1 Emotional working memory loads increase negative interpertations of surprised facial

2 expressions

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11 Abstract

12 Individual differences in interpretations of emotional ambiguity are a useful tool for

13 measuring affective biases.

14 While trait-like, these biases are also susceptible to experimental manipulations. In the

15 present study, we capitalize on this malleability to expand on previous research suggesting

16 that subjective interpretations are stable independently of cognitive load.

17 We tested the effects of working memory loads containing either neutral or emotional

18 content on concurrent interpretations of surprised facial expressions.

19 Here we show that interpretations of surprise are more negative during maintenance of

20 working memory loads with emotional content compared to those with neutral content.

21 Two or three sentences explaining what the **main result** reveals in direct comparison

22 to what was thought to be the case previously, or how the main result adds to previous

23 knowledge.

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

25 Two or three sentences to provide a **broader perspective**, readily comprehensible to

26 a scientist in any discipline.

27 *Keywords:* ambiguity, working memory, bias

28 Word count: X

29 Emotional working memory loads increase negative interpertations of surprised facial

30 expressions

# 31 Introduction

32 Even simple tasks (e.g., remembering a phone number) reveal the limits of human

33 cognition. In fact, many researchers believe that there is a magic number of the amount of

34 information able to be held in working memory (7 +- 2 paper). Others have focused on the

35 limits of working memory and successful task performance to inform industrial and

36 organizational policies (Sweller, Merrienboer, & Paas, 1998). Despite the large amount of

37 research around working memory and cognitive control, much controversy remains around

38 the mechanisms through which attention to perceptually salient stimuli affect attentional

39 processes and subsequent cognitive control (Lavie, Hirst, Fockert, & Viding, 2004).

40 Specifically, there is a divide amongst researchers that believe cognitive loads either inhibit

41 perceptions of non-relevant stimuli

42 Recent work suggests that ambiguity resolution, at least in the context of surprised

43 facial expressions, requires more cognitive resources/processing compared to clearly valenced

44 faces (Mattek, Whalen, Berkowitz, & Freeman, 2016; Neta & Tong, 2016). Surprised facial

45 expressions are ambiguous without contextual information. For instance, a surprised facial

46 expression may indicate either positive (e.g., winning the lottery) or negative (e.g., a snake

47 in the woods) events/contexts. Previous work shows that individuals differ in their tendency

48 to interpret these expressions as either positive or negative (Neta, Norris, & Whalen, 2009).

49 This difference is trait-like (Neta et al., 2009) and generalizes to non-face stimuli (Neta,

50 Kelley, & Whalen, 2013); however, these individual differences are also malleable and may

51 differ depenending on experimental manipulations (Brown, Raio, & Neta, 2017; Neta &

52 Tong, 2016). Importantly, this behavioral bias is related to depressive symptomology (**???**);

53 specifically, more pubertally mature individuals show a correlation between negative bias and

54 more severe depressive symptoms.

55 It is well known that distractors and task irrelevant stimuli can have detrimental

56 effects on performance in a variety of tasks (cite, cite, cite). Further, emotional stimuli may

57 further exacerbate attentional interference compared to neutral stimuli. For example, the

58 Stroop task (**???**) has been modified by some researchers to include emotional stimuli (**???**)

59 which has pronounced effects when the emotional words are population specific (e.g., trauma

60 words in a PTSD sample). Similarly, others have shown

61 Mattek and colleagues (2016) recently showed that different levels of cognitive load

62 (i.e., holding either a single or seven digit number in working memory) does not affect

63 subjective interpretations of surprised facial expressions, but that high cognitive loads do

64 mitigate mouse trajectories. While the authors interpret this as a distinction between

65 trait-like biases and dynamic cognitive-motor processes, there may be more domain-specific

66 processes (e.g., emotional components) that span across these two measures of valence bias.

67 Indeed, neuroimaging work suggests that separate systems handle attentional biasing for

68 domain-specific (emotional vs. non-emotional) task relevancy (Egner, Etkin, Gale, & Hirsch,

69 2008). Given the task irrelevance of the numeric distractors in Mattek and colleagues’ (2016)

70 work, it follows that the resources required for interpreting ambiguity as positive (Neta et al.,

71 2009) may not have been recruited for working memory maintenance.

72 In the present study, we aim to test the effects of low and high working memory loads

73 in both emotional and neutral domains. We expect that trials in which participants are

74 maintaining an emotional working memory load will be more negative than neutral trials.

75 Further, we predict that higher working memory laod trials, specifically in the emotional

76 domain, will result in even more exaggerated negative interpretations.

77 Notes: Allie showed that depletion doesn’t affect ratings, but we thought that there

78 may be an effect of specific domains of depletion (i.e., neutral vs. emotional) on ratings.

79 Focus on EMO > NEU ratings and POS > NEG MDs. MT analyses could be supplementary

80 material, but you’ll be going down the rabbit hole. Recently, others have suggested a

81 dynamic social trait space model for judgments of faces (Stolier, Hehman, & Freeman, 2018),

82 and it may be important to consider additional components of the categorization process,

83 such as domain-specific loads.

84 **Methods**

85 We report how we determined our sample size, all data exclusions (if any), all

86 manipulations, and all measures in the study.

# 87 Participants

88 58 subjects were recruited from the University of Nebraska-Lincoln. All subjects

89 provided written informed consent in accordance with the Declaration of Helsinki and all

90 procedures were approved by the local Institutional Review Board (Approval

91 #20141014670EP). The data from eight subjects were excluded due to technical difficulties

92 or an error in the experiment script. This left 50 individuals in the final sample.

93 **Material**

94 **Stimuli.** The stimuli included faces taken from the NimStim (Tottenham et al.,

95 2009) and Karolinska Directed Emotional Faces (Lundqvist, Flykt, & Öhman, 1998) stimuli

96 sets. The faces consisted of 47 unique identities including 11 angry , 12 happy , and 24

97 surprised expressions organized pseudorandomly. The scenes were taken from the

98 International Affective Picture System (Lang, Bradley, & Cuthbert, 2008). A total of 288

99 scenes (72 positive, 72 negative, and 144 neutral) were selected for the image matrices. The

100 positive and negative images did not differ on arousal (report t-test). The scenes were

101 organized into low (two images) and high (six images) cognitive load of either neutral or

102 emotional (equal number of positive and negative) images (Figure 1).

103 **Software.** The task was completed in MouseTracker (Freeman & Ambady, 2010) and

104 participants used a mouse to click the appropriate response for the face ratings (i.e.,

105 “POSITIVE” or “NEGATIVE”) and the memory probe (i.e., “YES” or “NO”).

106 **Procedure**

107 Participants were randomly assigned to complete one of the task versions. The tasks

108 included 1441 trials split between working memory probe and face rating trials. On each

109 trial, participants first viewed an image matrix of either neutral or emotional images, which

110 the participants were instructed to remember for the duration of the trial. The image matrix

111 was presented for four seconds and the images were swapped from low and high load

112 matrices across versions of the task. After the image matrix a happy, angry, or surprised face

113 appeared for one second and the participants rated the face by clicking on either the positive

114 or negative response option. After the face rating, a single image probe appeared and

115 participants indicated whether or not the image probe was present in the previous image

116 matrix.

117 **Data analysis**

118 We used R (Version 3.6.0; **???**) and the R-packages \* }dplyr\* [@ }R-dplyr], *forcats*

119 (Version 0.4.0; **???**), *ggplot2* (Version 3.1.1; **???**), *papaja* (Version 0.1.0.9842; **???**), *purrr*

120 (Version 0.3.2; **???**), *readr* (Version 1.3.1; **???**), *readxl* (Version 1.3.1; **???**), *stringr* (Version

121 1.4.0; **???**), *tibble* (Version 2.1.3; **???**), *tidyr* (Version 0.8.3.9000; **???**), and *tidyverse*

122 (Version 1.2.1; **???**) for all our analyses. Data preprocessing was completed in R using the

123 mousetrap package (**???**). First, percent negative ratings were calculated for happy, angry,

124 and surprised faces across all trial types. Next, we used Shapiro-Wilks test to determine

125 normality of the data. Afterwards, since the rating data were non-normally distributed, we

126 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.

127

128

# Subjective ratings

**Results**

129 Friedman’s test results showed significantly different distributions across the conditions

130 *χ*2(3.00) = 27.41, p < .001. Follow up Wilcoxon signed rank tests revealed that surprise is

131 rated as more negative when holding emotional content in working memory compared to

132 neutral content. Low emotional load ratings were significantly more negative than low, Z =

133 3.31, p = .001, neutral and high, Z = 3.62, p < .001, neutral loads. The same was true for

134 high emotional load ratings and low, Z = 4.52, p < .001, and high, Z = 3.72, p < .001,

135 neutral loads. However, there was no discernable effect of load. That is, the comparisons

136 between low and high load ratings for both emotional, Z = -1.10, p = .273, and neutral, Z =

137 -0.03, p = .975, load ratings were not significantly different.

138 **Reaction times**

139 RT on trials with an emotional working memory load are longer than neutral trials,

140 F(1,48)= 3.966, p = .052.

141 **Discussion**

142 The effect of high vs. low load is still not apparent in these data, just like Mattek et

143 al. 2016. An alternative explanation is that the high load manipulation is not sufficiently

144 difficult to recruit the targeted cognitive resources; however, future work will be needed to

145 better test this alternative.

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