Published in final edited form as:

Psychophysiology. 2018 May ; 55(5): e13024. doi:10.1111/psyp.13024.

In the mind's eye: The late positive potential to negative and neutral mental imagery and intolerance of uncertainty

Annmarie MacNamara

Department of Psychological and Brain Sciences, Texas A&M University, College Station, TX

Abstract

There are many advantages to human beings' ability to generate and sustain mental imagery in the absence of exteroceptive stimuli; however, this ability may also underlie emotional disorders characterized by worry, rumination or excessive concern about the future. For instance, fear-based disorders may be characterized by heightened ERPs to negative imagery. On the other hand, distress disorders may be characterized by attempts to avoid engaging with negative mental imagery, and therefore reduced electrocortical response. Prior ERP work has used negative and neutral pictorial stimuli to establish the parameters of response in healthy individuals, before taking these paradigms to clinical samples to assess aberrant emotion processing. Yet despite its clinical relevance, no study to date has elicited a late positive potential (LPP), a robust measure of emotion processing, to standardized negative imagined scenes. Here, participants listened to audio descriptions of negative and neutral scenes, and were asked to imagine these scenes as vividly as possible. Results showed that negative imagined scenes elicited an increased late positive potential (LPP), lasting approximately 10 seconds after audio description offset, as well as heightened ratings of arousal and unpleasantness. Moreover, participants with greater self-reported cognitive concerns about uncertain future events (higher prospective intolerance of uncertainty) showed reduced emotional modulation of the LPP. These data provide the first evidence of sustained electrocortical processing of standardized negative imagery elicited in the absence of salient visual cues, and suggest that cognitive risk for anxiety in an unselected sample may be represented phenotypically by blunted LPPs to negative imagery.

Keywords

LPP; ERPs; event-related potential; mental imagery; IU; blunting

Introduction

Mental imagery refers to perceptual experience that occurs in the absence of sensory input. Dysfunctional emotional mental imagery may be central to the development and maintenance of emotional disorders. For example, patients with post-traumatic stress disorder (PTSD) may experience intrusive and jarring images reminiscent of trauma, accompanied by physiological and emotional reactivity. Other disorders, such as obsessive

compulsive disorder (OCD) or generalized anxiety disorder (GAD) may be characterized by a different kind of dysfunction defined by attempts to avoid engaging with emotional imagery (e.g., via compulsions or excessive worry). On the other hand, repeated exposure to feared emotional imagery (e.g., via exposure-based therapy) may promote habituation and extinction of fear and anxiety. Among healthy individuals, individual variability in emotional imagery, measured via brain activity or physiological responding, may reveal risk for psychopathology or current, sub-threshold symptom profiles.

In early work examining physiological responding to emotional imagery, verbal descriptions of emotional scenes elicited increased heart rate acceleration, respiration, muscle activity, eye movement, respiration and skin conductance response among healthy individuals (Lang, Kozak, Miller, Levin, & McLean, 1980). Since this time, other researchers have used similar methods to study physiological responding during mental imagery. For example, Vrana and Lang (1990) found that eyeblink startle was increased for recall of fear-eliciting compared to neutral scenes, and that this effect was greater when participants were asked to imagine these scenes as opposed to simply relax or focus on verbal descriptors (Vrana & Lang, 1990). Similarly, scripts describing high arousing compared to low arousing scenes have been shown to elicit reductions in carbon dioxide levels and more rapid inhalation/exhalation associated with hyperventilation (Van Diest et al., 2001). In sum, this work suggests that emotional imagery modulates the peripheral nervous system in a manner similar to that observed during the actual perception of emotional stimuli (Ji, Heyes, MacLeod, & Holmes, 2016). More recent work has used neural measures to assess the impact of emotional mental imagery on the central nervous system.

The perception of emotional stimuli such as scenes and faces has been found to modulate areas of the brain such as the amygdala, medial prefrontal cortex (mPFC), anterior cingulate cortex (ACC), insula and visual cortex (Phan, Wager, Taylor, & Liberzon, 2002; Sabatinelli et al., 2011). Research suggests that some of the same brain areas are activated during imagined emotional stimuli. For example, imagining negative scenes and faces has been shown to activate the insula, amygdala, ACC and mPFC among other regions (Costa, Lang, Sabatinelli, Versace, & Bradley, 2010; Kim et al., 2007; Kosslyn et al., 1996; Schienle, Schäfer, Pignatelli, & Vaitl, 2009; Shin et al., 2000). In addition, recent work has found that imagining threatening scenes activates brain regions associated with the actual experience of threat, including in the ventromedial prefrontal cortex and periaqueductal gray matter (Shuhama et al., 2016). In addition, amygdala activation during imagery has been found to correlate with subjective ratings of arousal, whereas nucleus accumbens and mPFC activation has been found to correlate with ratings of pleasure (Costa, Lang, et al., 2010).

In addition to fMRI and eyeblink startle, event-related potentials (ERPs) such as the late positive potential (LPP) provide an excellent and highly reliable means of measuring neural response to negative stimuli. The LPP is a centro-parietally maximal ERP component that begins approximately 300 ms after stimulus presentation and is larger for emotional compared to neutral stimuli (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Foti, Hajcak, & Dien, 2009; Hajcak, MacNamara, & Olvet, 2010). The vast majority of work to date has used pictorial stimuli to elicit the LPP, though a handful of studies have suggested that it may be possible to elicit an LPP to imagined scenes. For example, work by Suess and

Abdel Rahman (2015) found that emotional modulation of the LPP is possible when participants are cued to imagine faces presented earlier on in the trial (Suess & Abdel Rahman, 2015) - though this effect was observed only when using a parietal-occipital cluster of electrodes (P3, Pz, P4, PO3, POz, PO4), rather than the centro-parietal cluster used to score the LPP elicited by faces themselves (Pz, Cz, C1, C2, CP1, CP2). In addition, larger LPPs were observed when participants were asked to recall arousing versus non-arousing regions of previously presented emotional or neutral scenes (Thiruchselvam, Hajcak, & Gross, 2012) or negative versus neutral autobiographical memories (Speed, Levinson, Gross, Kiosses, & Hajcak, 2017). Finally, when participants were asked to continue imagining emotional and neutral scenes after picture offset, an LPP was observed, lasting 6 seconds beyond the duration of picture presentation (Hajcak & Olvet, 2008). Nonetheless, no study to date has determined whether it is possible to elicit an LPP when participants are asked to *generate* novel emotional imagery.

Negative mental imagery may have particular relevance to the internalizing disorders, and recent work has examined how psychophysiological reactivity to negative imagery differs across an anxiety spectrum. For example, work using startle eyeblink has shown that reactivity to negative imagined scenes varies from most to least across diagnoses of circumscribed fear, such as specific phobia or social anxiety, to disorders of more diffuse distress and anxiety, such as GAD and multiple-trauma PTSD (Lang, McTeague, & Bradley, 2014, 2016). Similar results have also been found within disorders, with startle potentiation to negative imagery *reduced* among participants with *greater* self-reported distress. Results using fMRI have also supported the idea of an anxiety spectrum. That is, work by Costa and colleagues (2010), found that undergraduate participants low in self-reported depression and anxiety showed evidence of increased amygdala activity to negative imagined scenes, whereas those high in depression and anxiety failed to show heightened amygdala activation to negative imagined scenes (Costa, McTeague, Bradley, & Lang, 2010). Similarly, greater self-reported worry has been associated with reduced activation in the insula, ACC and prefrontal cortex when healthy participants were asked to imagine negative scenes (Schienle et al., 2009). Therefore, although somewhat paradoxical, psychophysiological and neural reactivity to negative imagined scenes appears to decrease as self-reported distress increases across an anxiety spectrum.

Among healthy participants, cognitive tendencies such as intolerance of uncertainty (IU) may serve as transdiagnostic risk factors for the development of distress disorders associated with emotional blunting. Intolerance of uncertainty, which refers to self-reported discomfort with ambiguous or uncertain future events, has been associated risk for disorders like GAD and PTSD (Norr et al., 2013; Oglesby, Boffa, Short, Raines, & Schmidt, 2016; Shihata, McEvoy, & Mullan, 2017). Moreover, IU has been shown to mediate associations between neuroticism and symptoms of anxiety and depression (McEvoy & Mahoney, 2012). In prior work examining skin conductance response, IU was found to be associated with reduced discrimination between threatening and safe cues in a fear conditioning and generalization paradigm, over and above other anxiety-related measures (Morriss, Macdonald, & van Reekum, 2016). Similarly, the LPP to fear conditioned and threat generalization stimuli was found to be reduced among participants with higher IU, controlling for trait anxiety (Nelson, Weinberg, Pawluk, Gawlowska, & Proudfit, 2015). Therefore, results suggest that greater IU

might correspond to *blunted* neural responding to negative stimuli and that it might more closely track these effects than more general measures of emotional distress. To-date, no work has tested this hypothesis using negative imagery.

The current study set out to determine a) whether it would be possible to elicit an LPP in response to standardized negative and neutral imagery, in the absence of salient visual stimuli and b) whether an imagery-elicited LPP might covary with self-reported IU. To this end, a group of unselected participants listened to verbal descriptions of negative or neutral scenes and were asked to imagine themselves in each scene, as vividly and realistically as possible. The LPP was assessed during a 20 second window, beginning with the onset of the verbal description and lasting 10 seconds after the offset of the audio description (audio descriptions lasted 10 seconds each). At the end of each trial, participants rated the valence and arousal of each scenario. It was predicted that: imagined negative scenes would be rated as more unpleasant and more arousing than neutral scenes and that the LPP would be larger to negative versus neutral imagined scenes. In addition, it was expected that emotional modulation of the LPP would be smaller among participants with greater self-reported IU, controlling for trait anxiety.

Method

Participants

Participants were 48 undergraduates who completed the experiment for course credit (26 female; age $M = 19.15$, $SD = 3.50$; 83% White [77% Non-hispanic], 6% Asian, 6% Other, 4% Black).

Clinical Measures and Rating Scales

The IUS (short form) is a 12-item that assesses responses to uncertainty, ambiguous situations, and the future (Carleton, Norton, & Asmundson, 2007) and is derived from the original 27-item version (Freeston, Rhéaume, Letarte, Dugas, & Ladouceur, 1994). Participants make their responses using a 5-point Likert scale ranging from 1 (not at all characteristic of me) to 5 (entirely characteristic of me), with higher scores indicating higher IU. Factor analyses (Birrell, Meares, Wilkinson, & Freeston, 2011) have found that total IU is represented by two factors - prospective IU (7 items), which refers to the cognitive discomfort with uncertain future events, whereas inhibitory IU (5 items) refers to behavioral inhibition or avoidance in the face of uncertainty (Carleton et al., 2007). In prior work, prospective and inhibitory IU have been shown to have distinct and opposing relationships with psychophysiological responses (e.g., Jackson, Nelson, & Hajcak, 2016).

The State Trait Anxiety Inventory, trait version (STAI; Spielberger, 1983) is a 20-item measure that assesses ongoing (chronic) anxiety. Responses are made using a Likert-type scale, ranging from 1 (Almost Never) to (Almost Always). Higher scores indicate greater trait anxiety.

The self-assessment manikins (SAM; Bradley & Lang, 1994) are visual analog rating scales that are used for rating valence and arousal, from 1 (least arousing, least pleasant) to 9 (highly arousing, highly pleasant).

Stimuli

Descriptive scenes were drawn from the Affective Norms for English Text (ANET; Bradley & Lang, 2007) and from stimuli created in-house. All scenes were worded so as to facilitate the listener imagining him or herself in the scene (e.g., “While folding laundry, you listen to the radio, which alternates between music and commercials. After you finish folding, you turn off the radio.”). There were 28 negative and 28 neutral scenes; all descriptions were read in a female voice.

Procedure and Imagery Task

After giving their consent to participate in the experiment, participants began by completing the IUS, the STAI trait anxiety measure and a demographic form. Next, they were trained in and performed the imagery task (Figure 1) while continuous EEG was recorded.

There were 4 blocks of 14 trials (2 negative, 2 neutral blocks), block order was randomized across participants. Negative and neutral scenes were randomly assigned to blocks (according to block type) and were not repeated across the experiment. Each trial began with a white fixation cross presented in the center of a black background for 1,000 ms. Next, the white fixation cross was replaced by a yellow fixation cross and participants heard an audio description of a negative or neutral scene through earphones. The audio description lasted approximately 10 seconds; the yellow fixation cross remained onscreen for a total of 20 seconds – i.e., for approximately 10 seconds after the audio description ended. Participants were instructed to imagine themselves in the scene described in the audio recording “as vividly and realistically as possible”. They were instructed to begin imagining the scene as soon as possible, and to continue imagining it for the full duration of the yellow fixation cross (i.e., for 20 seconds after audio description onset). Next participants rated the arousal and valence of the audio description, using 9-point SAM manikins (Bradley & Lang, 1994); participants had 3 seconds to make each of these ratings. After the offset of the SAM manikins, the screen was blank (i.e., black background) for 5,000–5,500 ms, until the beginning of the next trial, which was signaled by the presentation of the white fixation cross displayed on a black background. Participants were told that in between trials, they could relax until the next trial/onset of the white fixation cross. Over the course of 4 practice trials, participants were trained in line with Lang’s recommendations for imagery induction (Lang et al., 1980), which focus on reinforcing participants for responding to the scene as if it were a real perceptual experience. At the end of each practice trial, the research assistant asked participants to describe the scenario they had just heard and to detail how they had imagined it. The experimenter provided positive feedback when participants reported experiencing the scene in a visceral manner (i.e., with all five of their senses), making suggestions as needed.

EEG Recording and Data Reduction

Continuous EEG recordings were collected using an ActiCap and the ActiCHamp amplifier system (Brain Products GmbH, Gilching Germany). Thirty electrode sites were used based on the 10/20 system. The electrooculogram (EOG) was recorded from four facial electrodes: two that were placed approximately 1 cm above and below the right eye, forming a bipolar channel to measure vertical eye movement and blinks and two that were placed

approximately 1 cm beyond the outer edges of each eye, forming a bipolar channel to measure horizontal eye movements. The EEG data were digitized at 24-bit resolution and a sampling rate of 500 Hz.

EEG data was processed offline using Brain Vision Analyzer 2 software (Brain Products GmbH, Gilching Germany). Data were segmented for each trial beginning 200 ms prior to audio description onset and continuing for 20.2 seconds (20 seconds beyond audio onset); baseline correction for each trial was performed using the 200 ms prior to picture onset. The signal from each electrode was re-referenced to the average of the left and right mastoids (TP9/10) and band-pass filtered with high-pass and low-pass filters of 0.01 and 30 Hz, respectively. Eye blink and ocular corrections used the method developed by Miller, Gratton and Yee (1988). Artifact analysis was used to identify a voltage step of more than 50.0 μV between sample points, a voltage difference of 300.0 μV within a trial, and a maximum voltage difference of less than 0.50 μV within 100 ms intervals. Trials were also inspected visually for any remaining artifacts, and data from individual channels containing artifacts were rejected on a trial-to-trial basis.

Based on visual inspection of topographic maps, and in line with prior research (e.g., MacNamara et al., 2013), the LPP was scored by averaging amplitudes at pooling, CP1, CP2 and Pz¹. Grand-average waveforms (Figure 2) suggested that the LPP began around 1,000 ms after audio description onset. Therefore, the LPP was quantified using two equally sized time windows: between 1,000–10,500 ms and 10,500–20,000 ms after audio description onset, in order to assess the LPP elicited both during and after audio descriptions.

Data Analysis

Valence and arousal ratings were compared between conditions using paired t-tests. The LPP was analyzed using a 2 Time (early, late) X Imagery Type (Neutral, Negative) repeated measures ANOVA. To examine the degree to which prospective and inhibitory IU were associated with differential LPPs to negative versus neutral imagery, residual scores were calculated for each participant. Residual scores were used instead of difference scores (i.e., negative minus neutral) because residual scores are more effective at isolating variance unique to a particular condition and are more suited to analyses involving individual differences (Meyer, Lerner, De Los Reyes, Laird, & Hajcak, 2017). To create residual scores, the LPP to neutral imagery was entered as a predictor of the LPP to negative imagery. Unstandardized residuals representing variance unique to negative imagery after controlling for the response to neutral imagery were saved for each participant and from each regression; these residual scores were used in subsequent analyses. After creating residuals, partial correlations were used to examine: a) the association between the LPP and prospective IU, controlling for inhibitory IU and STAI trait anxiety; and b) the association between the LPP and inhibitory IU, controlling for prospective IU and STAI trait anxiety.

¹When examining the voltages for negative minus neutral pictures during the imagery epoch (i.e., 10,500–20,000), the largest/peak positivity was at electrode Pz (5.05 μV), followed by P3 (4.36 μV), CP1 (4.06 μV), CP2 (3.93 μV) and P4 (3.90 μV). When the LPP was scored at a pooling consisting of Pz, P3 and P4, the overall results were unchanged: Time X Imagery Type interaction [$F(1,47) = 20.608, p < .001, \eta_p^2 = .30$]. Follow up tests showed that negative imagery elicited a larger LPP than neutral imagery during the late [$t(47) = 3.13, p = .003, \text{neutral } M = -.45, SD = 7.93; \text{negative } M = 4.09, SD = 7.37$], but not the early time window [$t(47) = .49, p = .63, \text{neutral } M = -.94, SD = 6.70; \text{negative } M = -.45, SD = 5.92$].

Residuals were also created and exploratory partial correlations conducted in the same manner for valence and arousal ratings.

Internal consistency of the LPP, valence and arousal ratings was assessed using even-odd reliability. That is, correlations were assessed between residuals (as described above) created from averages created separately for even and odd trials. The Spearman Brown formula was used to correct these correlations (Nunnally, 1978). Cronbach's alpha was used to assess internal consistency for clinical measures. All analyses were performed using SPSS statistical software version 22.0 (IBM, Armonk, NY).

Results

Ratings

Reliability was very good to excellent for valence ($r = .83$) and arousal ($r = .95$) ratings. Participants rated trials with negative imagery as more arousing [$t(42) = 16.90, p < .001, d = 3.20$, neutral $M = 2.16, SD = 1.01$; negative $M = 6.20, SD = 1.47$] and more unpleasant [$t(43) = 16.13, p < .001, d = 3.78$, neutral $M = 5.32, SD = .77$; negative $M = 2.49, SD = .72$] than trials with neutral imagery.

Late Positive Potential

Reliability for the 10,500–20,000 ms LPP ($r = .56$) was consistent with prior work that used pictorial stimuli (Moran, Jendrusina, & Moser, 2013), although not as good as for the clinical measures or subjective ratings. Figure 2 depicts grand average waveforms for negative and neutral imagery at representative midline sites, as well as scalp distributions showing the difference between negative minus neutral imagery, shown separately for the early and late time windows. Statistical analyses revealed a significant effect of Time, such that the LPP was larger during the late time window [$F(1,47) = 35.39, p < .001, \eta_p^2 = .43$]. However, this was qualified by a Time X Imagery Type interaction [$F(1,47) = 17.61, p < .001, \eta_p^2 = .27$]. Follow up tests showed that negative imagery elicited a larger LPP than neutral imagery during the late [$t(47) = 2.53, p = .01, d = .48$, neutral $M = .10, SD = 9.27$; negative $M = 4.36, SD = 8.51$], but not the early time window [$t(47) = .07, p = .95, d = .01$, neutral $M = -1.38, SD = 7.17$; negative $M = -1.44, SD = 5.73$]; the overall effect of Imagery Type was not significant ($p = .11$).

Individual Differences

Table 1 presents descriptive statistics and bivariate correlations between each of the clinical measures and the LPP. Scores on the clinical measures were in line with those obtained on prior undergraduate samples (e.g., Nelson et al., 2015). As expected, the clinical scales were moderately to highly correlated. Because modulation of the LPP by Imagery Type was only significant in the late time window, partial correlations were only run using unstandardized residuals (see Methods section) for this time window. All scales also showed acceptable to excellent reliability (Table 1).

As is suggested by Figure 3, participants with higher prospective IU showed smaller LPPs to negative compared to neutral imagery in the late time window [$t(44) = -.30, p = .04$],

controlling for inhibitory IU and trait anxiety (STAI trait scores). Figure 4 shows grand-average waveforms and scalp distributions for amplitudes elicited by negative – neutral imagery, shown separately for participants with low prospective IU (left) and high prospective IU (right); median split is for illustrative purposes only. Associations between the LPP and inhibitory IU [$r(44) = .11, p = .48$; controlling for prospective IU and trait anxiety] and between the LPP and trait anxiety [$r(44) = .10, p = .49$; controlling for prospective and inhibitory IU] did not reach significance; the association between the LPP and total IU (controlling for trait anxiety) also did not reach significance [$r(45) = -.20, p = .18$]. Additionally, there were no significant associations between valence or arousal ratings and any of the clinical measures (all $ps > .16$).

Discussion

In prior work, standardized negative imagery has been found to modulate peripheral psychophysiological responses (e.g., startle eyeblink, heart rate) and brain activity assessed using fMRI (e.g., Costa, Lang, et al., 2010; Lang et al., 1980). The current study documents for the first time an LPP elicited by standardized negative imagery in the absence of salient visual cues. Imagined scenes also modulated self-reported valence and arousal, and emotional modulation of the LPP was found to be inversely associated with self-reported prospective IU. Results are informative as to the nature of the LPP; extend prior work conducted in patients (using eyeblink startle) to argue for a continuum of emotional blunting across healthy individuals and suggest that the LPP, as a cost-effective, portable and clinic-friendly measure, may provide an ideal means of assessing neural reactivity to clinically relevant negative imagery.

The vast majority of work assessing the LPP has used pictorial stimuli. Although a handful of studies have examined the LPP in the absence of exteroceptive visual stimuli, these studies have tended to ask participants to continue visualizing pictorial stimuli just after picture offset, or to imagine pictorial stimuli (or portions of pictorial stimuli) presented earlier on in the experiment. Some work has used words instead of pictures to elicit an LPP (Dillon, Cooper, Grent-'t-Jong, Woldoff, & LaBar, 2006), including one study that used keywords as cues for participants' negative or neutral autobiographical memories (Speed et al., 2017). However, in these studies, words remained onscreen while the LPP was elicited. The current study elicited an LPP in the absence of salient visual stimulation (i.e., in the "mind's eye"; Lang et al., 1980). Emotional modulation of the LPP was only evident during the ~10 seconds that followed audio description offset, most likely because participants needed to hear the entire description before they could fully imagine the scene and/or because it may have taken them some time to generate corresponding mental imagery. In a similar vein, prior work using an initially perceptually degraded picture that was revealed in a sequence of steps has found that the content of this picture did not modulate the LPP until participants indicated that the picture was identifiable (Cesarei & Codispoti, 2011). Additionally, in response to pictures that had been phase-scrambled - making the content more difficult to discern - the LPP was delayed until nearly 1000 ms after stimulus onset (Codispoti & De Cesarei, 2013). Therefore, modulation of the LPP may depend on participants' identification of scene content, and to the extent that this process is delayed (e.g., when listening to an audio description of a scene), so too will the LPP.

In addition to having a later onset than the LPP typically elicited by pictorial stimuli, positive amplitudes observed here also had a somewhat more posterior scalp distribution (though scoring the LPP at more posterior sites did not affect results). Other prior work that has investigated imagery cued by visual percepts (e.g., colored squares previously paired with facial stimuli; Suess & Abdel Rahman, 2015), has also revealed an LPP that was maximal somewhat more posteriorly than is typically observed. For instance, Suess & Abdel-Rahman (2015) found a significant effect of emotion when scoring the LPP at posterior sites (P3, Pz, P4, PO3, POz, PO4), but not when scoring it more centroparietally (Pz, Cz, C1, C2, CP1, CP2), where effects of picture type were evident. On the other hand, Speed and colleagues (2017) investigated mental imagery of autobiographical memories cued by idiographic keywords, and found that the LPP was maximal at Pz, Cz, CP1, and CP2 - sites that are not so posterior and resemble those used here (i.e., Pz, CP1, and CP2). Nonetheless, variation in the topography of the LPP and scoring that includes more posterior sites is not uncommon, and does not appear to be specific to imagery-elicited amplitudes (e.g., Dunning & Hajcak, 2009; Ferrari, Codispoti, Cardinale, & Bradley, 2008; Hajcak, MacNamara, Foti, Ferri, & Keil, 2013; Keil et al., 2002).

Although differences were observed between the parietal positivity elicited in the current study and that elicited by stimulus percepts in other studies - e.g., later onset, more parieto-occipital distribution - there appear to be more commonalities than dissimilarities. To further investigate similarities and differences between the imagery-elicited and picture-elicited LPP, source localization or fMRI work may be helpful. In research that has examined mental imagery using fMRI alone, imagery has been found to involve activation of the visual cortex, just as with actual visual percepts (Dijkstra, Bosch, & van Gerven, 2017)². Nonetheless, other fMRI work has emphasized distinctions between the brain regions involved in the perception of visual stimuli and imagery (e.g., Amedi, Malach, & Pascual-Leone, 2005). Going forward, it may be useful to collect both EEG and fMRI data in the same participants, to investigate brain regions involved in generation of the imagery-elicited LPP and the extent to which these overlap with the picture-elicited LPP.

Reliability of the LPP observed here was in line with what has been observed in prior work using pictorial stimuli (Moran et al., 2013), though it was lower than for the clinical measures. Future might seek to improve the psychometrics of the LPP and other psychophysiological measures. For instance, perhaps tasks used to elicit these measures could be refined by subjecting them to some of the same procedures used in scale development (e.g., identification of a set of highly reliable set of stimuli/"items") and thresholds could continue to be established for improved reliability using different tasks (e.g., number of artifact-free trials per condition needed; Moran et al., 2013). Ongoing attention to reliability (including test-retest, not assessed here) will be necessary if the LPP is to be used in a clinical context in the future (Hajcak, Meyer, & Kotov, 2017).

²Interestingly, a prevailing mechanistic account of the LPP suggests that the LPP might reflect enhanced processing in the visual cortex that is sustained via re-entrant projections from the amygdala (Keil et al., 2009; Sabatinelli, Lang, Keil, & Bradley, 2007), though the LPP has also been shown to involve a number of other contributing brain regions, including the amygdala, insula, temporal cortex, posterior parietal cortex and orbitofrontal cortex (Liu, Huang, McGinnis-Deweese, Keil, & Ding, 2012; Sabatinelli, Keil, Frank, & Lang, 2013).

Avoidance of negative imagery may contribute to the development and maintenance of internalizing psychopathology. For example, experiential avoidance – i.e., the tendency to avoid experiences that might arouse unpleasant emotions – is known to promote negative affect and worry (Hayes, Wilson, Gifford, Follette, & Strosahl, 1996) and is associated with anxiety symptom severity, even after accounting for age, depression and gender (Dugas et al., 2007). In prior work, IU, which predisposes individuals to the development of internalizing disorders, has been closely related to self-reported experiential avoidance (Lee, Orsillo, Roemer, & Allen, 2010). Here, prospective IU was represented phenotypically by blunted electrocortical responding to negative imagery. Though the mechanism behind emotional blunting is unclear, possibilities include avoidance or neuroplastic changes leading to damaged or “broken” defensive responding (Avgustinovich, Kovalenko, & Kudryavtseva, 2005).

The results observed here fit with prior work showing that prospective IU was associated with a reduced LPP to conditioned fear stimuli (Nelson et al., 2015) and that GAD, which is associated with high IU, may be characterized by a reduced LPP to aversive pictures (Weinberg & Hajcak, 2011). Of note, our results were observed specifically for prospective (not inhibitory) IU, in line with prior work (Nelson et al., 2015) and suggesting that cognitive rather than behavioral factors may underlie blunted responding to negative imagery. In addition, results observed here were found specifically when controlling for inhibitory IU and trait anxiety. That is to say, when they were not included in the model, inhibitory IU and trait anxiety appeared to suppress the association between prospective IU and the LPP – i.e., results did not quite reach significance (Watson, Clark, Chmielewski, & Kotov, 2013). Given that trait anxiety assesses a relatively broad tendency (i.e., a propensity towards negative affect in general), its addition to the model may have helped control non-specific variance in prospective IU, boosting the association between prospective IU and the LPP (Horst, 1941). It is worth noting, however, that in the startle literature, trait anxiety *has* been associated with blunted eyeblink startle to negative stimuli in a patient sample (Lang et al., 2016; McTeague & Lang, 2012). Therefore, although in a broad sense a similarity is observed between the current results and the eyeblink startle literature, further work is needed to understand differences in these results and how blunted responding may vary across different psychophysiological or neural levels of analysis, which should not be assumed equivalents. In sum, reduced electrocortical processing of negative imagery appears to track cognitive risk for anxiety across an unselected sample and might provide a useful means of identifying individuals who do not yet endorse symptoms or affective blunting on a subjective level.

Self-reported ratings of valence and arousal at the end of each trial confirmed that negative imagined scenes were experienced as more unpleasant and more arousing than neutral imagined scenes across participants. IU was not associated with ratings, suggesting that the LPP may provide a more sensitive measure of risk for internalizing disorders, possibly because subjective ratings require an individual to be aware of his or her affective response, whereas the LPP does not (Thiruchselvam et al., 2012). Behavioral therapies, which necessitate emotional engagement and arousal in order to facilitate extinction, often rely on subjective reports of arousal during exposure to conditioned (i.e., fear-eliciting) stimuli. It is unclear whether ERP measures of emotional engagement during negative imagery might

provide a useful means of monitoring treatment progress, though some work suggests they might (Wangelin & Tuerk, 2015).

Having established that the LPP can be used to measure the sustained processing of standardized negative imagery in the absence of salient visual cues, the current results lay the groundwork for future investigations aimed at modulating this response, or examining how it may go awry in disorders like anxiety and depression. For example, future work might wish to determine whether the LPP elicited by negative imagery varies along a continuum among patients. Additionally, given its cost-effectiveness, portability and ease of administration, the LPP to imagined scenes might provide a useful way of assessing readiness for exposure-based therapies, or predicting treatment outcome more generally.

Acknowledgments

Annamarie MacNamara is supported by National Institute of Mental Health grant, K23MH105553. The author thanks Gina Thomas and Blake Barley for their assistance with the study.

References

- Amedi A, Malach R, Pascual-Leone A. Negative BOLD differentiates visual imagery and perception. *Neuron*. 2005; 48(5):859–872. <https://doi.org/10.1016/j.neuron.2005.10.032>. [PubMed: 16337922]
- Avgustinovich DF, Kovalenko IL, Kudryavtseva NN. A model of anxious depression: persistence of behavioral pathology. *Neuroscience and Behavioral Physiology*. 2005; 35:917–924. <http://doi.org/10.1007/s11055-005-0146-6>. [PubMed: 16270173]
- Birrell J, Meares K, Wilkinson A, Freeston M. Toward a definition of intolerance of uncertainty: a review of factor analytical studies of the Intolerance of Uncertainty Scale. *Clinical Psychology Review*. 2011; 31(7):1198–1208. <https://doi.org/10.1016/j.cpr.2011.07.009>. [PubMed: 21871853]
- Bradley MM, Lang PJ. Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*. 1994; 25(1):49–59. [https://doi.org/10.1016/0005-7916\(94\)90063-9](https://doi.org/10.1016/0005-7916(94)90063-9). [PubMed: 7962581]
- Bradley, MM., Lang, PJ. Tech Rep No D-1. University of Florida; Gainesville, FL: 2007. Affective Norms for English Text (ANET): Affective ratings of text and instruction manual.
- Carleton RN, Norton MAPI, Asmundson GJG. Fearing the unknown: a short version of the Intolerance of Uncertainty Scale. *Journal of Anxiety Disorders*. 2007; 21(1):105–117. <https://doi.org/10.1016/j.janxdis.2006.03.014>. [PubMed: 16647833]
- Cesarei AD, Codispoti M. Scene Identification and Emotional Response: Which Spatial Frequencies Are Critical? *Journal of Neuroscience*. 2011; 31(47):17052–17057. <https://doi.org/10.1523/JNEUROSCI.3745-11.2011>. [PubMed: 22114274]
- Codispoti M, De Cesarei A. Time will Tell: Emotional Responses to Phase Scrambled Natural Scenes. *Psychophysiology*. 2013; 50(S23) <https://doi.org/10.1111/psyp.12120>.
- Costa VD, Lang PJ, Sabatinelli D, Versace F, Bradley MM. Emotional imagery: assessing pleasure and arousal in the brain's reward circuitry. *Human Brain Mapping*. 2010; 31:1446–1457. <https://doi.org/10.1002/hbm.20948>. [PubMed: 20127869]
- Costa VD, McTeague LM, Bradley MM, Lang PJ. Timing of hedonic discrimination in mesolimbic reward centers. *Psychophysiology*. 2010; 47(Suppl 1):S29. <https://doi.org/10.1111/j.1469-8986.2010.01111.x>.
- Cuthbert BN, Schupp HT, Bradley MM, Birbaumer N, Lang PJ. Brain potentials in affective picture processing: Covariation with autonomic arousal and affective report. *Biological Psychology*. 2000; 52:95–111. [https://doi.org/10.1016/S0301-0511\(99\)00044-7](https://doi.org/10.1016/S0301-0511(99)00044-7). [PubMed: 10699350]
- Dijkstra N, Bosch SE, van Gerven MAJ. Vividness of Visual Imagery Depends on the Neural Overlap with Perception in Visual Areas. *The Journal of Neuroscience: The Official Journal of the Society*

for Neuroscience. 2017; 37(5):1367–1373. <https://doi.org/10.1523/JNEUROSCI.3022-16.2016>. [PubMed: 28073940]

- Dillon DG, Cooper JJ, Grent-‘t-Jong T, Woldoff MG, LaBar KS. Dissociation of event-related potentials indexing arousal and semantic cohesion during emotional word encoding. *Brain and Cognition*. 2006; 62:43–57. <https://doi.org/10.1016/j.bandc.2006.03.008>. [PubMed: 16678953]
- Dugas MJ, Savard P, Gaudet A, Turcotte J, Laugesen N, Robichaud M, ... Koerner N. Can the components of a cognitive model predict the severity of generalized anxiety disorder? *Behavior Therapy*. 2007; 38(2):169–178. <https://doi.org/10.1016/j.beth.2006.07.002>. [PubMed: 17499083]
- Dunning JP, Hajcak G. See No Evil: Directing Visual Attention Within Unpleasant Images Modulates the Electrocortical Response. *Psychophysiology*. 2009; 46:28–33. <https://doi.org/10.1111/j.1469-8986.2008.00723.x>. [PubMed: 18992071]
- Ferrari V, Codispoti M, Cardinale R, Bradley MM. Directed and motivated attention during processing of natural scenes. *Journal of Cognitive Neuroscience*. 2008; 20:1753–1761. <https://doi.org/10.1162/jocn.2008.20121>. [PubMed: 18370595]
- Foti D, Hajcak G, Dien J. Differentiating neural responses to emotional pictures: Evidence from temporal-spatial PCA. *Psychophysiology*. 2009; 46:521–530. <https://doi.org/10.1111/j.1469-8986.2009.00796.x>. [PubMed: 19496228]
- Freeston MH, Rhéaume J, Letarte H, Dugas MJ, Ladouceur R. Why do people worry? *Personality and Individual Differences*. 1994; 17(6):791–802. [https://doi.org/10.1016/0191-8869\(94\)90048-5](https://doi.org/10.1016/0191-8869(94)90048-5).
- Hajcak G, MacNamara A, Foti D, Ferri J, Keil A. The dynamic allocation of attention to emotion: Simultaneous and independent evidence from the late positive potential and steady state visual evoked potentials. *Biological Psychology*. 2013; 92:447–455. <https://doi.org/10.1016/j.biopsycho.2011.11.012>. [PubMed: 22155660]
- Hajcak G, MacNamara A, Olvet DM. Event-related potentials, emotion, and emotion regulation: An Integrative Review. *Developmental Neuropsychology*. 2010; 35:129–155. <https://doi.org/10.1080/87565640903526504>. [PubMed: 20390599]
- Hajcak, G., Meyer, A., Kotov, R. Psychometrics and the Neuroscience of Individual Differences: Internal Consistency Limits Between-Subjects Effects. *Journal of Abnormal Psychology*. 2017. <https://doi.org/10.1037/abn0000274>
- Hajcak G, Olvet DM. The persistence of attention to emotion: Brain potentials during and after picture presentation. *Emotion*. 2008; 8:250–255. <https://doi.org/10.1037/1528-3542.8.2.250>. [PubMed: 18410198]
- Hayes SC, Wilson KG, Gifford EV, Follette VM, Strosahl K. Experiential avoidance and behavioral disorders: a functional dimensional approach to diagnosis and treatment. *Journal of Consulting and Clinical Psychology*. 1996; 64(6):1152–1168. <https://doi.org/10.1037/0022-006X.64.6.1152>. [PubMed: 8991302]
- Horst P. The role of predictor variables which are independent of the criterion. *Social Science Research Council*. 1941; 48(4):431–436.
- Jackson F, Nelson BD, Hajcak G. The uncertainty of errors: Intolerance of uncertainty is associated with error-related brain activity. *Biological Psychology*. 2016; 113:52–58. <https://doi.org/10.1016/j.biopsycho.2015.11.007>. [PubMed: 26607441]
- Ji JL, Heyes SB, MacLeod C, Holmes EA. Emotional Mental Imagery as Simulation of Reality: Fear and Beyond—A Tribute to Peter Lang. *Behavior Therapy*. 2016; 47(5):702–719. <https://doi.org/10.1016/j.beth.2015.11.004>. [PubMed: 27816082]
- Keil A, Bradley MM, Hauk O, Rockstroh B, Elbert T, Lang PJ. Large-scale neural correlates of affective picture processing. *Psychophysiology*. 2002; 39:641–649. <https://doi.org/10.1111/1469-8986.3950641>. [PubMed: 12236331]
- Keil A, Sabatinelli D, Ding M, Lang PJ, Ihssen N, Heim S. Re-entrant projections modulate visual cortex in affective perception: evidence from Granger causality analysis. *Hum Brain Mapp*. 2009; 30:532–40. <https://doi.org/10.1002/hbm.20521>. [PubMed: 18095279]
- Kim SE, Kim JW, Kim JJ, Jeong BS, Choi EA, Jeong YG, ... Ki SW. The neural mechanism of imagining facial affective expression. *Brain Research*. 2007; 1145:128–137. <https://doi.org/10.1016/j.brainres.2006.12.048>. [PubMed: 17359942]

- Kosslyn SM, Shin LM, Thompson WL, McNally RJ, Rauch SL, Pitman RK, Alpert NM. Neural effects of visualizing and perceiving aversive stimuli: a PET investigation. *Neuroreport*. 1996; 7(10):1569–1576. <https://doi.org/10.1097/00001756-199607080-00007>. [PubMed: 8904757]
- Lang PJ, Kozak MJ, Miller GA, Levin DN, McLean A. Emotional Imagery: Conceptual Structure and Pattern of Somato-Visceral Response. *Psychophysiology*. 1980; 17(2):179–192. <https://doi.org/10.1111/j.1469-8986.1980.tb00133.x>. [PubMed: 7375619]
- Lang PJ, McTeague LM, Bradley MM. Pathological anxiety and function/dysfunction in the brain's fear/defense circuitry. *Restorative Neurology and Neuroscience*. 2014; 32:63–77. <https://doi.org/10.3233/rnn-139012>. [PubMed: 23777635]
- Lang PJ, McTeague LM, Bradley MM. RDoC, DSM, and the reflex physiology of fear: A biodimensional analysis of the anxiety disorders spectrum. *Psychophysiology*. 2016; 53(3):336–347. <https://doi.org/10.1111/psyp.12462>. [PubMed: 26877123]
- Lee JK, Orsillo SM, Roemer L, Allen LB. Distress and avoidance in generalized anxiety disorder: exploring the relationships with intolerance of uncertainty and worry. *Cognitive Behaviour Therapy*. 2010; 39(2):126–136. <https://doi.org/10.1080/16506070902966918>. [PubMed: 19714542]
- Liu Y, Huang H, McGinnis-Deweese M, Keil A, Ding M. Neural Substrate of the Late Positive Potential in Emotional Processing. *The Journal of Neuroscience*. 2012; 32:14563–14572. <https://doi.org/10.1523/JNEUROSCI.3109-12.2012>. [PubMed: 23077042]
- McEvoy PM, Mahoney AEJ. To be sure, to be sure: intolerance of uncertainty mediates symptoms of various anxiety disorders and depression. *Behavior Therapy*. 2012; 43(3):533–545. <https://doi.org/10.1016/j.beth.2011.02.007>. [PubMed: 22697442]
- McTeague LM, Lang PJ. The anxiety spectrum and the reflex physiology of defense: from circumscribed fear to broad distress. *Depression and Anxiety*. 2012; 29:264–281. <https://doi.org/10.1002/da.21891>. [PubMed: 22511362]
- Meyer A, Lerner MD, De Los Reyes A, Laird RD, Hajcak G. Considering ERP difference scores as individual difference measures: Issues with subtraction and alternative approaches. *Psychophysiology*. 2017; 54(1):114–122. <https://doi.org/10.1111/psyp.12664>. [PubMed: 28000251]
- Moran TP, Jendrusina AA, Moser JS. The psychometric properties of the late positive potential during emotion processing and regulation. *Brain Research*. 2013; 1516:66–75. <https://doi.org/10.1016/j.brainres.2013.04.018>. [PubMed: 23603408]
- Morriss J, Macdonald B, van Reekum CM. What Is Going On Around Here? Intolerance of Uncertainty Predicts Threat Generalization. *PloS One*. 2016; 11(5):e0154494. <https://doi.org/10.1371/journal.pone.0154494>. [PubMed: 27167217]
- Nelson BD, Weinberg A, Pawluk J, Gawlowska M, Proudfit GH. An Event-Related Potential Investigation of Fear Generalization and Intolerance of Uncertainty. *Behavior Therapy*. 2015; 46(5):661–670. <https://doi.org/10.1016/j.beth.2014.09.010>. [PubMed: 26459846]
- Norr AM, Oglesby ME, Capron DW, Raines AM, Korte KJ, Schmidt NB. Evaluating the unique contribution of intolerance of uncertainty relative to other cognitive vulnerability factors in anxiety psychopathology. *Journal of Affective Disorders*. 2013; 151(1):136–142. <https://doi.org/10.1016/j.jad.2013.05.063>. [PubMed: 23778202]
- Nunnally, JC. *Psychometric theory*. McGraw-Hill; 1978.
- Oglesby ME, Boffa JW, Short NA, Raines AM, Schmidt NB. Intolerance of uncertainty as a predictor of post-traumatic stress symptoms following a traumatic event. *Journal of Anxiety Disorders*. 2016; 41:82–87. <https://doi.org/10.1016/j.janxdis.2016.01.005>. [PubMed: 26803928]
- Phan KL, Wager T, Taylor SF, Liberzon I. Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. *Neuroimage*. 2002; 16:331–348. <https://doi.org/10.1006/nimg.2002.1087>. [PubMed: 12030820]
- Sabatinielli D, Fortune EE, Li Q, Siddiqui A, Krafft C, Oliver WT, ... Jeffries J. Emotional perception: Meta-analyses of face and natural scene processing. *NeuroImage*. 2011; 54(3):2524–2533. <https://doi.org/10.1016/j.neuroimage.2010.10.011>. [PubMed: 20951215]

- Sabatinelli D, Keil A, Frank DW, Lang PJ. Emotional perception: correspondence of early and late event-related potentials with cortical and subcortical functional MRI. *Biological Psychology*. 2013; 92(3):513–519. <https://doi.org/10.1016/j.biopsycho.2012.04.005>. [PubMed: 22560889]
- Sabatinelli D, Lang PJ, Keil A, Bradley MM. Emotional Perception: Correlation of Functional MRI and Event-Related Potentials. *Cerebral Cortex*. 2007; 17(5):1085–1091. <https://doi.org/10.1093/cercor/bhl017>. [PubMed: 16769742]
- Schienze A, Schäfer A, Pignatelli R, Vaitl D. Worry tendencies predict brain activation during aversive imagery. *Neuroscience Letters*. 2009; 461:289–292. <https://doi.org/10.1016/j.neulet.2009.06.041>. [PubMed: 19545612]
- Shihata S, McEvoy PM, Mullan BA. Pathways from uncertainty to anxiety: An evaluation of a hierarchical model of trait and disorder-specific intolerance of uncertainty on anxiety disorder symptoms. *Journal of Anxiety Disorders*. 2017; 45:72–79. <https://doi.org/10.1016/j.janxdis.2016.12.001>. [PubMed: 27984787]
- Shin LM, Dougherty DD, Orr SP, Pitman RK, Lasko M, Macklin ML, ... Rauch SL. Activation of anterior paralimbic structures during guilt-related script-driven imagery. *Biological Psychiatry*. 2000; 48(1):43–50. [https://doi.org/10.1016/S0006-3223\(00\)00251-1](https://doi.org/10.1016/S0006-3223(00)00251-1). [PubMed: 10913506]
- Shuhama R, Rondoni C, de Araujo DB, de Freitas Caetano G, Dos Santos AC, Graeff FG, Del-Ben CM. Behavioral and neuroimaging responses induced by mental imagery of threatening scenarios. *Behavioural Brain Research*. 2016; 313:358–369. <https://doi.org/10.1016/j.bbr.2016.06.059>. [PubMed: 27452804]
- Speed, BC., Levinson, AR., Gross, JJ., Kiosses, DN., Hajcak, G. Emotion regulation to idiographic stimuli: Testing the Autobiographical Emotion Regulation Task. *Neuropsychologia*. 2017. <https://doi.org/10.1016/j.neuropsychologia.2017.04.032>
- Spielberger, CD. Manual for the State-Trait Anxiety Inventory. Consulting Psychologist Press; 1983.
- Suess F, Abdel Rahman R. Mental imagery of emotions: Electrophysiological evidence. *NeuroImage*. 2015; 114:147–157. <https://doi.org/10.1016/j.neuroimage.2015.03.063>. [PubMed: 25842292]
- Thiruchselvam R, Hajcak G, Gross JJ. Looking inward: shifting attention within working memory representations alters emotional responses. *Psychological Science*. 2012; 23(12):1461–1466. <https://doi.org/10.1177/0956797612449838>. [PubMed: 23137969]
- Van Diest I, Winters W, Devriese S, Vercamst E, Han JN, Van de Woestijne KP, Van den Bergh O. Hyperventilation beyond fight/flight: respiratory responses during emotional imagery. *Psychophysiology*. 2001; 38(6):961–968. <http://doi.org/10.1111/1469-8986.3860961>. [PubMed: 12240672]
- Vrana SR, Lang PJ. Fear imagery and the startle-probe reflex. *Journal of Abnormal Psychology*. 1990; 99(2):189–197. <https://doi.org/10.1037/0021-843X.99.2.189>. [PubMed: 2348014]
- Wangelin BC, Tuerk PW. Taking the pulse of prolonged exposure therapy: physiological reactivity to trauma imagery as an objective measure of treatment response. *Depression and Anxiety*. 2015; 32(12):927–934. <https://doi.org/10.1002/da.22449>. [PubMed: 26522237]
- Watson D, Clark LA, Chmielewski M, Kotov R. The Value of Suppressor Effects in Explicating the Construct Validity of Symptom Measures. *Psychological Assessment*. 2013; 25(3):929–941. <https://doi.org/10.1037/a0032781>. [PubMed: 23795886]
- Weinberg A, Hajcak G. Electrocardiac evidence for vigilance-avoidance in Generalized Anxiety Disorder. *Psychophysiology*. 2011; 48:842–851. <https://doi.org/10.1111/j.1469-8986.2010.01149.x>. [PubMed: 21073479]

Figure 1.

Each trial began with the presentation of a white fixation cross on a black background for 1,000 ms. Next, the white fixation cross was replaced with a yellow fixation cross, and an audio description of a negative or neutral scenario (~10 seconds) was played through earphones. Participants were instructed to imagine the scene as vividly and realistically as possible as soon as they were able, continuing after audio offset until the fixation cross disappeared from the screen (at 20 seconds). At the end of the trial, participants rated the valence and arousal of the scene.

Figure 2.

Grand-average waveforms at representative midline sites across the scalp (from top to bottom: Fz, Cz, Pz, Oz) as well as scalp distributions of the negative minus neutral difference, shown separately for the 1,000–10,500 ms window (left) and the 10,500–20,000 ms window (right). Audio descriptions onset at 0 ms and lasted for approximately 10 seconds.

Figure 3. Scatterplot depicting the association between the LPP elicited by negative imagery (controlling for the LPP to neutral imagery) and prospective IU (controlling for inhibitory IU and trait anxiety).

Figure 4. Grand-average waveforms at the centro-parietal pooling where the LPP was scored, and scalp distributions of the negative minus neutral difference, for the early (1,000–10,500 ms) and late (10,500–20,000 ms) windows, shown separately for participants with low prospective IU (left) and high prospective IU (right). Median split for illustrative purposes only.

Table 1

Correlations and descriptive statistics.

	1	2	3	4	5
1. Prospective IU					-.24
2. Inhibitory IU		.62*	.91*	.52*	-.03
3. Total IU			.89*	.57*	-.16
4. STAI Trait				.60*	.00
5. LPP (Unstd. Resid.)					
<i>M (SD)</i>	19.19 (4.54)	10.81 (4.14)	30.00 (7.81)	44.79 (10.18)	
<i>Cronbach's α</i>	.72	.86	.85	.92	

* $p < .001$; reliability for the LPP was assessed using even-odd reliability (see Results).