Research Note

The Effect of Stimulus Valence on Lexical Retrieval in Younger and Older Adults

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Purpose: Although there is evidence that emotional valence of stimuli impacts lexical processes, there is limited work investigating its specific impact on lexical retrieval. The current study aimed to determine the degree to which emotional valence of pictured stimuli impacts naming latencies in healthy younger and older adults.
Method: Eighteen healthy younger adults and 18 healthy older adults named positive, negative, and neutral images, and reaction time was measured.
Results: Reaction times for positive and negative images were significantly longer than reaction times for neutral images. Reaction times for positive and negative images were not significantly different. Whereas older adults

demonstrated significantly longer naming latencies overall than younger adults, the discrepancy in latency with age was far greater when naming emotional pictures.
Conclusions: Emotional arousal of pictures appears to impact naming latency in younger and older adults. We hypothesize that the increase in naming latency for emotional stimuli is the result of a necessary disengagement of attentional resources from the emotional images prior to completion of the naming task. We propose that this process may affect older adults disproportionately due to a decline in attentional resources as part of normal aging, combined with a greater attentional preference for emotional stimuli.

There is a large body of evidence demonstrating that cognitive processes are influenced by emotion (e.g., Berrin-Wasserman, Winnick, & Borod, 2003; Charles, Mather, & Carstensen, 2003; Estes & Adelman, 2008; Ihssen, Heim, & Keil, 2007; Kousta, Vinson, & Vigliocco, 2009; Kuperman, Estes, Brysbaert, & Warriner, 2014; Mammarella, Borella, Carretti, Leonardi, & Fairfield, 2013; Mather & Carstensen, 2005; Vinson, Ponari, & Vigliocco, 2014; Yap & Seow, 2014). Emotion has generally been defined as having two dimensions: valence and arousal. Valence is the degree of positivity or negativity of a stimulus (i.e., how pleasant/appetitive vs. unpleasant/aversive, respectively), whereas arousal is the degree of excitability resulting from a stimulus (i.e., how emotionally intense; see introduction of Briesemeister, Kuchinke, & Jacobs, 2011). There is evidence to suggest that emotional valence has a facilitative effect on cognitive–linguistic processes from a motivational perspective. A motivational model proposes that emotional stimuli are adaptively important

for self-preservation, leading to faster processing (Lang, Bradley, & Cuthbert, 1990). For example, research suggests that adults perform lexical decisions faster when the words are emotional than when they are neutral (Kousta et al., 2009; Vinson et al., 2014; Yap & Seow, 2014). It has also been suggested that emotional stimuli may be processed faster because of their richer semantic representations for emotional words (Yap & Seow, 2014). That is, emotionality has a similar effect as word frequency on lexical processing: Higher-frequency words result in faster processing because of richer semantic representations due to repeated exposure, whereas emotional valence of words may facilitate processing by enhancing "semantic richness."

In contrast, Kuperman et al. (2014) found that negative stimuli were recognized more slowly than neutral and positive stimuli in a lexical-decision task. The authors attributed this finding to an automatic vigilance effect (Estes & Adelman, 2008), whereby negative stimuli result in longer processing times or naming latencies due to an attentional preference. That is, it takes longer for humans to withdraw attention from negative or threatening stimuli given its evolutionary importance. Estes and Verges (2008) suggested that the automatic vigilance effect may vary depending on the nature of the task. When the valence is task-irrelevant, lexical processing may be slowed due to increased difficulty in attentional disengagement from

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negative or aversive stimuli relative to neutral or positive stimuli. For example, it could be argued that the emotional valence of words is irrelevant to making a lexical decision, and so it takes longer to make a decision for negative stimuli because attention to the negative emotion becomes a distractor. However, for valence-relevant tasks, such as if someone were asked to judge the positivity or negativity of a word, the automatic vigilance effect suggests that valence will have a facilitative effect on lexical processing (Estes & Verges, 2008).

Other studies have suggested that emotional stimuli, regardless of valence, may inhibit lexical processing altogether. For example, Ihssen et al. (2007) found that emotional stimuli interfered with lexico-semantic processes when task-irrelevant emotionally arousing pictures were shown between trials of a lexical-decision task. The authors suggested that emotional stimuli could facilitate or inhibit cognitive processes depending on the level of arousal and the type of the task (e.g., complexity) as well. They found that emotional images that were more arousing had an inhibitory effect on subsequent lexical processing. Given that both negative and positive images are typically more arousing than neutral images, this suggests that there may be an inhibitory effect for both positive and negative images in comparison to neutral images. Overall, it is clear that lexical processing can be affected by emotional valence, but the direction of these influences (facilitative vs. inhibitory) resulting from positive versus negative stimuli as well as the influence of task, remains unclear.

It is well known that cognitive–linguistic abilities, such as memory, attention, and inhibition, decline as part of the normal aging process (Craik & Salthouse, 2008; Hasher & Zacks, 1988; Park & Schwarz, 2000; Salthouse, 2003). However, studies have shown that emotion can influence or modulate cognitive-aging effects. For example, Mammarella et al. (2013) found that working memory performance in older adults was enhanced when emotional stimuli (positive and negative) were used. That is, the decline in working memory performance was smaller for emotional stimuli than for neutral stimuli. The authors suggest that, overall, negative stimuli may result in a narrowing of focus on the information, which may help compensate for age-related decline in working memory. The authors also report the possibility that greater levels of death anxiety in older adults may result in greater attention toward threatening stimuli. Others have shown a relative preservation of memory abilities in older adults for positive stimuli (Charles et al., 2003; Mather & Carstensen, 2005). This result has been interpreted according to the socio-emotional selectivity theory (Mather & Carstensen, 2005), which states that emotional regulation improves with age. Charles et al. (2003) defined emotional regulation as, "the maintenance of positive affect and the decrease of negative affect" (p. 310). They suggested that older adults may devote more cognitive resources to positive stimuli and thus show superior memory for positive stimuli than for negative stimuli. Given the evidence that emotion may modulate the aging effects on memory, and that aging effects are observed

with other cognitive–linguistic processes, such as attention and inhibition, it is plausible to expect that emotion may impact these and other cognitive–linguistic processes that are impacted by aging as well.

Lexical retrieval is one specific cognitive–linguistic skill that declines with age (Borod, Goodglass, & Kaplan, 1980; Nicholas, Obler, Albert, & Goodglass, 1985). Older adults show an increase in errors and reaction time (RT) when naming pictures (Feyereisen, 1997; Mortensen, Meyer, & Humphreys, 2006). It has been hypothesized that the decline in lexical retrieval with aging may be due to an overall decline in cognition (Baciu et al., 2015); however, alternate theories exist (Au et al., 1995; Burke & Shafto, 2004). Although the literature examining the impact of aging on lexical retrieval is rather robust, there has been little investigation into the effect of emotion on lexical retrieval in younger and older adults. As observed with memory and lexical processing, it is possible that a bias toward emotional stimuli may affect lexical retrieval of emotional stimuli as well. Moreover, if greater attentional resources are devoted to emotional stimuli, it is possible that a different pattern of aging effects on lexical retrieval exists for emotional stimuli.

The current study aims to determine whether the emotional valence of pictures (a) impacts naming latencies in healthy adults, and (b) differentially impacts naming latencies in younger versus older adults. It is postulated that positively and negatively valenced stimuli will result in different naming RTs than neutral stimuli. Given the inconsistency of the existing literature on the direction of the effect of emotion on lexical processes and the lack of research specifically investigating lexical retrieval, there is little basis on which to predict the direction of this effect (faster vs. slower RTs for emotional stimuli). We do predict, however, that the effect of emotion on lexical-retrieval latencies will be greater for older adults than for younger adults. There is some research to suggest that emotional stimuli have a facilitative effect on working memory abilities of older individuals (Mammarella et al., 2013; Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005) and thus, may assist with mitigating the effects of age-related changes on lexical-retrieval latencies. We accordingly predict the relationship between emotion and lexical retrieval will be modulated by age, as has been shown in previous studies investigating working memory (Mammarella et al., 2013; Mikels et al., 2005).

Method
Participants

Forty-eight participants were recruited to participate in the study. Eighteen healthy younger adults (18 to 27 years; M = 22.1 years) and 18 healthy older adults (60 to 80 years; M = 68.7 years) met inclusion criteria and completed the study. Older adults were excluded if they demonstrated mild cognitive impairment, as determined by a score below 27 on the standard version of the Mini-Mental State Examination–Second Edition. (MMSE-2; Folstein, Folstein, White, &

Messer, 2010). By self-report, both younger and older adults were native speakers of English and right-handed. All reported a negative history of diagnosed neurological disease or impairment, psychological or language disorders, and uncorrected vision or hearing impairments. Further, participants affirmed that they were not taking any drugs or medication that could impair judgment or thinking at the time of testing (see Table 1 for demographic data).

Stimuli

Positive, negative, and neutral pictures were obtained from the International Affective Picture System, (IAPS; Lang, Bradley, & Cuthbert, 2008), a widely used and standardized set of pictures rated for emotional valence and emotional arousal. Pictures were chosen on the basis of concreteness, valence (positivity vs. negativity), and arousal (excitability). A list of pictures was created that included 20 items each of positive, negative, and neutral images. The positive, negative, and neutral images did not differ in concreteness ratings, $F(2, 39) = 1.92$, $p = .16$, which were taken from the Medical Research Council (MRC) Psycholinguistic Database (Coltheart, 1981). If the plural form was not included in the database, the singular form was used. Multiple-word targets are not included in the MRC database (e.g., rolling pin, ice cream), so these items were left out of the concreteness analysis. Positive, negative, and neutral images differed significantly on emotional valence ratings, $F(2, 57) = 648.11$, $p < .001$, and arousal, $F(2, 57) = 57.73$, $p < .001$. Pairwise comparisons revealed that neutral images had a significantly lower arousal rating than positive and negative pictures, $t(38) = 8.13$, $p < .001$ and $t(38) = 10.12$, $p < .001$, respectively, but ratings for positive and negative images were not significantly different, $t(38) = 1.99$, $p = .15$. The positive, negative, and neutral target labels did not differ in terms of number of syllables, $F(2, 57) = 0.16$, $p = .86$, or word frequency, $F(2, 57) = 1.16$, $p = .32$, as determined by frequencies taken from the Corpus of Contemporary American English (Davies, 2008).

Procedure

Participants were asked to name the 60 color photographs "as quickly and accurately as possible." Pictures were presented on a laptop computer with a 14 or 15.6 in. display using E-Prime 2.0 software (Psychology Software Tools Inc., 2012). Picture dimensions were 1024 × 768 pixels.

Pictures were presented in blocks according to emotional valence (20 positive, 20 negative, and 20 neutral) to limit possible carryover effects of arousal and valence from trial to trial (McKenna, 1986; Schmidt & Schmidt, 2016). Order of block and image presentation within blocks were randomized across participants. Each picture was presented for 5000 ms with a blank screen following for 2000 ms, allowing participants a total of 7000 ms to name each item. All sessions were audio-recorded with an Olympus digital voice recorder, Model WS-801 or Model WS-821 (Olympus, Center Valley, PA). A bell sounded concurrent with picture presentation onset to provide an audible start time captured by the audio recorder. Between blocks, participants completed portions of the Spatial Span subtest of the Wechsler Memory Scale (Wechsler, 1997) as a distractor task in an attempt to avoid both carryover of emotional valence between blocks and task fatigue.

Data Analysis

Reaction time and accuracy were measured for each item and averaged within blocks for each participant. Names were considered accurate if they matched the target word, were synonyms of the target word, or varied in plurality from the target (e.g., dolphin for dolphins), and if they were provided before the onset of the following picture. Trials in which participants gave an inaccurate response or were unable to name the picture in the allotted time were excluded from the analysis.

Table 2 displays each of the pictures named, according to their target name and dominant word, the latter being the most common correct response when it differed from the target name. Also displayed are the percent word-agreement values for each target and dominant word. Supplemental analyses were conducted using only the dominant word to determine if valence groups were still matched for concreteness, number of syllables, and word frequency. Positive, negative, and neutral targets still did not differ in concreteness ratings, $F(2, 37) = 0.80$, $p = .46$, number of syllables, $F(2, 57) = 0.07$, $p = .94$, or word frequency, $F(2, 57) = 0.89$, $p = .42$.

Reaction times for each of the 60 trials were measured using Praat acoustic analysis software, v. 6.0.10 (Boersma & Weenink, 2015) to determine the elapsed time from presentation of the picture (the audible bell) to the onset of the participants' correct response. Three separate raters performed RT measurements, and data from 25% of

Table 1. Participant demographics.

Age group	n	Gender (% female, % male)	Age (years)			Education (years)		
			M	SD	Range	M	SD	Range
Younger	18	67, 33	22.1	2.61	18–27	15.6	1.97	12–19
Older	18	67, 33	68.7	6.19	60–80	15.3	2.93	12–20

Note. All participants identified as White/Caucasian, with the exception of two who identified as African American and Asian, respectively.

Table 2. Picture target words.

Valence	Percent target[a]	Dominant word[b] (%)
Negative		
Airplane crash	28.6	Plane crash (37.1)
Bear[c]	94.3	
Bomb	59.4	
Cemetery	63.9	
Cigarette butts	57.1	
Cockroaches	16.7	Beetles (44.4)
Dog	88.2	
Electric chair[c]	100.0	
Fire	94.4	
Gun	88.9	
Rat	75.8	
Shark	94.3	
Skulls	100.0	
Snake	97.2	
Spider	85.7	
Stitches	42.9	Scar (42.9)
Tank[c]	100.0	
Tombstone	26.5	
Tornado	94.3	
Trash[c]	47.1	
Neutral		
Basket	94.4	
Book	100.0	
Buttons	100.0	
Clock	100.0	
Fan	100.0	
Fork	100.0	
Hammer	100.0	
Lightbulb	77.8	
Mug	22.2	Cup (50.0)
Plate	97.1	
Rolling pin	100.0	
Rubber bands	100.0	
Scissors	100.0	
Sewing machine	96.9	
Shoes	86.1	
Suitcases	44.4	Luggage (55.5)
Tissue	77.8	
Towel	100.0	
Umbrella	100.0	
Whistle	100.0	
Positive		
Baby	100.0	
Beach[c]	87.5	
Bride	71.4	
Brownies	100.0	
Bunnies	52.8	
Butterfly	100.0	
Children	47.2	Kids (52.8)
Cruise	5.6	Cruise ship (36.1)
Cupcake	100.0	
Fawn	25.0	Deer (63.9)
Dolphins	88.6	
Fireworks	100.0	
Flowers	91.7	
Ice cream	66.7	
Kittens	88.9	
Money	94.4	
Monkeys	72.2	
Parrot	84.8	
Puppies	86.1	
Sunset	41.7	Sun (55.6)

[a]Percent target is the percentage of correct responses that matched the target. [b]The dominant word was provided if it differed from the target word. [c]Fewer than 90% of participants correctly named these items in the time allotted, so they were excluded from the analysis.

participants were randomly selected for intra- and inter-rater reliability measurements. Reliability was calculated utilizing the method reported by Kuhl et al. (1997), which consists of calculating the mean percentage difference between RT measurements between raters. The mean intra-rater difference was 1.50% and mean interrater difference was 2.12%, both of which were indicative of high reliability, according to Kuhl et al., (1997).

Given that participants were healthy adults, a picture was considered an outlier if fewer than 90% of participants named the item correctly within the allotted time. There were five pictures that met this criterion. After excluding outliers, the positive block included 19 trials, the negative block included 16 trials, and the neutral block included 20 trials.

A two-factor mixed analysis of variance (ANOVA) was conducted to determine if the mean RTs for positive, neutral, and negative images (within-group) differed by age (between-groups). To better account for variability of items and improve generalizability of results, a linear mixed effects regression was performed as well.

Results

Figure 1 and Table 3 display RTs for each age group in each condition. All assumptions for a mixed ANOVA were satisfied with the exception of homogeneity of variance and minor deviations in normality: Two of six kurtosis statistics fell outside of the accepted range, and two of six Shapiro-Wilk tests (SW; Shapiro & Wilk, 1965) were significant, $SW = .877$, $df = 18$, $p = .023$; $SW = .882$, $df = 18$, $p = .028$. A log transformation of the RT data was conducted in order to resolve these violations of normality and homogeneity, as is common for RT data (Ratcliff & Murdock, 1976; van der Linden, 2006). Re-analysis revealed that the assumptions of normality and homogeneity of variance were met following the transformation.

Results revealed a statistically significant within-subject main effect for emotional valence, $F(2, 68) = 67.55$, $p < .001$, with a large effect size (partial $\eta^2 = .67$), indicating that there were significant differences between RTs for pictures having different emotional valence. Bonferroni pairwise comparisons revealed significant differences in RT between positive and neutral images, $t(35) = 8.79$, $p < .001$, and between negative and neutral images, $t(35) = 11.75$, $p < .001$. Reaction times for positive and negative images did not differ significantly, $t(35) = 1.29$, $p = .59$. The between-subjects main effect of age was significant as well, $F(1, 34) = 62.89$, $p < .001$, with a large effect size (partial $\eta^2 = .65$), indicating a significant overall difference between age groups for RT.

Of primary interest, the interaction between emotional valence and age group was also significant, $F(2, 68) = 9.27$, $p < .001$, with a large effect size (partial $\eta^2 = .21$), indicating that there was a significant difference by age in RTs for emotional images. Figure 1 shows that both groups named emotional pictures more slowly than neutral pictures, but that this effect was considerably larger for older adults.

Figure 1. Effects of emotional valence and age on picture-naming reaction time. Shown are group mean reaction times and standard errors for naming of pictures having different valence by two age groups.
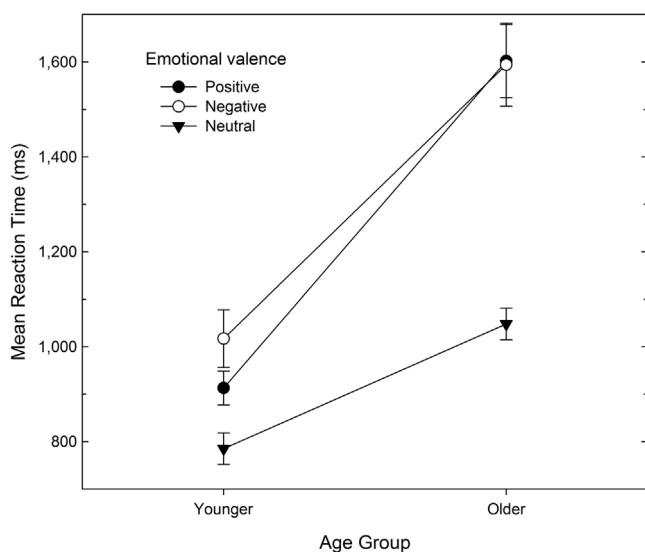
Bonferroni pairwise comparisons revealed that among younger participants, RTs were significantly different between positive and neutral images, $t(17) = 3.53$, $p = .01$, and between negative and neutral images, $t(17) = 6.29$, $p < .001$; however, RT was not significantly different between positive and negative images, $t(17) = 2.16$, $p = .13$. Among older participants, RTs were also significantly different between positive and neutral images, $t(17) = 9.47$, $p < .001$, and between negative and neutral images, $t(17) = 10.29$, $p < .001$, but not significantly different between positive and negative images, $t(17) = .263$, $p = 1.00$. Additional post hoc comparisons revealed that younger and older adults differed significantly on RTs for positive, negative, and neutral images: $t(34) = 8.93$, $p < .001$; $t(34) = 5.76$, $p < .001$; and $t(34) = 5.57$, $p < .001$, respectively.

A linear mixed-effects regression analysis was also conducted to examine the relationship between valence of pictures, age, and RT for picture naming to account for the language-as-fixed-effect fallacy, which asserts that effects demonstrated for language stimuli may not generalize beyond the specific sample of stimuli selected (Clark, 1973). R (R Core Team, 2016) and lme4 (Bates, Maechler, Bolker, & Walker, 2015) were utilized to perform the analysis. Valence, age, and their interaction were entered as fixed effects. Item and subject were included as random intercepts to account for the repeated-measures design and for variability of items (due to word characteristics, such as word frequency and number of syllables). Visual inspection of residual plots revealed deviations from homoscedasticity, thus a log transformation was conducted on RT data. Likelihood ratio tests were performed on each model compared to the model without the effect of interest to determine significance using restricted maximum-likelihood estimation. This test yielded the same results as the ANOVA (see Table 4), with age accounting for a significant effect over the intercept-only model, valence accounting for a significant effect beyond age, and the interaction accounting for more than the main effects of age and valence. The model that included age, valence, and their interaction was shown to be the best-fitting model, as evidenced by the lowest Akaike information criterion and Bayesian information criterion and a significant likelihood ratio test. This analysis provides additional support for the robustness of these effects.

Discussion

The present study aimed to determine the degree to which emotional valence of pictures impacted naming latencies in healthy adults, clarify the direction of this effect (longer vs. shorter latencies), and determine whether valence impacted younger versus older adults differently. Reaction times for positive and negative images were significantly longer than RTs for neutral images, and RTs for positive and negative images did not differ. Consistent with past studies (Au et al., 1995; Baciu et al., 2015; Borod et al., 1980; Nicholas et al., 1985), overall RTs were significantly longer for older adults than for younger adults. Pairwise comparisons revealed that this was the case for positive, negative, and neutral images. Of primary interest, the current data provide evidence that emotional valence

Table 3. Descriptive statistics of response time and accuracy for positive, negative, and neutral pictures by group.

Emotional valence	Age group	*M* reaction time	*SD*	Range	Accuracy (%)
Positive	Younger	912.92	151.04	715.02–1,343.50	99.1
	Older	1,601.98	325.76	1,037.02–2,349.74	98.8
	Total	1,257.45	429.79	715.02–2,349.74	99.0
Negative	Younger	1,017.04	257.57	665.71–1,774.12	98.6
	Older	1,594.24	370.82	948.80–2,357.59	96.2
	Total	1,305.64	429.75	665.71–2,357.59	97.4
Neutral	Younger	785.15	140.78	596.90–1,135.32	98.1
	Older	1,048.05	141.41	689.44–1,249.48	99.7
	Total	916.60	192.65	596.90–1,249.48	98.9

Note. Dependent variable: reaction time (ms); *SD* = standard deviation; Accuracy = *M* percent correct.

Table 4. Linear mixed models.

Model	Number of fixed effects	Number of random effects	AIC	BIC	Likelihood ratio test[a]	
					χ^2	p
Intercept only	1	2	−1592.3	−1569.8	—	—
Age	2	2	−1631.5	−1603.3	(1) = 41.15	< .001
Age + valence	4	2	−1643.6	−1604.1	(2) = 16.12	< .001
Age + valence + (age × valence)	6	2	−1679.5	−1628.7	(2) = 39.87	< .001

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion.

[a]The likelihood ratio test compares each model with the previous one.

of pictures impacts the performance of older adults more than younger adults. That is, the difference between naming latencies for neutral versus emotional pictures was far greater in older compared to younger adults.

With regard to the finding that emotional images resulted in longer RTs than neutral images for both younger and older adults, it is possible that the emotional processing component of the pictures interfered with lexical retrieval for both groups of participants. Consistent with some previous studies, emotional valence of pictures was not directly relevant to the naming task used in this study (i.e., attending to the emotional valence of the pictures was not relevant or required for the task of picture naming), and may therefore have interfered with lexical retrieval (Citron, 2012; Estes & Verges, 2008; Ihssen et al., 2007). As proposed by Ihssen et al. (2007), these findings support the idea that lexical processing may be inhibited by more arousing stimuli. Given that positive and negative stimuli are more arousing than neutral stimuli, as demonstrated by the arousal ratings of images from the IAPS, and that RTs for positive and negative stimuli were not significantly different from one another, data from the current study suggest that it is the emotional arousal of emotional pictures that led to inhibition of, or interference with, lexical retrieval.

Findings from this study found no difference between RTs for positive and negative stimuli directly contradicting previous research supporting the "automatic vigilance" effect. This theory states that negative stimuli result in longer processing times and naming latencies due to an attentional preference for negative stimuli. Nevertheless, the current data seem to support the idea that slower lexical processing of negative and positive stimuli occurs because it is more difficult to disengage attention from the emotional aspects of the pictures. It is possible that difficulty with attentional disengagement (e.g., switching attention from the emotionally arousing quality of the images to the naming task) could be the mechanism by which lexical retrieval was inhibited for both positive and negative stimuli. Further, this interference effect for emotional stimuli may have been more pronounced for the older adults due to decreased cognitive resources, particularly in the realm of attention. This is consistent with previous research reporting an age-related decline in attentional switching and an increase in distractibility by non-task-relevant stimuli

(Andrés, Parmentier, & Escera, 2006; Commodari & Guarnera, 2008).

As an alternative, this more pronounced interference effect for older adults could be due to a greater attentional bias toward emotional stimuli as compared to younger adults. This follows the suggestion that older adults may demonstrate a greater attentional preference for positive stimuli due to better emotion regulation abilities (Charles et al., 2003; Mather & Carstensen, 2005). Moreover, older adults may demonstrate a greater attentional preference for negative stimuli due to a greater sense of death anxiety (Fox & Knight, 2005). We hypothesize that reduced attentional resources to facilitate attentional disengagement in older adults, combined with an overall greater attentional preference for emotional stimuli, contributed to the observed interaction effect.

The results of the current study further support the idea that the effect of emotion on lexical processes may be task dependent. As suggested by Ihssen et al. (2007), emotion may affect performance differentially, depending on the relevance of the emotion to the task as well as the complexity of the task. Given that many studies investigating the impact of emotion on lexical processing have utilized lexical decision as their primary measure, the current study, which utilized a picture-naming task and therefore a different type of lexical process (lexical retrieval), adds to the discussion of how emotional stimuli might facilitate or interfere with lexical processes. The current data provide evidence that, in a picture-naming task, task-irrelevant, emotionally arousing stimuli interfere with lexical retrieval, particularly in older people. Future research should seek to replicate these findings, determine moderating factors, and further investigate the impact of task-relevant emotional stimuli on lexical retrieval.

Although the stimuli in the current study were matched for word concreteness, frequency, and number of syllables, images were not matched for visual complexity. It is possible that more visually complex images could have resulted in longer visual-processing time resulting in longer naming latencies. A post hoc analysis of visual complexity was conducted, in which pictures were converted to a vector format (i.e., .pict file), and compared via size in kilobytes (Vitevitch, Armbrüster, & Chu, 2004). A one-way ANOVA determined that picture size between valence groups was not significantly

different, $F(2, 57) = 0.15$, $p = .86$. In addition, given that the mixed-effects regression model is meant to account for item variability, such as might be expected in visual complexity, and it yielded the same conclusions as did the ANOVA, visual complexity likely did not impact the current results.

To determine whether the current results were influenced by articulatory differences across word lists, a post hoc analysis was conducted utilizing data from the English Lexicon Project (ELP; Balota et al., 2007). In the naming task used for the ELP, participants saw a written word and were asked to read it as quickly and accurately as possible (Balota et al., 2007, p. 446). This word-reading task is likely not dependent upon semantic knowledge, so we used it as a control for articulation, which could impact naming latencies. A one-way ANOVA was conducted to assess differences between ELP naming RTs for stimuli in the current three valence groups. If the plural form was not included in the database, the singular form was used. Also, as multiple-word targets are not included in the ELP database (e.g., rolling pin, ice cream), these items were left out of the analysis. Outliers excluded from the main analysis were also excluded from this analysis. This left the negative group with 14 items, the neutral group with 17 items, and the positive group with 18 items. In this data set, there were minor deviations from homogeneity of variance and normality: Two of three kurtosis statistics fell outside of the accepted range, and one of three Shapiro-Wilk tests (Shapiro & Wilk, 1965) were significant; $SW = .783$, $df = 17$, $p = .001$. Because the homogeneity of variance assumption was violated, Welch's F statistic and Games-Howell post hoc tests were employed. Naming RTs from the ELP were significantly different across emotional valence groups, Welch's $F(2, 22.462) = 3.91$, $p = .04$. Games–Howell multiple comparisons revealed a statistically significant difference between positive and negative groups only, with longer RTs for negative items, $t(30) = 2.72$, $p = .04$. It is important to note that ELP RTs for the neutral group were equivalent to those of the positive group, $t(33) = 1.06$, $p = .55$, and to those of the negative group, $t(29) = 1.76$, $p = .21$. These results stand in contrast to those found currently and displayed in Figure 1, in which RTs for neutral stimuli were significantly different from those for emotionally arousing stimuli. Accordingly, the results obtained currently are likely not simply a result of planning and programming for articulatory differences across lists. Rather, this analysis provides evidence that something other than articulatory differences (i.e., emotional valence) accounted for the observed differences in RT. Moreover, these data suggest that emotional valence may differentially impact distinct lexical processes, such as picture naming, word reading, and lexical decision.

This pattern of ELP RTs, in which negative RTs were larger than positive RTs, may also serve as a baseline of anticipated results, on the basis of articulatory planning. This anticipated baseline pattern may be seen in the results for the younger participants (negative RT > positive RT, see Figure 1), but the trend was nonsignificant, $t(17) = 2.16$, $p = .13$. The anticipated baseline pattern was not observed in the results for the older participants, and instead their positive and negative RTs are virtually identical. This suggests that the increase in RT for emotionally arousing stimuli in the older participants might be considered slightly larger for positive stimuli than for negative stimuli, once the anticipated baseline pattern corresponding to articulatory planning is accounted for.

Additional research is needed to replicate the current findings and further investigate moderating factors. Future research should also investigate whether emotional stimuli could have a facilitative effect for lexical retrieval in persons with acquired language disorders. Potential projects may investigate whether stimulating the neural substrates of emotion during language therapy may relateralize language driven by emotion centers that tend to be more heavily right-lateralized in the brain, or engage the limbic system as a lower level cognitive resource to facilitate higher level language function.

Conclusions

This study presents novel evidence that further clarifies how emotional valence might affect lexical retrieval. The current results show that emotional arousal of pictures appears to impact naming latency in both younger and older adults, with higher arousal leading to longer RTs. In accord with previous research, older adults took significantly longer to name pictures than younger adults. Results from the current study also indicate that the discrepancy in latency with age is far greater when naming pictures with positive and negative emotional valence, than when naming pictures with neutral emotional valence. We propose that this increase in naming latency for emotional stimuli may be the result of a necessary disengagement of attentional resources from the emotionally arousing images prior to completion of the naming task. Further, we propose that the greater impact of emotional arousal on naming latency for older adults may be due to a decline in attentional resources associated with the normal aging process and/or a greater attentional preference for emotional stimuli as compared to younger adults.

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