Emotional working memory loads increase negative interpertations of surprised facial expressions

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Abstract

Individual differences in interpretations of emotional ambiguity are a useful tool for measuring affective biases.

While trait-like, these biases are also susceptible to experimental manipulations. In the present study, we capitalize on this malleability to expand on previous research suggesting that subjective interpretations are stable independently of cognitive load.

We tested the effects of working memory loads containing either neutral or emotional content on concurrent interpretations of surprised facial expressions.

Here we show that interpretations of surprise are more negative during maintenance of working memory loads with emotional content compared to those with neutral content.

Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

One or two sentences to put the results into a more **general context**.

Two or three sentences to provide a **broader perspective**, readily comprehensible to a scientist in any discipline.

Keywords: ambiguity, working memory, bias

Word count: X

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Introduction

Even simple tasks (e.g., remembering a phone number) reveal the limits of human cognition. In fact, many researchers believe that there is a magic number of the amount of information able to be held in working memory (7 +- 2 paper). Others have focused on the limits of working memory and successful task performance to inform industrial and organizational policies (Sweller, Merrienboer, & Paas, 1998). Despite the large amount of research around working memory and cognitive control, much controversy remains around the mechanisms through which attention to perceptually salient stimuli affect attentional processes and subsequent cognitive control (Lavie, Hirst, Fockert, & Viding, 2004). Specifically, there is a divide amongst researchers that believe cognitive loads either inhibit perceptions of non-relevant stimuli

Recent work suggests that ambiguity resolution, at least in the context of surprised facial expressions, requires more cognitive resources/processing compared to clearly valenced faces (Mattek, Whalen, Berkowitz, & Freeman, 2016; Neta & Tong, 2016). Surprised facial expressions are ambiguous without contextual information. For instance, a surprised facial expression may indicate either positive (e.g., winning the lottery) or negative (e.g., a snake in the woods) events/contexts. Previous work shows that individuals differ in their tendency to interpret these expressions as either positive or negative (Neta, Norris, & Whalen, 2009). This difference is trait-like (Neta et al., 2009) and generalizes to non-face stimuli (Neta, Kelley, & Whalen, 2013); however, these individual differences are also malleable and may differ depenending on experimental manipulations (Brown, Raio, & Neta, 2017; Neta & Tong, 2016). Importantly, this behavioral bias is related to depressive symptomology (**???**); specifically, more pubertally mature individuals show a correlation between negative bias and more severe depressive symptoms.

It is well known that distractors and task irrelevant stimuli can have detrimental effects on performance in a variety of tasks (cite, cite, cite). Further, emotional stimuli may further exacerbate attentional interference compared to neutral stimuli. For example, the Stroop task (**???**) has been modified by some researchers to include emotional stimuli (**???**) which has pronounced effects when the emotional words are population specific (e.g., trauma words in a PTSD sample). Similarly, others have shown

Mattek and colleagues (2016) recently showed that different levels of cognitive load (i.e., holding either a single or seven digit number in working memory) does not affect subjective interpretations of surprised facial expressions, but that high cognitive loads do mitigate mouse trajectories. While the authors interpret this as a distinction between trait-like biases and dynamic cognitive-motor processes, there may be more domain-specific processes (e.g., emotional components) that span across these two measures of valence bias. Indeed, neuroimaging work suggests that separate systems handle attentional biasing for domain-specific (emotional vs. non-emotional) task relevancy (Egner, Etkin, Gale, & Hirsch, 2008). Given the task irrelevance of the numeric distractors in Mattek and colleagues' (2016) work, it follows that the resources required for interpreting ambiguity as positive (Neta et al., 2009) may not have been recruited for working memory maintenance.

In the present study, we aim to test the effects of low and high working memory loads in both emotional and neutral domains. We expect that trials in which participants are maintaining an emotional working memory load will be more negative than neutral trials. Further, we predict that higher working memory laod trials, specifically in the emotional domain, will result in even more exaggerated negative interpretations.

Notes: Allie showed that depletion doesn't affect ratings, but we thought that there may be an effect of specific domains of depletion (i.e., neutral vs. emotional) on ratings. Focus on EMO > NEU ratings and POS > NEG MDs. MT analyses could be supplementary material, but you'll be going down the rabbit hole. Recently, others have suggested a dynamic social trait space model for judgments of faces (Stolier, Hehman, & Freeman, 2018), and it may be important to consider additional components of the categorization process, such as domain-specific loads.

Methods

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study.

Participants

58 subjects were recruited from the University of Nebraska-Lincoln. All subjects provided written informed consent in accordance with the Declaration of Helsinki and all procedures were approved by the local Institutional Review Board (Approval #20141014670EP). The data from eight subjects were excluded due to technical difficulties or an error in the experiment script. This left 50 individuals in the final sample.

Material

Stimuli. The stimuli included faces taken from the NimStim (Tottenham et al., 2009) and Karolinska Directed Emotional Faces (Lundqvist, Flykt, & Öhman, 1998) stimuli sets. The faces consisted of 47 unique identities including 11 angry , 12 happy , and 24 surprised expressions organized pseudorandomly. The scenes were taken from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008). A total of 288 scenes (72 positive, 72 negative, and 144 neutral) were selected for the image matrices. The positive and negative images did not differ on arousal (report t-test). The scenes were organized into low (two images) and high (six images) cognitive load of either neutral or emotional (equal number of positive and negative) images (Figure 1).

Software. The task was completed in MouseTracker (Freeman & Ambady, 2010) and participants used a mouse to click the appropriate response for the face ratings (i.e., “POSITIVE” or “NEGATIVE”) and the memory probe (i.e., “YES” or “NO”).

Procedure

Participants were randomly assigned to complete one of the task versions. The tasks included 144[1] trials split between working memory probe and face rating trials. On each trial, participants first viewed an image matrix of either neutral or emotional images, which the participants were instructed to remember for the duration of the trial. The image matrix was presented for four seconds and the images were swapped from low and high load matrices across versions of the task. After the image matrix a happy, angry, or surprised face appeared for one second and the participants rated the face by clicking on either the positive or negative response option. After the face rating, a single image probe appeared and participants indicated whether or not the image probe was present in the previous image matrix.

Data analysis

We used R (Version 3.6.0; **???**) and the R-packages * }dplyr* [@ }R-dplyr], *forcats* (Version 0.4.0; **???**), *ggplot2* (Version 3.1.1; **???**), *papaja* (Version 0.1.0.9842; **???**), *purrr* (Version 0.3.2; **???**), *readr* (Version 1.3.1; **???**), *readxl* (Version 1.3.1; **???**), *stringr* (Version 1.4.0; **???**), *tibble* (Version 2.1.3; **???**), *tidyr* (Version 0.8.3.9000; **???**), and *tidyverse* (Version 1.2.1; **???**) for all our analyses. Data preprocessing was completed in R using the mousetrap package (**???**). First, percent negative ratings were calculated for happy, angry, and surprised faces across all trial types. Next, we used Shapiro-Wilks test to determine normality of the data. Afterwards, since the rating data were non-normally distributed, we submitted the data to non-parametric within-subjects testing: Friedman's test.

[1] Some versions of the task only included 142 trials due to a programming error.

Results

Subjective ratings

Friedman's test results showed significantly different distributions across the conditions $\chi^2(3.00) = 27.41$, p < .001. Follow up Wilcoxon signed rank tests revealed that surprise is rated as more negative when holding emotional content in working memory compared to neutral content. Low emotional load ratings were significantly more negative than low, Z = 3.31, p = .001, neutral and high, Z = 3.62, p < .001, neutral loads. The same was true for high emotional load ratings and low, Z = 4.52, p < .001, and high, Z = 3.72, p < .001, neutral loads. However, there was no discernable effect of load. That is, the comparisons between low and high load ratings for both emotional, Z = -1.10, p = .273, and neutral, Z = -0.03, p = .975, load ratings were not significantly different.

Reaction times

RT on trials with an emotional working memory load are longer than neutral trials, F(1,48)= 3.966, p = .052.

Discussion

The effect of high vs. low load is still not apparent in these data, just like Mattek et al. 2016. An alternative explanation is that the high load manipulation is not sufficiently difficult to recruit the targeted cognitive resources; however, future work will be needed to better test this alternative.

References

Brown, C. C., Raio, C. M., & Neta, M. (2017). Cortisol responses enhance negative valence perception for ambiguous facial expressions. *Scientific Reports*, *7*(1), 15107. doi:10.1038/s41598-017-14846-3

Egner, T., Etkin, A., Gale, S., & Hirsch, J. (2008). Dissociable neural systems resolve conflict from emotional versus nonemotional distracters. *Cerebral Cortex (New York, N.Y.: 1991)*, *18*(6), 1475–1484. doi:10.1093/cercor/bhm179

Freeman, J. B., & Ambady, N. (2010). MouseTracker: Software for studying real-time mental processing using a computer mouse-tracking method. *Behavior Research Methods*, *42*(1), 226–241. doi:10.3758/BRM.42.1.226

Lang, P., Bradley, M. M., & Cuthbert, B. N. (2008). International affective picture system (IAPS): Affective ratings of pictures and instruction manual., Technical Report A–8. University of Florida, Gainesville, FL.

Lavie, N., Hirst, A., Fockert, J. W. de, & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology: General*, *133*(3), 339–354. doi:10.1037/0096-3445.133.3.339

Lundqvist, D., Flykt, A., & Öhman, A. (1998). The karolinska directed emotional faces—KDEF (CD ROM)., Stockholm: Karolinska Institute, Departmentof Clinical Neuroscience, PsychologySection.

Mattek, A. M., Whalen, P. J., Berkowitz, J. L., & Freeman, J. B. (2016). Differential effects of cognitive load on subjective versus motor responses to ambiguously valenced facial expressions. *Emotion*, *16*(6), 929–936. doi:10.1037/emo0000148

Neta, M., Kelley, W. M., & Whalen, P. J. (2013). Neural responses to ambiguity involve domain-general and domain-specific emotion processing systems. *Journal of Cognitive Neuroscience*, *25*(4), 547–557. doi:10.1162/jocn_a_00363

Neta, M., Norris, C. J., & Whalen, P. J. (2009). Corrugator muscle responses are associated with individual differences in positivity-negativity bias. *Emotion (Washington, D.C.)*, *9*(5), 640–648. doi:10.1037/a0016819

Neta, M., & Tong, T. T. (2016). Don't like what you see? Give it time: Longer reaction times associated with increased positive affect. *Emotion (Washington, D.C.)*, *16*(5), 730–739. doi:10.1037/emo0000181

Stolier, R. M., Hehman, E., & Freeman, J. B. (2018). A dynamic structure of social trait space. *Trends in Cognitive Sciences*, *22*(3), 197–200. doi:10.1016/j.tics.2017.12.003

Sweller, J., Merrienboer, J. J. G. van, & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, *10*(3), 251–296. doi:10.1023/A:1022193728205

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., … Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research*, *168*(3), 242–249. doi:10.1016/j.psychres.2008.05.006