Psychology and Aging
2006, Vol. 21, No. 4, 815–820

0882-7974/06/$12.00 DOI: 10.1037/0882-7974.21.4.815

The Negativity Bias Is Eliminated in Older Adults: Age-Related Reduction in Event-Related Brain Potentials Associated With Evaluative Categorization

Stacey Wood and Michael A. Kisley
University of Colorado at Colorado Springs

Studies of younger adults have found that negative information has a stronger influence than positive information across a wide range of domains. T. A. Ito, J. T. Larsen, N. K. Smith, and J. T. Cacioppo (1998) reported that during evaluative categorization, extreme negative images produced greater brain activity than did equally extreme positive images in younger adults. Older adults have been reported to optimize affect and attend less to negative information. In this article, the negativity bias was examined in 20 older versus 20 younger adults during evaluative categorization, with a focus on brain activity occurring roughly 500 ms after presentation of visual stimuli. Results demonstrated a significant decrease in brain activity to both positive and negative stimuli ($p < .05$) and an elimination of the negativity bias in older adults.

Keywords: electrophysiology, emotion, aging

A large literature supports the existence of a negativity bias (Baumeister, Bratslavsky, Finkenaeuer, & Vohs, 2001; Cacioppo & Berntson, 1994; Cacioppo, Gardner, & Berntson, 1997; Ito, Cacioppo, & Lang, 1998; Rozin & Royzman, 2001; Taylor, 1991). Simply stated, the negativity bias is the tendency for humans to pay more attention to negative information than to positive information. Rozin and Royzman (2001) reviewed evidence that negative information is more salient than positive information that came from a range of psychological, literary, religious, and cultural sources. The authors described four mechanisms that support their theory that negative information is processed differently than positive information, including its potency, steeper gradients (responses are swifter), negative dominance when both negative and positive information are weighed, and negative differentiations (negative entities are more conceptually complex). Baumeister et al. (2001) reviewed a broad array of psychological topics and concluded that they were unable to come up with a single instance of reversals that demonstrated good is stronger than bad, perhaps with exception of some optimism in predicting the future and memory. In summary, both reviews make a strong case that there is something special about the processing and impact of negative information.

However, the authors of neither review made predictions for life span development, although the assumption would appear to be that the negativity bias is age invariant. Rozin and Royzman (2001) hypothesized that the negativity bias does not arise from a single mechanism but rather is "overdetermined" and driven by multiple mechanisms. There is no speculation on what the cognitive (attention, encoding, etc.) or neural mechanisms might be but general agreement that a negativity bias is likely adaptive.

These theories stand in contrast to recent work in aging. For example, older adults have been reported to attend more to positive information than to negative information and to be highly motivated to optimize well-being in their social goals (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000). This characteristic is likely responsible for older adults' reported lower rates of depression, higher rates of positive affect, and increased emphasis on emotionally satisfying relationships (Carstensen et al., 2000; Charles & Carstensen, 1999). Recent evidence suggests that age-related changes in emotional processing impact some aspects of cognition in addition to social behavior. Domains demonstrating a decrease in processing of negative versus positive information include attention, memory, decision making, and language (Charles, Mather, & Carstensen, 2003; Mather & Carstensen, 2003; Pennebaker & Stone, 2003; Wood, Busemeyer, Koling, Cox, & Davis, 2005). Age-related changes in brain activity associated with positive and negative information have also been demonstrated (Mather et al., 2004). Taken together, these studies call into question the dominance of negative information across all domains as people age.

Changes in emotional processing in older adults are thus well documented at this point in time. However, mechanisms underlying changes in emotional processing have not been definitively established. Early work on emotion and aging emphasized emotional dampening and poor emotional regulation (for a review, see

Stacey Wood and Michael A. Kisley, Department of Psychology, University of Colorado at Colorado Springs.

This work was funded by Grant NIA R15 AG021442-01 to Stacey Wood from the National Institute on Aging. We gratefully acknowledge Tiffany Ito, Mara Mather, and Alan Hartley for helpful consultation. Technical assistance was provided by Christina Burrows, Laura Engleman, Tara Noecker, and Janice Trew.

Correspondence concerning this article should be addressed to Stacey Wood, who is now at the Department of Psychology, Scripps College, 1030 Columbia Avenue, Claremont, CA 91711. E-mail: swood@scrippscol.edu or mkisley@uccs.edu

Isaacowitz, Charles, & Carstensen, 2000). More recent work has demonstrated that middle-aged and older adults appear to be more adept at emotional regulation, more emotionally complex, and better at integrating emotion and cognition than younger adults (Carstensen, 1992; Labouvie-Vief, 1999). Older adults demonstrate similar subjective experiences of arousal and the same abilities as younger adults to produce and experience different types of emotion (Levenson, Carstensen, Friesen, & Ekman, 1991). However, older adults demonstrate significantly lower levels of physiological arousal, especially on cardiovascular measures. In summary, significant differences in emotional regulation may account for some of the changes in emotional processing, but the exact relationship has yet to be determined.

The event-related potential (ERP) approach may provide an ideal opportunity to shed light on the mechanisms underlying changes in emotional regulation in aging. ERP methodology has been used successfully to study emotional processing and can be used to dissociate reactivity to positive versus negative information. Ito, Larsen, et al. (1998) determined that a negativity bias is present within 500 ms of stimulus onset during an evaluative (subjective) oddball paradigm. In this paradigm, participants evaluate images and characterize them as negative, positive, or neutral. Emotionally valenced images (positive and negative) occur much less frequently than neutral images do. A characteristic ERP waveform, the late positive potential (LPP), occurs during presentation of the oddball stimuli. This wave is similar to the P300, which is elicited during nonevaluative (i.e., semantic categorization) oddball tasks but may involve different neural processes (Crites & Caccioppo, 1996; Donchin, 1981). In younger adults, negative images produced larger LPPs than did positive images, even though the specific sets of images (selected from the International Affective Picture System; IAPS; National Institute of Mental Health Center for the Study of Emotion and Attention, 2001) were shown to be equally matched in terms of subjective emotional impact and arousal (Ito, Larsen, et al., 1998).

Our purpose in the current study is to determine if there are changes in how the brain characterizes emotional information during evaluative categorization in older adults. Because component P300 elicited during nonevaluative categorization tasks has been shown to decrease in amplitude with advancing age (Polich, 1997), we hypothesized that the LPP waveform, elicited during evaluative categorization tasks, would also decrease with age. However, unique to component LPP is the emotional bias described above. Thus, we further hypothesized older adults would exhibit an attenuation of the negativity bias, as measured by LPP amplitude, compared with younger adults. This ERP paradigm allows for deconstruction of visual information processing into component stages, thus allowing for dissociation of age-related effects. To this end, we also examined visual component P2, an earlier wave (approximately 200 ms poststimulus) that is not sensitive to aging (Polich, 1997) but is sensitive to top-down selective attention (Johannes, Munte, Heinze, & Mangun, 1995). Thus, age-related differences of component P2 amplitude suggest systematic differences in overall attention directed toward the images. By ruling out such an effect, we make a stronger case for specific age-related reduction in the neural processing associated with the LPP waveform and the associated negativity bias.

Method

Participants

Twenty younger adults between 19 and 22 years of age ($M = 21.0$ years, $SD = 1.1$ years; 5 men) and 20 older adults between 56 and 81 years of age ($M = 68.5$ years, $SD = 7.9$ years; 8 men) received course extra credit or monetary compensation (at a rate of $10 an hour) for their participation. Individuals were prescreened for self-reported visual problems and had to test 20/40 or better with a Snellen visual acuity chart to be included. As a final check of visual function, all participants read textual instructions on a computer screen at a distance of 2.5 ft (0.76 m) with no difficulty. All older participants scored 27 or higher on the Mini-Mental State Examination, consistent with intact cognitive function (Folstein, Folstein, & McHugh, 1975). Years of education were not significantly different between groups (for younger participants, $M = 14.15$ years, $SD = 0.81$ years; for older participants, $M = 15.05$ years, $SD = 2.44$ years). One younger and 5 older adults were taking beta-blocker medication at the time of testing. These medications, commonly used to treat hypertension, are also known to reduce anxiety. Therefore, we included medication status as a covariate on all group comparisons below.

Materials

Images were presented on a 17-in. liquid-crystal display color computer monitor 2.5 ft (0.76 m) from the participant. E-Prime (2002) was used for image presentation and response recording. Electroencephalographic signals were recorded on a Neuroscan NuAmps amplifier system under the control of a laptop computer running Scan 4.2 (2001).

Affectively neutral, positive, and negative images were selected from the IAPS (National Institute of Mental Health Center for the Study of Emotion and Attention, 2001) on the basis of normative ratings from younger adults and a previous ERP study (Ito, Cacioppo, et al., 1998; Ito, Larsen, et al., 1998). Because the present study involved an age group that has not been normed on these images, we collected quantitative ratings of bipolar valence (1 = *most negative*, 9 = *most positive*) and arousal (1 = *least arousing*, 9 = *most arousing*) using the Self-Assessment Manikin instrument (SAM; Lang, Bradley, & Cuthbert, 2001) for the six images used to compute ERPs. Average ratings for neutral images (e.g., IAPS Picture 6150 was an electrical outlet; IAPS Picture 7550 was a man at computer) were not significantly different between younger (for bipolar valence, $M = 4.93$, $SD = 0.86$; for arousal, $M = 2.08$, $SD = 1.38$) and older (for bipolar valence, $M = 5.45$, $SD = 1.00$; for arousal, $M = 3.05$, $SD = 1.70$) adults. Ratings for positive images (e.g., IAPS Picture 7340 was chocolate ice cream; IAPS Picture 7350 was pizza) were also not different between younger (for bipolar valence, $M = 7.73$, $SD = 1.27$; for arousal, $M = 4.65$, $SD = 2.48$) and older (for bipolar valence, $M = 7.83$, $SD = 1.48$; for arousal, $M = 5.60$, $SD = 2.46$) groups. Ratings for negative images (e.g., IAPS Picture 9140 was a decomposing calf; IAPS Picture 9571 was a dead cat) differed between groups on both bipolar valence, $F(1, 37) = 6.30$, $p < .05$, and arousal, $F(1, 37) = 5.92$, $p < .05$, where younger adults (for bipolar valence, $M = 1.65$, $SD = 1.05$; for arousal, $M = 4.55$, $SD = 2.06$) rated the images less negative and less arousing than older adults did (for bipolar valence, $M = 1.00$, $SD = 0.00$; for arousal, $M = 6.48$, $SD = 2.54$). Because of this differential in subjective rating between groups (i.e., more extreme ratings for negative images by older adults), subjective valence and arousal ratings for negative images were included as covariates on group comparisons but later dropped from the analyses because they were not found to exert any significant effects on ERP measures. Mean luminosity (i.e., luminance for all colors combined) was not significantly different between neutral, negative, and positive image groups ($\alpha = .05$).

Procedure

The procedure for this study was similar to that of Experiment 2 of Ito, Larsen, et al. (1998). After providing informed consent, participants were prepared for ERP recording and given instructions on the evaluative categorization task. Electrophysiological signals were then recorded during the task, which involved rating images as positive, negative, or neutral. After recording, quantitative bipolar valence and arousal ratings for select images were collected.

Before the categorization task, we preexposed participants to five prototypical negative, positive, and neutral images to provide them with emotional anchors for the characterization component of the task. They paced themselves through this task by pressing a button. For the evaluative categorization task, participants viewed each image for 1 s and then categorized the image as positive, negative, or neutral by pressing one of three buttons on a response pad with their right hand. The images were presented 1.2 s after each response. Images were presented in blocks of five with a pause between blocks that was terminated by a button press. Ninety images were used for computing ERPs: 30 were evaluatively consistent with preceding images (neutral compared with preceding neutral images) and 60 were evaluatively inconsistent (positive or negative compared with preceding neutral images). These images randomly occurred at either the third, the fourth, or the fifth positions in each block of five images, and all preceding images in the block were neutral. A total of 90 blocks were presented, with each image valence (positive, negative, neutral) occurring 10 times in each of the possible image positions (third, fourth, fifth). ERPs were computed separately from the resulting 30 positive, 30 negative, and 30 neutral presentations. Because individual categorization of image valence was not always the same as a priori grouping (see the Results section), average ERP waveforms were also computed on the basis of the former variable in a separate analysis. Results of this post hoc analysis were substantively similar to the original and thus are not shown here.

Electrophysiological Procedure and Analysis

Recordings were taken from chloride-coated silver electrodes attached to standardized frontal (Fz), central (Cz), and parietal (Pz) sites referenced to the left mastoid (the bony protrusion behind ear), with a ground electrode attached to the forehead. Ongoing electroencephalographic activity was bandpass filtered (0.1–100.0 Hz) and sampled at 1000 Hz. Eye movements were monitored with electrodes directly lateral and superior to the left eye. After the recording session, stimulus-locked ERP intervals (*epochs*) were computed from the electroencephalographic record from 100 ms before to 900 ms after image onset for the 90 analyzed image presentations. Standard corrections were applied so that the epochs were re-referenced to an electrode computed as the average of left and right mastoids and were baseline corrected for mean prestimulus voltage (i.e., the 100 ms preceding image presentation). Any trial for which a recording channel exceeded ± 100 μV was assumed to be corrupted by movement artifact and excluded from further analysis. Valence-specific averages (positive, negative, neutral) were computed from the remaining trials and low-pass filtered at 9 Hz (zero-phase shift, 24 dB/octave). Any participant for whom an average ERP waveform was computed from five single trials or less (because of artifact removal) was excluded from further analysis (n = 3 younger and 6 older adults). The mean number of trials used to compute average ERP waveforms did not differ between the remaining 17 younger (M = 18.27 trials, SD = 6.38 trials) and 14 older (M = 18.64 trials, SD = 6.47 trials) adults.

Previous research has shown that LPP amplitude is largest at recording site Pz (Cacioppo, Crites, Berntson, & Coles, 1993; Ito, Larsen, et al., 1998). Thus, LPP amplitude and latency for each waveform was taken from the largest peak voltage on electrode Pz between 400 and 900 ms post–image onset (Coles, Gratton, & Fabiani, 1990). Similar measures were taken for electrodes Cz and Fz, with the restriction that the peak had to be within ± 100 ms of Pz latency. Component P2 was defined as the largest positive deflection between 195 and 255 ms poststimulus (Johannes et al., 1995), also at site Pz.

Results

No evidence for systematic differences in overall task performance between groups could be found (only those individuals that were included in the final ERP analysis were included in the behavioral analysis: 17 younger adults and 14 older adults). The overall percentage of the 90 analyzed single trials to which participants responded as expected (i.e., responded *neutral* to neutral images, *negative* to negative images, etc.) was not significantly different between younger (M = 85.6%, SD = 12.3%) and older (M = 79.9%, SD = 15.3%) adults, $F(1, 29) = 1.33$, $p = .26$. When separating images into groups according to their valence, we found a main effect of valence, $F(2, 28) = 18.74$, $p < .001$, because participants responded *positive* to positive images (M = 85.5%, SD = 8.0%) and *negative* to negative images (M = 89.9%, SD = 4.0%) significantly more often than they responded *neutral* to neutral images (M = 73.0%, SD = 8.2%). However, there was no Age × Valence interaction effect for this measure. As expected, older adults (M = 808.6 ms, SD = 153.7 ms) exhibited longer mean reaction times than did younger adults (M = 725.5 ms, SD = 177.3 ms), although the difference was not significant, $F(1, 29) = 1.90$, $p = .18$.

Before comparing the two age groups on ERP measures, we tested for valence and scalp-distribution effects for younger adults only, in keeping with Ito, Larsen, et al. (1998). A 3 (valence: neutral, negative, positive) × 3 (electrode: Pz, Cz, Fz) multivariate analysis of variance (Wilks's Lambda approximation) revealed main effects for valence, $F(2, 15) = 9.35$, $p < .01$, and electrode, $F(2, 15) = 39.62$, $p < .001$, and a Valence × Electrode interaction, $F(4, 13) = 7.68$, $p < .01$. Bonferroni pairwise comparisons revealed that LPP amplitude elicited by neutral images (marginal M = 4.64 μV) was significantly smaller than LPP amplitude elicited by negative (M = 9.60 μV) or positive (M = 9.21 μV) images ($p < .01$). As expected, LPP amplitude at the parietal site (Pz: M = 12.98 μV) was larger than amplitude at central (Cz: M = 7.54 μV) or frontal (Fz: M = 2.93 μV) sites, and Cz amplitude was larger than Fz amplitude ($p < .001$). A planned comparison at Pz to test for the negativity bias in younger adults revealed larger mean LPP amplitude to negative (M = 17.31 μV) compared with positive (M = 14.06) images, $F(1, 16) = 5.14$, $p < .05$. Collectively, these results for younger adults generally replicate those of Ito, Larsen, et al. Mean LPP amplitudes and latencies at site Pz are provided in Table 1 and grand-averaged ERP waveforms for the younger adults are shown in the top of Figure 1.

Table 1
Means and Standard Deviations of Late Positive Potential Amplitude and Latency at Pz as a Function of Image Valence and Age Group

Measure and group	Neutral		Negative		Positive	
	M	*SD*	*M*	*SD*	*M*	*SD*
Amplitude (μV)						
Younger	7.57	3.96	17.31	8.86	14.06	6.44
Older	6.27	2.47	8.95	3.80	9.16	4.45
Latency (ms)						
Younger	548.3	103.6	508.5	52.2	514.0	40.7
Older	538.4	73.0	567.9	62.9	573.7	77.4

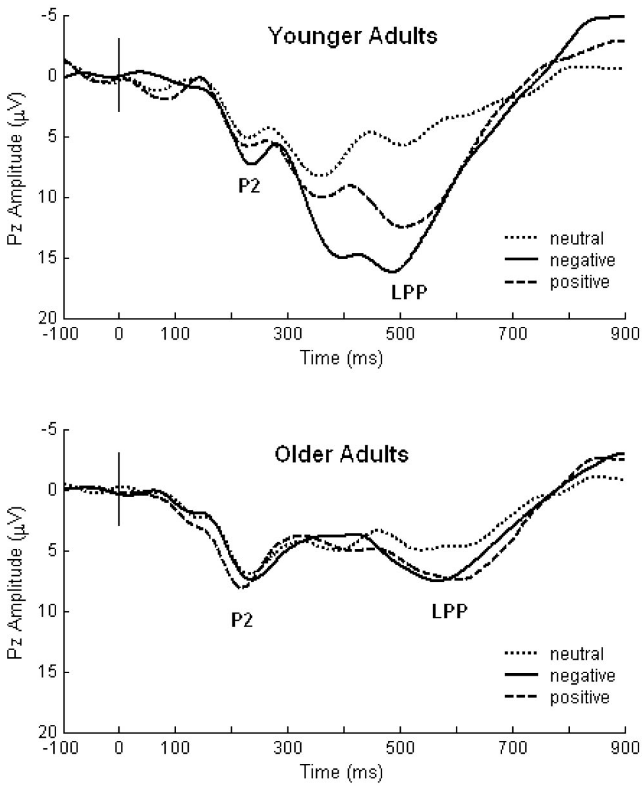

Figure 1. Grand-averaged event-related potential waveforms recorded from site Pz during evaluatively consistent (neutral) and inconsistent (negative and positive) image presentations. *Top*: This across-participants average demonstrates that peak late positive potential (LPP) amplitude is generally larger for inconsistent images and largest for negative images in younger adults ($N = 17$). *Bottom:* The grand-averaged waveform for older adults ($N = 14$) demonstrates generally smaller LPP amplitudes and later peak latencies for both negative and positive images compared with those of younger adults. However, note that amplitude of component P2 does not appear to differ between groups. In keeping with LPP convention, positivity has been plotted downward.

Comparison between groups was conducted at electrode Pz with valence as within-subjects and age group (younger vs. older) as between-subjects factors, with beta-blocker medication status as a covariate. Main effects were found for valence, $F(2, 27) = 13.04$, $p < .001$, and age group, $F(1, 28) = 8.12$, $p < .01$, and a significant Valence $\times$ Age Group interaction was revealed, $F(2, 27) = 3.40$, $p < .05$. Pairwise comparisons revealed that LPP amplitude elicited by neutral images ($M = 6.92$ μV) was smaller than LPP amplitude elicited by negative ($M = 13.13$ μV) or positive ($M = 11.61$ μV) images ($p < .001$). LPP amplitude for the younger adults ($M = 12.98$ μV) was significantly larger than that for the older adults ($M = 8.13$ μV), $p < .01$. Further tests revealed significant age effects for negative, $F(1, 28) = 9.57$, $p < .01$, and positive images, $F(1, 28) = 4.84$, $p < .05$, but not for neutral images, $F = 1.11$.

In older adults, there was a main effect for valence so that both negative and positive response amplitudes were significantly larger than the LPP amplitude evoked by neutral images ($M = 6.27$ μV), $F(1, 12) = 5.00$, $p < .05$, and $F(1, 12) = 4.72$, $p < .05$, respectively. Unlike for the younger adults, there was no evidence for a negativity bias for LPP amplitude at Pz in response to negative ($M = 8.95$ μV) compared with positive ($M = 9.16$ μV) images for the older adults.

A 2 (age group) $\times$ 3 (valence) ANOVA for component P2 revealed no main effect for age or valence and no significant Age $\times$ Valence interaction ($ps > .05$). The marginal peak mean amplitude was 7.9 μV for older adults and 7.2 μV for younger adults. These results are consistent with the idea that older and younger adults were equally attentive to the stimuli and engaged in the task (Johannes et al., 1995).

To test for possible speed-of-processing differences between groups, we subjected LPP latency at Pz to a similar analysis. Although younger adults (marginal $M = 523.6$ ms) exhibited shorter peak latency than did older adults ($M = 560.0$ ms), this effect was not significant. Summary statistics for both groups at electrode Pz are provided in Table 1, and grand-averaged positive and negative ERPs are compared between groups in the bottom of Figure 1.

Discussion

The negativity bias seen in the neural activity of younger adults during evaluative characterization is eliminated in older adults. Our results indicate that there is an overall dampening of brain activity associated with early processing of emotional images and no evidence for the negativity bias in older versus younger adults. However, older adults' subjective experience of emotional images was comparable to or stronger than that of younger adults. There was no detectable difference between groups for an earlier component (P2) or for LPP amplitude evoked by neutral images. The demonstrated age-related decrease in amplitude of ERP component LPP elicited during an evaluative categorization task is consistent with previous findings of decreased amplitude of P300 elicited during nonevaluative categorizations (Bashore, Ridderinkhof, & van der Molen, 1997; Kok, 2000; Polich, 1996). However, decreased LPP amplitude and attenuation of the negativity bias for this component is particularly pertinent in the domain of emotional stimulus processing.

We reported a dissociation between subjective ratings and neural reactivity in the older adult groups. These results mirror Levenson et al.'s (1991) findings that autonomic nervous system arousal declines but subjective experiences of emotion remain intact in older adults. Other studies of emotional processing have reported this dissociation (Gavazzeni, Weins, & Fischer, 2005; Mather & Carstensen, 2003). Specifically, Gavazzeni et al. found that older adults, compared with younger adults, exhibited enhanced subjective arousal but dampened autonomic reactivity in response to negative images. In a related finding, Mather et al. reported that older adults demonstrated increased amygdala activation to positive images, even though behavioral ratings of arousal for older adults were higher for negative versus positive pictures. Nevertheless, the dissociation between subjective ratings and ERP measures raises the issue of the behavioral significance of changes in evaluative characterizations. Age-related changes in memory, attention, language, and decision making have been reported that are consistent with a change in the negativity bias (Charles et al., 2003; Mather & Carstensen, 2003; Pennebaker & Stone, 2003; Wood, Busemeyer, Koling, Cox, & Davis, 2005). But it will be necessary in future studies to directly compare ERP responses with neurocognitive task performance before a definitive conclusion can be drawn regarding the significance of the effect.

An alternative explanation for the decreased LPP amplitudes found for older adults is that this group was using some type of emotional regulation of negative but not positive images, generally not paying attention and/or not performing the categorization task correctly. However, there was no difference between older and younger groups in terms of categorization accuracy. The increased length of the reaction times in the older adults, although not significantly different from those of the younger group, reflect classical findings of age-related slowing during task performance (Birren, 1965; Salthouse, 1996). It should be noted that although LPP amplitude evoked by emotionally valenced images was greatly reduced in older adults, it was still significantly larger than neutral LPP amplitude, suggesting that older adults were, in fact, processing emotional images differently than neutral images. Further, LPP amplitude evoked by the neutral images did not differ between groups. Finally, amplitude of age-invariant visual component P2, which is modulated by selective attention and sensitive to emotional information (Johannes et al., 1995), was not different between groups. If the younger adults had been systematically attending to the images more than the older adults were, we would have then expected P2 amplitude to be larger in the younger group. Taking these results together, we report that changes in the negativity bias are detectable specifically at the evaluative characterization stage (LPP) in older adults approximately 500–600 ms after stimulus onset.

In general, our findings are consistent with published research on emotional processing in older adults that finds differences in the way that older and younger adults process emotional information (see Charles et al., 2003; Mather et al., 2004). However, our data suggest that in terms of evaluative characterization, the main difference in emotional processing between younger and older adults is a decrease in reactivity to negative information rather than an increase in attention to positive information. When beginning this study, we originally hypothesized that we would see a negativity bias in younger adults (similar to that found in Ito, Larsen, et al., 1998) operationalized by an increased amplitude at LPP for negative versus positive information and a positivity bias for the older samples (on the basis of work by Carstensen and her collaborators; e.g., Carstensen et al., 2000) operationalized by an increased amplitude at LPP for positive versus negative images. We were able to replicate the negativity bias in younger adults but did not see the converse pattern in older adults. Instead, we saw a main effect for emotionally valenced versus neutral images but no difference in reactivity between negative and positive images. If the mechanism at work were an increase in reactivity to positive images rather than a decrease in reactivity to negative images, we would expect to see a larger LPP grand mean amplitude for positive images in the older sample. Such a finding should present a positivity bias. The older adults in this study do not appear to be biased toward either positive or negative information. This distinction has important implications. For example, in decision making, it may not be the case that older adults are biased by positive options but rather weigh positive and negative information more equally than do younger adults (Wood et al., 2005).

As reviewed in the introduction, Rozin and Royzman (2001) hypothesized that the negativity bias does not arise from a single mechanism but rather is overdetermined and driven by multiple mechanisms. If this view is correct, that is, if multiple mechanisms are driving the negativity bias, then one may expect to see dissociations in older adults, with some domains demonstrating a negativity bias (like impression formation and threat detection) and others demonstrating a positivity bias or even no bias depending on the stage of processing (early vs. late), type of stimuli (social or not), and methodological approach. For example, we found no age differences in processing at P2 but saw significant changes at LPP. Recent work on the effects of evaluative processing during alcohol intake suggests that LPP may be sensitive to changes in the dopamine reward pathway and mediated by frontal cortical circuits (Bartholow, Pearson, Gratton, & Fabiani, 2003). Changes in dorsolateral prefrontal cortex have been reported in older adults, and the possibility of frontally mediated changes of LPP is consistent with that finding (MacPherson, Phillips, & Della Sala, 2002). However, more work will need to be done to determine the underlying mechanism.

In summary, we found differences in how younger versus older adults react to negative information. These differences may reflect adaptations or age-related neural changes. Our approach using ERP data is unique to this field because the activity measured is separable from behavior (and, in fact, precedes it) and is substantively different from functional imaging data (e.g., fMRI). Therefore, we are not necessarily surprised to find differential changes or a lack of change in the negativity bias versus a positivity bias. In fact, this dissociation seems worthy of future pursuit.

References

Bartholow, B. D., Pearson, M. A., Gratton, G., & Fabiani, M. (2003). Effects of alcohol on person perception: A social cognitive neuroscience approach. *Journal of Personality and Social Psychology, 85,* 627–638.

Bashore, T. R., Ridderinkhof, K. R., & van der Molen, M. W. (1997). The decline of cognitive processing speed in old age. *Current Directions in Psychological Science, 6,* 163–169.

Baumeister, R. F., Bratslavsky, E., Finkenauer, C., & Vohs, K. D. (2001). Bad is stronger than good. *Review of General Psychology, 5,* 323–370.

Birren, J. E. (1965). Age changes in speed of behavior: Its central nature and physiological correlates. In A. T. Welford & J. E. Birren (Eds.), *Behavior, aging, and the nervous system* (pp. 191–216). Springfield, IL: Charles C Thomas.

Cacioppo, J. T., & Berntson, G. G. (1994). Relationship between attitudes and evaluative space: A critical review, with emphasis on the separability of positive and negative substrates. *Psychological Bulletin, 115,* 401–423.

Cacioppo, J. T., Crites, S. L., Berntson, G. G., & Coles, M. G. H. (1993). If attitudes affect how stimuli are processed, should they not affect the event-related brain potential? *Psychological Science, 4,* 108–112.

Cacioppo, J. T., Gardner, W. L., & Berntson, G. G. (1997). Attitudes and evaluative space: Beyond bipolar conceptualizations and measures. *Personality and Social Psychology Review, 1,* 3–25.

Carstensen, L. L. (1992). Social and emotional patterns in adulthood: Support for socioemotional selectivity theory. *Psychology and Aging, 7,* 331–338.

Carstensen, L. L., Pasupathi, M., Mayr, U., & Nesselroade, J. R. (2000). Emotional experience in everyday life across the adult lifespan. *Journal of Personality and Social Psychology, 79,* 644–655.

Charles, S. T., & Carstensen, L. L. (1999). The role of time in the setting of social goals across the life span. In F. Blanchard-Fields & T. Hess

(Eds.), *Social cognition and aging* (pp. 319–342). New York: Academic Press.

Charles, S. T., Mather, M., & Carstensen, L. L. (2003). Aging and emotional memory: The forgettable nature of negative images for older adults. *Journal of Experimental Psychology: General, 132,* 310–324.

Coles, M. G. H., Gratton, G., & Fabiani, M. (1990). Event-related brain potentials. In J. T. Cacioppo & L. G. Tassinary (Eds.), *Principles of psychophysiology: Physical, social, and inferential elements* (pp. 413–455). Cambridge, England: Cambridge University Press.

Crites, S. L., & Cacioppo, J. T. (1996). Electrocortical differentiation of evaluative and nonevaluative characterizations. *Psychological Science, 7,* 318–321.

Donchin, E. (1981). Surprise! . . . Surprise? *Psychophysiology, 18,* 493–513.

E-Prime. (2002). (Version 1.1.4.1) [Computer software]. Pittsburgh, PA: Psychological Software Tools.

Folstein, M., Folstein, S., & McHugh, P. R. (1975). "Mini-mental state": A practical method for grading the mental state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189–198.

Gavazzeni, J., Wiens, S., & Fischer, H. (2005). Emotional reactivity to negative and neutral pictures in younger and older adults [Abstract]. *Psychophysiology, 42,* S57.

Isaacowitz, D. M., Charles, S. T., & Carstensen, L. L. (2000). Emotion and cognition. In F. Craik & T. Salthouse (Eds.), *The handbook of aging and cognition* (2nd ed., pp. 593–631). Mahwah, NJ: Erlbaum.

Ito, T. A., Cacioppo, J. T., & Lang, P. J. (1998). Eliciting affect using the International Affective Picture System: Trajectories through evaluative space. *Personality and Social Psychology Bulletin, 24,* 855–879.

Ito, T. A., Larsen, J. T., Smith, N. K., & Cacioppo, J. T. (1998). Negative information weighs more heavily on the brain: The negativity bias in evaluative categorizations. *Journal of Personality and Social Psychology, 75,* 887–900.

Johannes, S., Munte, T. F., Heinze, H. J., & Mangun, G. R. (1995). Luminance and spatial attention effects on early visual processing. *Cognitive Brain Research, 2,* 189–205.

Kok, A. (2000). Age-related changes in involuntary and voluntary attention as reflected in components of the event-related potential (ERP). *Biological Psychology, 54,* 107–143.

Labouvie-Vief, G. (1999). Emotions in adulthood. In V. L. Bengston & K. W. Schaie (Eds.), *Handbook of theories of aging* (pp. 253–267). New York: Springer.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2001). *International Affective Picture System (IAPS): Instruction manual and affective ratings* (Technical Report A-5). Gainesville, FL: University of Florida, Center for Research in Psychophysiology.

Levenson, R. W., Carstensen, L. L., Friesen, W. V., & Ekman, P. (1991). Emotion, physiology, and expression in old age. *Psychology and Aging, 6,* 28–35.

MacPherson, S. E., Phillips, L. H., & Della Sala, S. (2002). Age, executive function, and social decision making: A dorsolateral prefrontal theory of cognitive aging. *Psychology and Aging, 17,* 598–609.

Mather, M., Canli, T., English, T., Whitfield, S., Wais, P., Ochsner, K., et al. (2004). Amygdala responses to emotionally valenced stimuli in older and younger adults. *Psychological Science, 15,* 259–263.

Mather, M., & Carstensen, L. L. (2003). Aging and attentional biases for emotional faces. *Psychological Science, 14,* 409–415.

National Institute of Mental Health Center for the Study of Emotion and Attention. (2001). *The International Affective Picture System: Digitized photographs.* Gainesville, FL: University of Florida, Center for Research in Psychophysiology.

Pennebaker, J. W., & Stone, L. D. (2003). Words of wisdom: Language use over the life span. *Journal of Personality and Social Psychology, 85,* 291–301.

Polich, J. (1996). Meta-analysis of P300 normative aging studies. *Psychophysiology, 33,* 334–353.

Polich, J. (1997). EEG and ERP assessment of normal aging. *Electroencephalography and Clinical Neurophysiology, 104,* 244–256.

Rozin, P., & Royzman, E. B. (2001). Negativity bias, negativity dominance, and contagion. *Personality and Social Psychology Review, 5,* 296–320.

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review, 103,* 403–428.

Scan 4.2. (2001). [Computer software]. El Paso, TX: Compumedics NeuroScan.

Taylor, S. E. (1991). Asymmetrical effects of positive and negative events: The mobilization–minimization hypothesis. *Psychological Bulletin, 110,* 67–85.

Wood, S., Busemeyer, J., Koling, A., Cox, C., & Davis, H. (2005). Older adults as adaptive decision makers: Evidence from the Iowa Gambling Task. *Psychology and Aging, 20,* 220–225.

Received May 4, 2005
Revision received May 4, 2006
Accepted June 6, 2006 ■