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BRIEF ARTICLE



Playing with fire: effects of negative mood induction and working memory on vocabulary acquisition

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ABSTRACT

We investigated the impact of emotions on learning vocabulary in an unfamiliar language to better understand affective influences in foreign language acquisition. Seventy native English speakers learned new vocabulary in either a negative or a neutral emotional state. Participants also completed two sets of working memory tasks to examine the potential mediating role of working memory. Results revealed that participants exposed to negative stimuli exhibited difficulty in retrieving and correctly pairing English words with Indonesian words, as reflected in a lower performance on the prompted recall tests and the free recall measure. Emotional induction did not change working memory scores from pre to post manipulation. This suggests working memory could not explain the reduced vocabulary learning in the negative group. We argue that negative mood can adversely affect language learning by suppressing aspects of native-language processing and impeding form-meaning mapping with second language words.

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Hot cognition; vocabulary; working memory; emotions; second language acquisition

Researchers in psychology and cognitive science have explored the role of *hot cognition*, or cognitive processing influenced by emotions, on adult learning (Pekrun, 2006) and working memory (WM) (Gray, 2004; Storbeck, Davidson, Dahl, Blass, & Yung, 2015). Similar inquiries into adult second language (L2) learning, however, are lacking, despite an increasing call for more research in this area (Swain, 2013). With the present study, we attempt to fill this gap in the literature by investigating how affective states influence lexical acquisition, a key component of L2 learning, under explicit learning conditions.

Hot cognition, learning, and adult language acquisition

The term *hot cognition* refers to the union of cognition and emotion. Very often, mental actions involved in learning, decision-making, and evaluating information are processed through an affective filter. Recent

empirical research has highlighted the symbiotic relationship between emotions and learning in academic environments. It is assumed that positive emotions facilitate creative learning strategies, whereas negative emotions cause cognitive deactivation (Pekrun, 2006; Pekrun, Goetz, Titz, & Perry, 2002). Conversely, Pekrun et al. (2002) recognised that certain positive emotions could be detrimental, while negative emotions, such as anxiety and shame, might stimulate cognitive activity. Pessoa (2009) expanded these ideas by proposing the *dual competition* framework, where emotional and executive systems mutually interact during cognitive processing. He posited that high-arousal affect, either positive or negative, generally impaired cognitive task performance. Low-arousal stimuli, on the other hand, could be actively suppressed or even could enhance behavioural performance if task relevant.

The significance of hot cognition on adult language learning has been recognised for several decades.

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Schumann (1994) noted that “if one decides to analyze perception, attention, or memory mechanisms in SLA [second language acquisition] independently of affective mechanisms, one is making a large simplifying assumption” (p. 240). That said, the bulk of research on the interface of emotions and adult language learning generally falls into one of four camps: (a) the mental representation of emotional vocabulary in bilinguals; (b) taboo word sensitivity in participants’ first language versus other languages; (c) pedagogical considerations of teaching emotionally-laden L2 materials; and (d) foreign language anxiety. Further inquiry into specialised areas of SLA, however, is warranted. In this study, we focus on L2 vocabulary learning, which is one of the cornerstones of learning a new language. Vocabulary size has a moderately strong correlation with L2 users’ speaking, listening, reading, and writing abilities (Alderson, 2005). Furthermore, the task we use, which is known as paired-associates learning, has stood the test of time as a predictor of foreign language learning success. It features in a variety of both historic assessments (e.g. Modern Language Aptitude Test; see Carroll & Sapon, 1959) and contemporary tests of foreign language aptitude (e.g. High-Level Language Aptitude Battery; see Linck et al., 2013) and therefore offers an indication of how well L2 learners may perform on other language-related tasks.

WM capacity and adult language learning

WM can be defined as a “multicomponent system responsible for active maintenance of information in the face of ongoing processing and/or distraction” (Conway et al., 2005, p. 770). A key individual-differences variable (Conway et al., 2005), WM capacity (WMC) is generally regarded as a stable predictor of outcome performance in cognitive tasks. Individuals with greater WMC are usually better at multitasking, following directions, and comprehending languages (Engle, 2010; Gathercole, 2006). The notion of a strong relationship between WM and L2 acquisition is not new within the SLA community. Usage-based researchers believe WM facilitates linguistic chunking (Ellis, 1996), an inductive learning process that facilitates the acquisition of vocabulary and morphosyntax. Cowan (2015) also surmised that L2 usage likely stresses various WM storage buffers because of the interpretation, coordination, and storage of various information sources, such as spatial or visual contexts and phonological input. This is particularly relevant to

learning under explicit conditions, as WM may play a greater role when consciousness and attention are involved (see Linck & Weiss, 2011).

Complex WM span tasks provide a way of measuring WMC (Conway et al., 2005; Storbeck & Maswood, 2016). In their study, Unsworth and Spillers (2010) tested participants on separate attention control and secondary (longer-term) memory tasks, as well as a variety of WM span tasks, including the operation, symmetry, and reading span tasks. Results from structural equation modelling revealed WMC to be a joint function of both secondary memory abilities and attention control. Moreover, the aforementioned WM span tasks have provided a partial window into language processing ability, with reading span tasks being most strongly related with adult L2 learning (see Linck, Osthus, Koeth, & Bunting, 2014; Wen, 2012). Another WM test directly linked with language learning is the non-word repetition task. The ability to repeat non-words or pseudo-words with consistent accuracy is closely and specifically related to vocabulary acquisition (Bolibaugh & Foster, 2013; Gathercole, 2006; Wen, 2012). Gathercole (2006) posited a strong link between the ability to repeat non-words and the acquisition of phonological forms of new lexical items. She suggested that word learning is mediated by temporary phonological storage that is essential to both L1 and L2 acquisition.

WMC and emotions

In the last two decades, the concept of WMC as a singularly unchanging feature, impervious to hot cognitive influencers, has eroded. Gray (2004) discovered evidence of an intersection between emotion and cognitive control. He concluded that positive affect enhanced verbal WM performance but diminished spatial WM. The converse was true for negative states, with performance decreasing on verbal WM tasks but increasing on spatial WM tasks. Conway et al. (2005) also argued that WM span scores can reflect both an individual’s stable condition (i.e. general fluid intelligence) and state-dependent variation. Engle (2010) reconfirmed the findings from Conway et al.’s article, which he co-authored, that WMC possessed two characteristics, one for state and one for trait. Factors influencing the state variable included stereotype threat, anxiety, and fatigue. More recently, Storbeck et al. (2015) used a series of experiments involving various mood-inducing video clips and follow-on WM tasks to show that positive

emotions activated cognitive processes closely related to language, such as semantic memory and verbal WM. Negative moods, on the other hand, improved cognitive functioning related to spatial WM and spatial perception.

Studies have further explored the effects of temporary emotional loads on WMC, using different affective stimuli. Curci, Lanciano, Soleti, and Rimé (2013) compared initial to subsequent operation-word span task results of two groups (negative and neutral) after exposure to prisoner of war torture accounts and board game instructions, respectively. Results showed that exposure to negative emotional stimuli significantly reduced WMC by triggering ruminative processes. Storbeck and Maswood (2016) evaluated the effect of positive, neutral, and negative emotional states (induced by television or film clips) on participants' operation-word and spatial memory span task results. The authors found that positive mood significantly enhanced WM scores on both span tasks, while the negative and neutral moods exhibited no influence on performance.

Present study

In this study, we examined if, and to what extent, emotionally-charged stimuli (negative and neutral film clips) affected novice language learners' vocabulary acquisition performance. Because deliberate vocabulary acquisition is a prime example of explicit learning and explicit learning relies on WM (Linck & Weiss, 2011), we also evaluated the mediating role of WM in the learning process. Where appropriate, we report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study.

Method

Participants

Seventy undergraduates from a large Midwestern university participated in the study ($M_{\text{Age}} = 23.5$; $SD_{\text{Age}} = 6.57$). We randomly assigned the students to either a neutral ($n = 35$) or a negative ($n = 35$) emotional induction group, but ensured males ($n = 18$) and females ($n = 52$) were equally distributed over the two groups. All participants were native speakers of English with no knowledge of Indonesian, Malaysian, or Arabic.

Materials

Twenty-four Indonesian words with corresponding pictorial representations were selected as the experimental items. All lexical items were concrete nouns. To equalise the learning burden, none of the words were English cognates and word length was controlled. The experimental items consisted of only 2-syllable Indonesian terms: eight 4-letter words, eight 5-letter words, and eight 6-letter words. Examples include *ikan* (fish), *telur* (egg), and *piring* (plate). We gauged participants' WM using three tasks: (a) the automated operation span task (OSPAN) from Unsworth, Heitz, Schrock, and Engle (2005), which is considered a valid measure of verbal WMC; (b) the automated symmetry span task (SSPAN) from Unsworth et al. (2005), which assesses spatial WMC; and (c) the Arabic non-word repetition task (ANWR) from Bolibaug and Foster (2013), which measures the phonological loop component of WM.

For emotional stimuli, we selected film clips from the Emotional Movie Database with specific valence and arousal ratings (Carvalho, Leite, Galdo-Álvarez, & Gonçalves, 2012). All film clips were soundless and 40 s in length. The negative emotional induction group viewed six *horror* film clips known to generate high arousal and low valence levels. The neutral emotional induction group viewed six *scenery* film clips known to produce low arousal and mid-range valence levels. At different points during the study, we obtained subjective affective ratings from Self-Assessment Manikins (SAMs) on a nine-point Likert scale that measured the participants' valence levels (*sad/unpleasant* to *happy/pleasant*) and arousal levels (*relaxed/unaroused* to *stimulated/aroused*).

Procedure

Figure 1 graphically depicts this study's procedure. To begin, everyone completed an initial affective rating and then took the three WMC tests to supply a WM baseline. Subsequently, participants viewed the six film clips that corresponded to their respective condition. They then completed a second affective rating to record their emotional well-being. Immediately afterwards, vocabulary learning began. Participants were presented with a target Indonesian word and its English translation (e.g. "telur = egg"), alongside its pictorial representation, for eight seconds at a time. Presentation of all 24 words in a random order was considered one complete block.

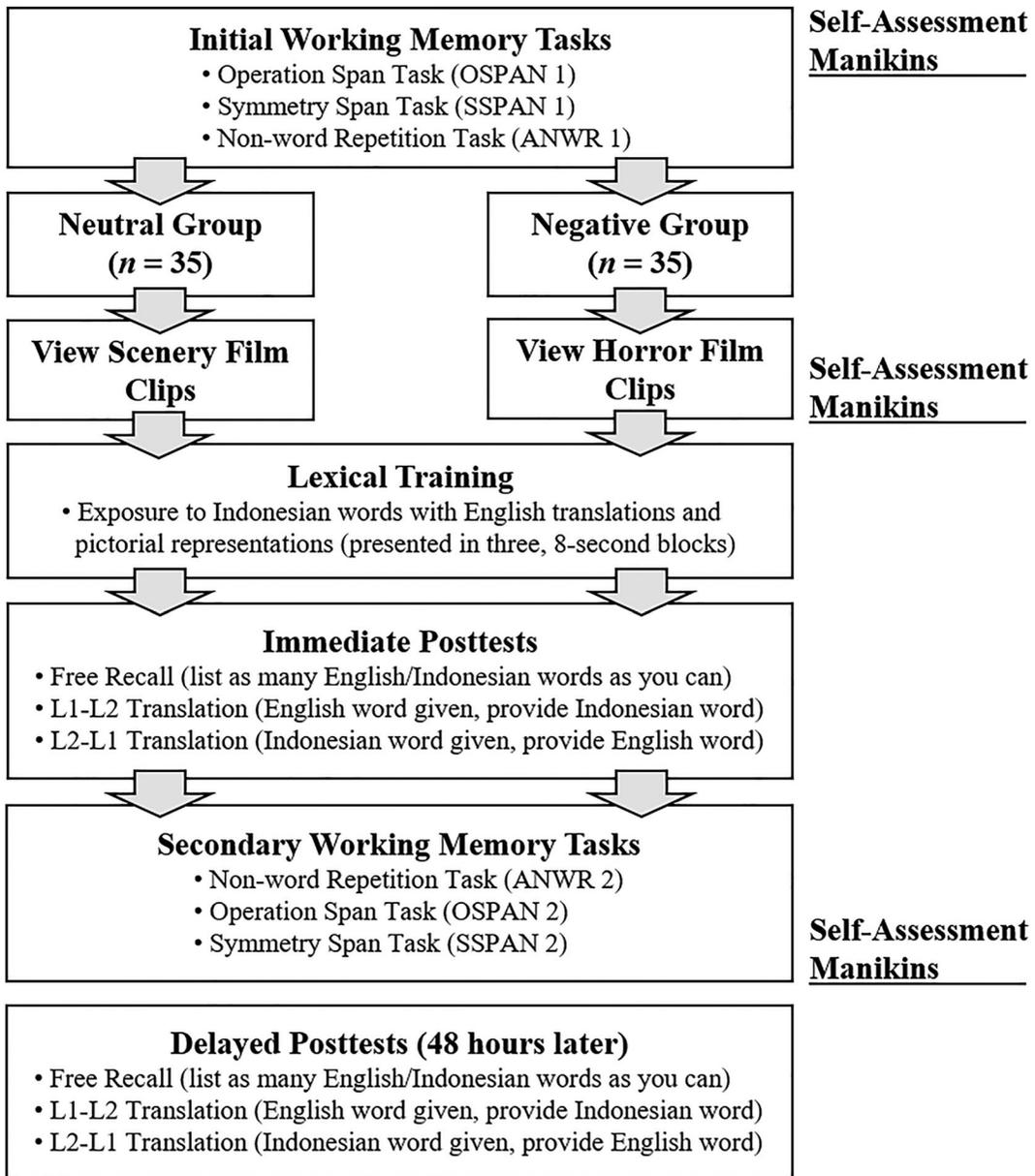


Figure 1. Summary of the current study's procedure.

Participants received three blocks of training in total and could thus study each word pair for up to 24 s. This exposure time is believed to be sufficient to obtain mid-range levels of performance in paired-associates vocabulary learning (Barcroft, 2003).

After completing the training, all participants took a free recall test (to measure productive knowledge of form) in which they wrote down as many Indonesian and English words as they could remember.

They further completed two translation posttests (to gauge knowledge of form-meaning connections) adapted from Barcroft (2003). The first, a productive test, was an L1 to L2 recall. Participants read the English words and supplied the Indonesian equivalents. The second, a receptive test, was an L2 to L1 recall. Participants read the Indonesian terms and wrote the English equivalents. The time allotted to complete each posttest was 2.4 min (see Barcroft,

2003). We administered multiple tests to obtain a more complete picture of learners' vocabulary knowledge (Nation & Webb, 2011). Next, we administered secondary WMC tasks to determine if the emotional stimuli had affected learners' cognitive resources, followed by a final affective rating. After a 48-hour period, participants completed another free recall test and two more identical translation posttests. For each translation test, we randomised the presentation order from the corresponding immediate posttest.

Results

We analyzed the affective ratings to gauge the effectiveness of our emotional induction. Both groups reported changes in their valence levels over the course of the experiment, as indicated by Friedman's tests for the negative group, $\chi^2(2) = 54.19$, $p < .001$, and the neutral group, $\chi^2(2) = 18.20$, $p < .001$. After applying the Bonferroni correction to adjust for multiple testing, only the negative group registered a significant difference between the start of the experiment and after the film clips, $z = -5.04$, $p < .001$, $r = -.60$, indicating a generally sad or unpleasant emotional state. No significant emotional changes were registered during the same period for the neutral group, $z = -.56$, $p = .575$, $r = -.07$. Valence ratings from both groups converged at the end of the experiment, marking a significant recovery from emotional induction by the negative group and a decrease in happiness levels in the neutral group, potentially due to fatigue.

Significant differences in self-reported arousal levels also occurred over time for the negative group, $\chi^2(2) = 12.81$, $p = .002$, and the neutral group, $\chi^2(2) = 7.17$, $p = .028$. Again, post hoc analysis pointed to a significant increase in arousal only in the negative group, $z = -2.72$, $p = .006$, $r = -.32$, from the study's beginning to the end of the film clips. No significant changes in arousal were registered over the same period for the neutral group, $z = -1.91$, $p = .056$, $r = -.23$, confirming the effectiveness of the two treatments. Similar to the findings for valence, the negative group showed recovery from their induced arousal at the conclusion of the experiment, whereas the increase in arousal levels for the neutral group fell short of significance.

Immediate and delayed vocabulary posttests. Two of the primary researchers assigned point values for all tests using the Lexical Production Scoring Protocol adapted from Barcroft (2003). Inter-rater reliability for

all six posttests was very high ($\alpha > .99$), allowing us to generate the participants' absolute scores by averaging the two ratings. Figure 2 presents the results graphically.

We found that participants from the neutral emotional group outperformed their counterparts in all measures. Results from separate 2 (Group) \times 2 (Time) mixed-design ANOVAs revealed significant differences for Time (immediate and delayed posttest) in each vocabulary posttest, $p < .001$. This meant participants in both groups demonstrated significant decay in vocabulary knowledge over a 48-hour time span. More importantly, we found a significant main effect of Group in the L2 to L1 recall test scores, $F(1, 68) = 6.67$, $p = .012$, $\eta_p^2 = .089$, but no Time \times Group interactions. This indicated the individuals exposed to the negative film clips performed less well overall, with a medium effect size.

Because emotionality affected retrieval of L1 translations the most, we decided to conduct a post-hoc analysis of the free recall data for each language separately. Remember that during free recall, participants could recall words from either Indonesian or English. Would we find a similar selective impairment of English recall here too? Mixed-design ANOVAs for the written English and Indonesian words, with $\alpha = .025$ to adjust for multiple testing, revealed a near-significant difference with moderate effect size in the amount of English words recalled by both groups, $F(1, 68) = 4.81$, $p = .032$, $\eta_p^2 = .066$. The negative group recalled fewer English words overall. No significant differences between groups, $F(1, 68) = .61$, $p = .435$, $\eta_p^2 = .009$, occurred for recalled Indonesian words.

Immediate and delayed WM tests

We analyzed the results pre and post film clips from all three WM measures (OSPAN, SSPAN, and ANWR). Two native Arabic speakers judged participant recordings from the ANWR tests. Because inter-rater reliability was high ($\alpha = .91$ for pre-treatment scores and $\alpha = .95$ for post-treatment scores), we calculated the participants' absolute scores from an average of the two ratings. The results are found in Table 1.

Separate 2 (Group) \times 2 (Time) mixed-design ANOVAs for each set of WM tasks confirmed the two groups maintained comparable WM test scores. We found a significant main effect for Time (pre and post) with the SSPAN, $F(1, 63) = 6.72$, $p = .012$, $\eta_p^2 = .096$, and ANWR tasks, $F(1, 68) = 66.25$, $p < .001$,

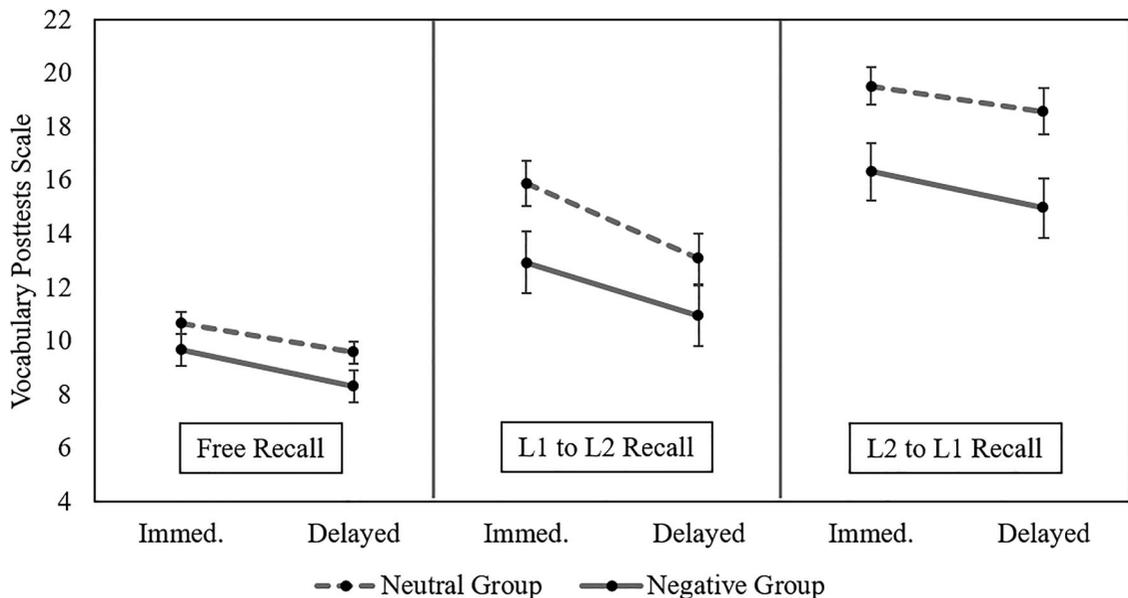


Figure 2. Performance plots for all vocabulary posttests. Note that the range of possible scores, 0–24, has been truncated for ease of visualization. Error bars represent ± 1 SEM.

$\eta_p^2 = .493$, indicating a test-retest effect, or improved performance at Time 2. Crucially, no significant interactions were found for any of the WM tasks, suggesting a lack of cognitive impairment from the negative emotional induction.

Mediation analysis

Since we found no impact of negative affect on WM performance, it seemed unlikely that WM would mediate the role of emotions in vocabulary learning. To verify this claim, however, we performed a formal mediation analysis on the data. We selected the immediate vocabulary posttest scores for outcome variables. Additionally, we utilised the three WM

post-treatment measures as mediating variables, which is where any impacts of the emotional induction would have manifested themselves. When using the total WM score as a mediating variable, bias-corrected, bootstrapped analysis (5000 samples) confirmed a non-significant indirect effect of emotional induction on free recall performance, $b = 0.03$, BCa CI $[-0.62, 0.69]$, L1 to L2 recall performance, $b = 0.01$, BCa CI $[-1.33, 1.43]$, and L2 to L1 recall performance, $b = 0.01$, BCa CI $[-1.23, 1.11]$, through WM as a unitary construct, with BCa CIs extending symmetrically around 0. Non-significant results were also found when analyzing OSPAN, SSPAN, and ANWR performance as separate, mediating variables for each immediate posttest.

Table 1. Descriptive statistics for all Pre and Post treatment WM Tasks.

WM Task	N ^a	Scale	Neutral group		Negative group	
			M (SD)	95% CI	M (SD)	95% CI
OSPAN 1	69	0–75	59.76 (8.15)	(56.92, 62.61)	60.97 (12.15)	(56.80, 65.15)
OSPAN 2	70		62.26 (7.98)	(59.52, 65.00)	62.69 (12.64)	(58.35, 67.03)
SSPAN 1	67	0–42	30.11 (6.21)	(27.98, 32.25)	27.69 (8.13)	(24.76, 30.62)
SSPAN 2	66		31.18 (5.86)	(29.10, 33.26)	30.91 (8.85)	(27.77, 34.05)
ANWR 1	70	0–168	115.93 (21.12)	(108.68, 123.18)	112.96 (21.55)	(105.55, 120.36)
ANWR 2	70		127.07 (21.68)	(119.63, 134.52)	129.07 (22.14)	(121.47, 136.68)

Note: Test 1 was performed pre film clips and test 2 was performed after the vocabulary training and posttests.

^aScores from participants with accuracy ratings below 80% were removed. According to the Georgia Institute of Technology Attention and WM Lab, complex span scores are discarded if the accuracy on processing trials falls below 85%. However, the rule is admittedly arbitrary in nature, and scores may be retained above 80% on a case by case basis (see <http://englelab.gatech.edu/faq.html>).

Discussion

Our findings demonstrate that negative emotions restrict certain aspects of explicit vocabulary learning, specifically with the form-meaning mapping and retrieval of L1 lexical items during paired-associates learning. Immediate and delayed posttest results confirmed that participants from the neutral group scored higher than those from the negative group in all vocabulary posttests, yet performance separation only reached near significance or significance when it involved the retrieval of English words (i.e. L2 to L1 recall and free recall of L1 words). Interestingly, this same effect did not occur when participants were asked to supply the newly acquired Indonesian items (i.e. L1 to L2 recall and free recall of L2 words). According to Jiang (2004), learners do not automatically link concepts and L2 word forms in the initial stages of L2 vocabulary learning. Instead, meaningful associations only begin to develop over long-term use and experience in the L2. Likewise, acquisition of L2 words in a decontextualised setting (e.g. foreign language classrooms or laboratories) may promote what Pavlenko (2005) described as *disembodied cognition*. Under this theory, L2 learners do not assign affective connotations to newly acquired lexical forms. The phenomenon of disembodied cognition contrasts with the language emotionality that often develops for the same L1 translations through years of conditioning and socialisation (i.e. childhood). Research on the affective nature of taboo and swear words in the L1 and L2 (Dewaele, 2004) supports this assertion, showing that bilingual speakers often exhibit higher expressions of emotionality when using L1 taboo words, rather than their L2 counterparts. This same effect was apparent in the current study, where the newly acquired L2 items were immune to negative emotionality. Instead, L1 productive and receptive knowledge were suppressed for participants experiencing high-arousal, low-valence affective induction, and this hindered the participants' ability to establish complete L2-L1 form-meaning connections. These emotional effects were also durable, as demonstrated by the negative group's lower delayed posttest performance on the L2 to L1 translation test.

Regarding emotional impacts to WM, the results in Table 1 indicated that negative emotional induction did not significantly reduce participants' verbal, spatial, or phonological WM. With respect to the complex span tasks, our findings aligned with Storbeck and Maswood (2016) who also reported similar

performances on verbal (OSPAN) and spatial (SSPAN) WM in neutrally and negatively induced participants. These results run counter to Curci et al. (2013), who reported rumination effects in the negative group following stimulus exposure. Differences in how mood was induced (verbal for Curci et al. versus silent films in our study) may offer a partial explanation for the diverging findings. In the present study, both groups improved their WM scores over time for three likely reasons. First, the emotional stimuli may not have been strong enough to compete with the extremely high levels of cognitive effort and focus needed to complete the WM tasks. These results are promising, demonstrating that robust, healthy individuals cannot easily be brought off-kilter during periods of high cognitive functioning. Complex span tasks (i.e. OSPAN and SSPAN) tax executive control, which likely leaves few resources available to be occupied by distractors. Future researchers should employ more extreme stimuli, such as threat of shock or persistent exposure to high-arousal, graphic visuals (Pessoa, 2009), to register interference with cognitive functioning. Next, due to the inclusion of L2 vocabulary training and testing modules, participants did not complete the secondary WM tests immediately after stimulus exposure. The short time gap likely weakened any rumination effects from the negative film clips. Specifically, 15 min appeared to represent a boundary condition on the potential effects of high-arousal, negative emotions on WM. Therefore, emotional induction should occur immediately before or even within WM tasks when attempting to disrupt cognitive focus. Finally, the post-treatment lexical tasks may have contributed to a faster emotional recovery for those in the negative group. Previous researchers, for example, have found success in reducing the intensity of negative emotional experiences by taxing cognitive capabilities (van den Hout et al., 2010). As affect did not appear to hinder WM performance, we attributed the increase in scores to task familiarisation and test-retest strategies.

Because of these reasons, we could not confirm a potential mediating role of WM in vocabulary learning under emotional strain. In the field of child psychology, Owens, Stevenson, Norgate, and Hadwin (2008) found significant mediating effects of verbal WM in the relationship between *trait* anxiety levels and general academic performance for younger students. Aside from differences in participant populations and subject matter, our research focused on *state* anxiety, which may help to explain the lack of

mediation by WM. As previously discussed, temporarily induced negative mood states from non-threatening stimuli may lack the potency to disrupt cognitive performance as measured by WMC tasks. Further research is needed to determine what other variables (e.g. *trait* differences) may underlie the relationship between emotionality and adult L2 learning.

In summary, negative emotional induction caused interference with deliberate vocabulary learning by disrupting L1 semantic activation (word recall) and receptive form-meaning mapping (L2-L1 translation) during paired-associates training. WM performance remained unaffected and did not mediate the relationship between mood states and vocabulary learning. The findings inform language instructors that negative feelings can adversely affect student performance on a variety of language-related tasks that rely on concepts expressed in the L1. These include recalling newly learned vocabulary and translation, but may extend to other parts of the curriculum that have a heavy memorisation component and are taught in the student's native language, where emotional embodiment is greatest.

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