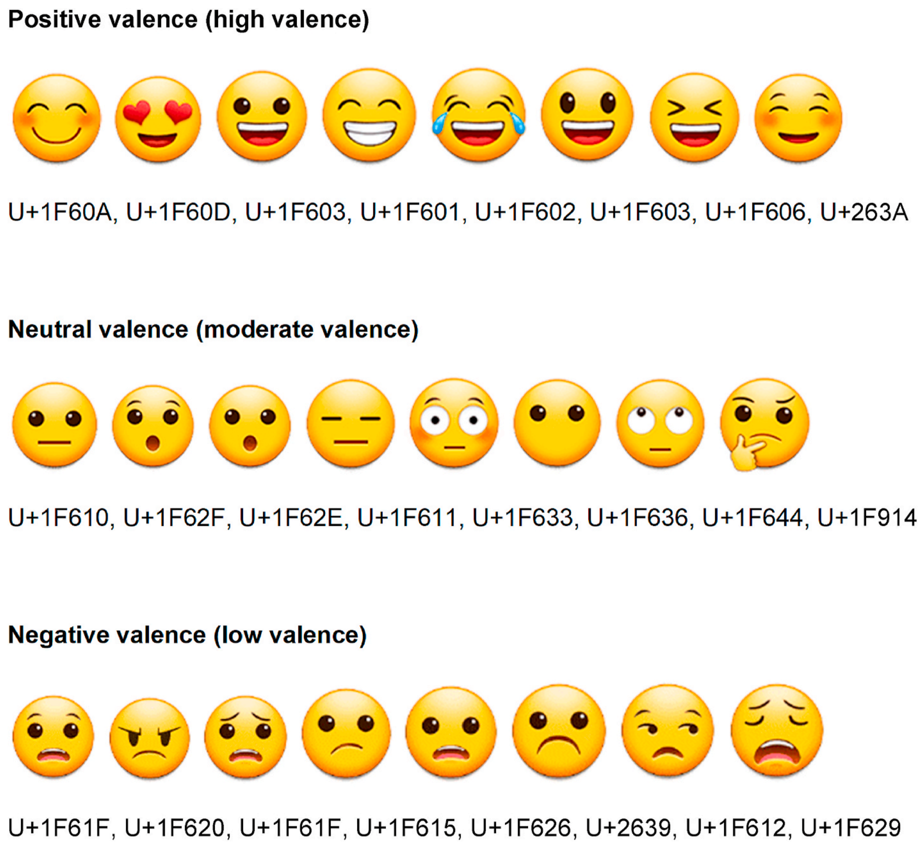
Conceptualization: LK, SRC, HW, SM. Methodology: LK, SRC, HW, SM. Software: LK. Validation: LK. Formal analysis: HW, SM, SRC, GD. Investigation: GD. Resources: LK, GD. Data Curation: LK, GD. Writing - Original Draft: LK. Writing - Review & Editing: LK, HW, SRC, SM, GD. Visualization: LK. Supervision: LK. Project administration: LK.

Declaration of competing interest

There are no conflicts of interest to disclose.

Appendix 1. Emoji stimuli

Below are the emoji used to represent the three valence conditions. These are taken from the Unicode Emoji Chart which is accessible here: http://unicode.org/emoji/charts/full-emoji-list.html. We used emoji from the Samsung platform column in all cases. The specific code per emoji is listed chronologically underneath each icon.



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