

EMOTION AND IMAGERY:
A PSYCHOPHYSIOLOGICAL ANALYSIS
OF IMAGERY ABILITY AND NARRATIVE ENGAGEMENT

By

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To my parents, Kevin and Patricia McTeague

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Abstract of Dissertation Presented to the Graduate School
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By

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Lang (1979) proposed that emotional imagery involves the mobilization of physiological systems involved in actual experience and as such, despite the difficulties imposed by the inherent subjectivity of mental events, could be reliably indexed as the physiological output associated with imagination. The validity of this premise has been consistently demonstrated in the emotional modulation of physiological systems indicative of: affective communication through facial action (facial EMG), autonomic mobilization (heart rate and skin conductance), and action readiness (startle responses). Study 1 of this investigation aimed to address whether a measure utilized in other paradigms to index attention allocation (probe P300) could viably reflect differences in attentional engagement during narrative imagery. While replicating and extending findings from previous studies on the modulation of facial EMG, autonomic measures, and reflexes as a function of pleasantness and arousal, probe P300 responses reliably varied with emotional arousal, suggesting that narrative imagery is a potent affective foreground that grabs natural selective attention and prioritizes the processing of the motivationally significant image at the expense of the intruding probe.

Study 2 of this investigation examined whether ability to achieve vivid, mental imagery is a crucial individual difference that should be accounted for in efforts to delineate the foundations and processes of emotional imagery. Betts (1909) defined imagery ability in terms of the subjective experience of images conjured in different sensory modalities and accordingly devised the Questionnaire Upon Mental Imagery (QMI). Previous evidence on the association of the QMI and physiological reactivity during imagery is equivocal. To address whether physiological outcomes would improve the predictive validity of Betts' conceptualization of imagery ability and hence capture important variance in affective modulation during narrative imagery, a series of text prompts were adapted from the QMI to be presented as "sensorimotor" imagery prompts in the context of an experimental physiological procedure—a kind of "psychophysiological" QMI. Neither self-reported imagery ability as assessed on the QMI or in the context of the physiological paradigm was systematically related to reactivity during narrative imagery. Findings are discussed in terms of potential alternative sources of variation in responding, highlighting individual differences in fearfulness and anxiety.

CHAPTER 1 INTRODUCTION

From the perspective of natural science, human emotions include three measurable response classes: verbal reports of experience, overt actions, and associated physiological mobilization. Several theorists have suggested (Bradley, 2000; Dickinson & Dearing, 1979; Konorski, 1967) that primitive survival reflexes are the foundation for emotion's physiological mobilization and action. That is, humans and other animals approach pleasant things that sustain life (appetitive motivation) and fight or flee in the face of threats to their continued existence (defensive motivation). Humans, however, seldom react as directly as do less complex species. With the development of the cerebral cortex, emerged a greater capacity for inhibition and delay, and for assessing alternatives and outcomes. Nevertheless, the primitive reactance is yet adumbrated in muscles and glands, supported by neural circuits deep within the brain and widely shared among species. For this reason, emotions (fear and anger; joy and desire) are action dispositions (Frijda, 1986; Lang, Bradley, & Cuthbert, 1997) and as such are often most evident when we are overtly passive, but mobilized somatically and autonomically for actions that may never actually take place.

Mental Imagery in Clinical Fear and Anxiety

One of the conditions in which this is evident is mental imagery of human experience, and thus, has been used extensively in treatment to reinstate clinically-relevant emotional experiences (e.g., counter-conditioning, extinction). Emotional imagery, in fact, is an essential component in conventional behavioral methodologies implemented to treat the entire anxiety spectrum (e.g., specific phobia (Craske, Antony, & Barlow, 2006), posttraumatic stress disorder (Foa, Hembree, & Rothbaum, 2007), generalized anxiety disorder (Zinbarg, Craske, & Barlow, 2006)). Lang, Melamed, & Hart (1970) demonstrated the physiological activation inherent during clinically-

pertinent image processing by recording a desensitization intervention implemented in two samples of phobics. The authors found in the first experiment that fearful imagery evoked elevated autonomic arousal that reduced with repeated processing. Furthermore, participants who showed greater autonomic mobilization to fear scenes also showed greater reduction over the course of the intervention and ultimately indicated more subjective desensitization. In a follow-up study the authors discovered that the fear hierarchies developed with each participant for desensitization, yielded autonomic gradients that varied with subjective fearfulness and imagery vividness. Essentially phobics showed increased autonomic reactivity coincident with verbal report of fear and image clarity and furthermore those individuals demonstrating the most correspondence between verbal evaluation and efferent physiology experienced the greatest therapeutic gains. Taken, together these data suggest that physiological reactivity during emotional imagery provides useful information for delineating the phenomenology of fear and anxiety, importantly including enhanced diagnostic and prognostic impressions. The current investigation is an effort to further develop imagery-based experimental procedures intended for translation to the clinical environment, focusing on both expanding the breadth of physiological measurement and emotional content processed as well as considering the role of imagery vividness in reactivity.

Bioinformational Model of Emotion

Relying on a propositional network model, Lang (1979) posited that emotions result from the activation of associated neural networks, which code information according to both sensory and semantic properties. Deviating from earlier models that focused on sensory intake, Lang additionally emphasized the role of relevant response units in the distributed structure and function of an emotional network. These response units code for outcomes such as overt behavior, efferent physiology, and emotional language, including both expressive and evaluative

responses (Lang, Cuthbert, & Bradley, 1998). This theory implies that the parameters of input stimulation will necessarily influence the degree of activation of select network units, the spread of activation across multiple nodes or units, and ultimately, determine the strength of the response. Additional predictive parameters are the specific demands of the eliciting context, which may limit the behavioral repertoire (e.g., escape, avoidance, freezing). In summary, an emotional episode is determined by cues that activate stimulus, meaning, and response representations in memory and the consequent output as demonstrated in behavior, physiology, and language.

Imagery as a Window to Emotional Experience

Lang (1977) suggested that emotional imagery might be a mental phenomenon that would allow a window for systematic investigation into affective action dispositions. Lang's conceptualization makes the distinction that simply tapping into one modality such as imagining a motor movement (e.g., Neuper & Pfurtscheller, 2001) or imagining a sensory percept (e.g., Kosslyn, Ganis, & Thompson, 2001) is insufficient for emotional experience. Rather, emotional imagery involves the convergence of the neural networks and physiology involved in an actual emotional experience (i.e., sensory experience, physiological changes, semantic appraisals, behavioral dispositions).

Although psychophysiological research on imagery has a long history (Jacobson, 1931) involving many investigators, the most sustained research program has been carried forward by Lang and colleagues, endeavoring to test the bioinformational and biphasic models of emotion (e.g., Cuthbert et al., 2003; Lang, Levin, Miller, & Kozak, 1983; Miller et al., 1987; Vrana & Lang, 1990; Weerts & Lang, 1978). Over the course of three decades, emotional imagery has been utilized to characterize the contributions of varied physiological systems to affective profiles in community and college sample controls as well as anxiety and mood disorder patients.

For a single trial in the typical imagery design, a participant memorizes or listens to an emotional or neutral scene described with a combination of stimulus, meaning, and response elements (e.g., “The large snake darts forward, fangs protruding, striking my leg in a flash of pain”). Then following a tone cue, the participant imagines being personally involved in the ongoing scene until an additional tone signals the offset of imagery. In accordance with the bioinformational model, the differences in efferent physiology to fearful versus neutral imagery are accentuated when physiological response properties (e.g., “your heart pounded”) are included in imagery text prompts focusing on stimulus properties (Lang, Kozak, Miller, Levin, & McLean, 1980; Miller et al., 1987). Prompts depicting scenes of higher arousal, either through inclusion of robust response properties, exciting contextual descriptions, and/or intense perceptual experiences, have reliably shown enhanced affective recruitment (e.g., Cuthbert et al., 2003).

Emotional Imagery and Physiological Reactivity

The extent of affective motivation during emotional imagery has been shown to activate facial muscles involved in affect communication (e.g., corrugator, zygomatic, and orbicularis EMG); to mobilize the autonomic nervous system (e.g., heart rate, skin conductance); and to ready the somatic system for action (e.g., potentiation of the startle reflex). The imagery experiments presented here assess all of these aspects of emotion activation. The following is a brief review of previous research that examined these changes in physiological reactivity during emotional processing.

Affect communication through facial action

Corrugator supercilii. The corrugator supercilii muscles are responsible for contraction of the eyebrows, and when the motor response is large enough, produce an identifiable frown (Tassinari & Cacioppo, 2000). Corrugator EMG activity varies linearly with hedonic valence, with the largest responses elicited during unpleasant imagining, intermediate tension during

neutral and the least activity for pleasant imagery. In fact, the corrugator muscle often shows relaxation below baseline during pleasant processing (Lang, Greenwald, Bradley, & Hamm, 1993; Larsen, Norris & Cacioppo, 2003; McTeague, Bradley, & Lang, 2002; McTeague, Dimoulas, Strauss, Bradley, & Lang, 2003).

Zygomatic major. The zygomaticus major muscles pull the corners of the mouth into a smile (Larsen et al., 2003) and are most active during highly pleasant processing (e.g., pictures or imagery of nurturance or food). Interestingly, the most highly pleasant stimuli (e.g., cuddling babies) are not the most arousing (erotica) and, hence, zygomatic EMG change covaries more closely with valence than arousal. Zygomatic EMG change also emerges during highly unpleasant stimuli such as mutilations and contamination, often associated with subjective reactions of disgust.

Orbicularis oculi. The orbicularis oculi muscles are responsible for the blink response to abrupt startle probes. Additionally continuous measurement of the muscle throughout the imagery period has shown strong, sustained linear covariation with arousal in that neutral scenes elicit the least change from baseline, followed by low and then high arousal scenes irrespective of valence (Bradley, Cuthbert, & Lang, 1995; McTeague et al., 2006).

Autonomic mobilization

Heart rate. Changes in heart rate can reflect activation in either the parasympathetic or sympathetic nervous systems (e.g., Brownley, Hurwitz, & Schneiderman, 2000). During a six second picture-processing period, a triphasic waveform results with an initial deceleration, then acceleration, and secondary deceleration. Averaged cardiac waveforms show relative deceleration for unpleasant pictures and a relative acceleration for pleasant pictures (Hamm, Greenwald, Bradley, & Lang, 1993). In contrast, heart rate activity during imagery has consistently shown acceleration (vagal release and sympathetic activation) during both pleasant

and unpleasant imagining relative to neutral with greater acceleration during scenes rated higher in arousal (e.g., Cook, Hawk, Davis, & Stevenson, 1991; Patrick, Cuthbert, & Lang, 1994; Witvliet & Vrana, 2000). For example, imagery of sports victory and attacking animals reliably prompt heart rate acceleration (e.g., Bradley et al., 1995; McTeague et al., 2002). Emphasizing the action-oriented process of narrative imagery, Lang (1977, 1979) suggested that the relative heart rate acceleration during imagery might be due to the activation of a perceptual-motor memory that cues somatic response units reminiscent of actual experience. In contrast, picture viewing is a passive, observational task and averaged waveforms suggest an overall orienting deceleration (Bradley, 2000) with preferentially sustained orienting for stimuli conferring threat, starkly opposite to the pronounced heart rate acceleration during narrative imagery of similar content.

Skin conductance level. Eccrine sweat glands are innervated by the sympathetic nervous system and, as such, increased skin conductance due to sweating is considered a measure of sympathetic activity of the autonomic nervous system (e.g., Dawson, Schell & Filion, 2000). During narrative imagery (e.g., Cook et al., 1991; Cuthbert et al., 2003; Miller, Patrick, & Levenston, 2002) protracted changes in skin conductance level (SCL) vary linearly with rated emotional arousal, independent of affective valence; highly arousing pleasant and unpleasant relative to neutral imagining produces larger increases. The magnitude of skin conductance responses to highly pleasant and unpleasant stimuli often does not differ.

Action readiness: The probe startle response

Whereas heart rate, skin conductance, corrugator, zygomatic, and orbicularis EMG are somatic muscle changes naturally evoked by perception and imagery, the startle probe is a separate stimulus administered during foreground affective processing. The magnitude of the reflexive eyeblink to a probe stimulus is utilized as an index of motive system dominance (i.e.,

appetitive or defensive motivation) as efferents from the central nucleus of the amygdala influence startle magnitude via synapses on the nucleus reticularis pontis caudalis (Davis & Lang, 2001). Similar to the elevated whole body startle observed in rats following shock sensitization or conditioning (Davis, 2000), humans show reliably potentiated blink responses to acoustic startle probes, most discernibly in orbicularis EMG activity. Startle response potentiation has been hypothesized to reflect activation of the defensive motivational system, thereby accentuating the defensive reflex (shock; Greenwald, Bradley, Cuthbert, & Lang, 1998; Hamm et al., 1993; pictures; Lang, Bradley, & Cuthbert, 1990).

Recent studies have shown that this pattern of affective modulation varies according to the type of cognitive processing invoked. During picture perception, the acoustic startle reflex is potentiated when viewing aversive compared to neutral pictures and, conversely, inhibited during viewing of pleasant relative to neutral pictures (Lang, Bradley, & Cuthbert, 1990). However, during imagery augmented startle responding has been found for both high arousing, pleasant and unpleasant compared to neutral imagery (Bradley et al., 1995; Cook et al., 1991; McTeague et al., 2003; Miller et al., 2002; Witvliet & Vrana, 1995; 2000). Bradley et al. (1995) suggested that similar to the interpretation of autonomic output during imagery startle facilitation during arousing narrative scenarios reflects the motor response dispositions engaged during imagined action. However, other investigators (Miller et al., 2002) have posited that augmented startle during imagery is a function of attention, independent of emotion. In short the underlying mechanisms are still under debate and further investigation is necessary to disaggregate the processes yielding response differences during picture and imagery processing. The current investigation attempts to increase the existing database on startle reflex modulation during imagery with the inclusion of a larger stimulus set more thoroughly representative of valence and

arousal dimensions as well as including more simultaneous recordings of other physiological systems, which can potentially clarify emotional and attentional contributions.

In addition to the blink reflex, the startle probe prompts a punctate superimposed deflection in skin conductance level. Vrana and colleagues (Vrana, 1995; Witvliet & Vrana; 1995) have demonstrated that similar to startle responding, larger magnitude responses occur secondary to acoustic startle probes delivered during narrative imagery of both arousing pleasant and unpleasant scenes further verifying that ongoing affective processing modulates the startle reflex.

Extending the Assessment of Narrative Imagery: Electrocortical Activity as a Potential Index of Attentional Engagement

One of the primary goals of this investigation was the examination of event-related potentials to the startle probes elicited during imagery. Event-related potentials (ERPs) are the aspects of the electrocortical potential that are specifically time-locked to events and are regarded as manifestations of brain activities that occur in preparation for, or in response to discrete events. ERPs have subcomponents with time-varying fields resulting from summation of electromagnetic activity generated by neural populations in different parts of the brain (Fabiani, Gratton, & Coles, 2000). Components are operationalized as part of a waveform with a circumscribed scalp distribution and a theoretically circumscribed relationship to manipulated experimental variables (Handy, 2005). Of note, features of the waveform such as peaks and troughs can result from the summation of several contributing sources and therefore do not represent functionally homogeneous neural or cognitive processes. Nonetheless, ERP components are usually defined in terms of both proposed functional significance and underlying neural sources.

The P300 is a component of the ERP that peaks approximately 300 ms after stimulus onset, is maximum at parietal locations, and has been reliably shown to increase with the extent of directed attention toward a task. It has been proposed to reflect attention allocation and context-updating of the environment (Donchin & Coles, 1988). For example, during picture-viewing, the onset of pleasant and unpleasant compared to neutral slides results in more positivity (e.g., Amrhein, Muhlberger, Pauli, & Weidemann, 2004; Keil et al., 2007) suggesting increased attention to motivationally-relevant pictures. However, when a secondary, unrelated interrupting stimulus such as an acoustic startle probe is delivered during the same picture-viewing task, the resultant P300 amplitude is *attenuated* during both defensive and appetitive perception relative to neutral content (Cuthbert, Schupp, Bradley, McManis, & Lang, 1998; Keil et al., 2007; Schupp, Cuthbert, Bradley, Birbaumer, & Lang, 1997), consistent with a hypothesis of sustained attention: With greater resource allocation to the interesting, arousing picture, less is available for processing the irrelevant, acoustic probe stimulus, attenuating the P300.

Of particular relevance to the current investigation, Schupp et al., (1997) found that not only were probe P300 responses during affective pictures less positive, but also this difference from neutral pictures persisted after picture offset when participants were instructed to sustain mental images of the pictures. Thus mental imagery of the emotional content appeared to yield effects similar to those during actual perception.

Although no data has been published concerning the influence of affective narrative imagery on the P300 to a startle probe it is expected based on picture-processing results that as affective arousal and hence motivational relevance increases during emotional imagery, probe P300 amplitude will show the same attentional decrease indicating engagement in the imagery task.

Imagery Ability: An Important Predictor of Emotional Reactivity?

The second study in this investigation addresses the issue of whether the ability to achieve vivid, mental imagery is a crucial individual difference that should be accounted for in efforts to delineate the foundations and processes of emotional imagery. Betts (1909) defined imagery ability in terms of the subjective experience of images conjured in different sensory modalities. The Questionnaire Upon Mental Imagery (Betts, 1909; revised Sheehan, 1967) was accordingly devised and is now a commonly used subjective measure of imagery ability or fidelity. On the 35-item self-report form participants are asked to generate images of stimuli from seven different sensory modalities (visual, auditory, olfactory, cutaneous, kinesthetic, gustatory, and interoceptive/organic) and to rate each image in terms of vividness in comparison to the clarity of actual experience. Although construct validity is undetermined due to the fundamental subjectivity of mental imagery, the QMI has demonstrated acceptable reliability (White, Sheehan, & Ashton, 1977).

In previous imagery studies subjective imagery ability as assessed on the QMI has sometimes been related (e.g., Arabian & Furedy, 1983; Lang et al., 1970; Levin, 1978; Miller et al., 1987) and sometimes not (e.g., McTeague et al., 2002, Witvliet & Vrana, 1995) to physiological reactivity. In terms of demonstrating a reliable association between imagery clarity and physiological reactivity, White (1978) found that while imagining food, good as opposed to poor imagers showed strong correspondence between salivation level and food preference. Marks (1972) found that during imagery of a static object good and poor imagers did not differ in eye movements. However, when instructed to imagine an action-oriented scene, no change in responsivity was evident in poor imagers whereas good imagers evinced increased oculomotor activity, which incremented further when scene prompts depicted eye movement. In the context of Pavlovian conditioning, Arabian and Furedy (1983) discovered that when good imagers

imagined a previous unconditioned stimulus (i.e., 45 degree below horizontal tilt) sustained heart rate deceleration was evident for ten seconds, the duration of the actual tilt condition; poor imagers showed equivalent heart rate deceleration but less prolonged and hence less consistent with the in vivo exposure. Specific to narrative imagery, Lang et al. (1970) found that heart rate increase during fearful imagery was positively correlated with ratings of imagery clarity. Similarly, Van Diest and colleagues (2001) found that suggestive of respiratory action mobilization, high arousal compared to low arousal scenes yielded drops in end-tidal fractional carbon dioxide concentration, most pronounced in better imagers. Similarly, Levin (1978) discovered greater heart rate elevations among good compared to poor imagers during fearful imagery. Miller et al. (1987) assessed good and poor imagers before and after training that encouraged somatovisceral recruitment during imagery. Both at baseline, but even more so after training good imagers showed stronger affective modulation during imagery as indexed in skin conductance, heart rate, and oculomotor activity. In short, subjective imagery ability has been shown to discriminate individuals based on the consistency of their efferent physiology during imagery to implied action and experience.

Imagery ability has, however, also shown inconsistent associations to physiological reactivity during imagining. Thus, although, Levin (1982) found that good compared to poor imagers showed more robust heart rate increases during imagery of feared scenarios, the pattern for electrodermal responding was just the opposite—poor imagers showed larger skin conductance increases and no group differences emerged in sternomastoid muscle tension. Cook, Melamed, Cuthbert, McNeil, & Lang (1988) found that imagery ability interacted with specific script content in the prediction of visceral activity. In particular, during dental imagery good imagers showed larger heart rate increases whereas no group difference was observed for speech

imagery or for electrodermal response to either content. More recently, McTeague et al. (2002) found no associations between imagery ability and reactivity during emotional imagery as indexed in autonomic (heart rate, skin conductance), facial EMG (corrugator and orbicularis) or blink magnitude to the acoustic startle probe.

The second experiment reported here is an effort to further explore the view that imagery ability is a significant moderator variable that should be considered in evaluating imagery processing of emotional content. To this end a series of text prompts were adapted from the QMI to be presented as “sensorimotor” imagery prompts in the context of an experimental physiological procedure—a kind of “psychophysiological” Questionnaire Upon Mental Imagery. Guided by Betts’ conceptualization but translated into the outcomes of psychophysiology, individuals who demonstrated greater physiological activity during imagery as a function of the experiential intensity (e.g., walking vs. running) of the depicted scene were operationalized as “physiologically vivid” imagers. Reactivity during the experimental adaptation of the QMI was correlated with subjective imagery vividness, and in turn both measures were related within-subject to patterns of emotional reactivity during more elaborate narrative imagery. In short, this design was implemented to address whether physiological outcomes would improve the predictive validity of Betts’ conceptualization of imagery ability.

Narrative Imagery: Hypotheses and Expected Findings

Participants imagined narrative scenarios that differed in pleasure and arousal while the previously described physiological measures were recorded. In addition evaluative ratings (i.e., pleasure and arousal) were collected for each imagined scene. Specific imagery scenarios corresponded to seven content categories: social reinforcement, high arousal pleasant, neutral, social threat, panic, contamination, and attack/danger.

- **Attentional Engagement.** Probe P300 responses were anticipated to decrease during emotionally arousing images reflecting greater engagement in the imagery task.

- **Autonomic Mobilization.** Increases in heart rate and skin conductance level were expected to be highest for the most arousing categories irrespective of valence (i.e., attack/danger and high arousal pleasant).
- **Affect Communication through Facial Action.** Corrugator EMG change was expected to show the greatest tension to the most unpleasant scenes (e.g., disgust) and relaxation below baseline to the most pleasant (e.g., nurturance/affiliation) scenes. Zygomatic EMG change was also anticipated to be largest for the most pleasant contents and to show moderate activity (in conjunction with orbicularis EMG) to highly aversive contents such as disgust, reflecting grimacing. Orbicularis EMG was also expected to show increases for both pleasant and unpleasant contents, and foremost for higher arousing contents (e.g., attack/danger).
- **Action Readiness: The Probe Startle Response.** Responses to the acoustic startle probe as indexed in both blink magnitude and skin conductance were expected to be greatest to probes delivered during imagery of the most arousing categories irrespective of valence.

Sensorimotor Imagery and Subjective Imagery Ability: Exploratory Analyses

Participants completed imagined simple sensory-motor experiences while the previously described physiological measures were recorded. In addition vividness ratings were collected for each imagined sensation. Depicted sensory experiences corresponded to the seven modalities represented on the QMI: kinesthetic, interoceptive, visual, acoustic, olfactory, gustatory, and cutaneous. Each modality was represented by prompts depicting low and moderate sensory intensity. Participants also completed the self-report QMI assessment of imagery vividness/ability.

- **Physiological Effects of Prompt Intensity.** Due to the stronger associated response elements, the moderate compared to low intensity sensory-motor prompts were expected to elicit more robust physiological reactivity. Specifically, as indices of intensity or arousal, larger responses were expected in blink magnitude to the startle probe, orbicularis EMG tension, skin conductance level, and heart rate.
- **Evaluative and Physiological Effects of Prompt Modality.** In the absence of data to guide hypotheses about relative potency of images in specific sensory modalities (e.g., olfactory vs. visual), exploratory tests were performed to assess modality differences in both subjective clarity (i.e., experimental vividness ratings and QMI) and physiological reactivity.
- **Association of Subjective Imagery Ability and Physiological Reactivity.**
 - The hypothesis was tested that elevated physiological reactivity to more intense prompts might coincide with higher experimental ratings of vividness.
 - In light of prior inconsistent findings concerning the relation between QMI and objective measures of imagery, the tentative hypothesis was proposed that individuals reporting high subjective clarity of their mental images on the QMI

would more reliably demonstrate increased physiological reactivity during moderate compared to low intensity imagery of simple sensory experiences.

Associations between Imagery Ability and Narrative Imagery: Exploratory Analyses

In the present study, the same participant completed assessments of both sensory-motor imagery ability and extent of emotional reactivity during narrative imagery. This within-subjects design enabled direct comparison of physiological engagement in the two conditions. QMI ratings were additionally examined in relation to narrative imagery.

- **Subjective Imagery Ability as a Predictor of Emotional Imagery.** On the basis of previous studies (e.g., Levin, 1982; Miller et al., 1987), if subjective imagery vividness covaries with affective reactivity, it was expected to be most evident in visceral responding, particularly unpleasant compared to neutral conditions.
- **“Psychophysiological” Imagery Ability as a Predictor of Emotional Imagery.**
 - In light of the similarities in the responding modalities, imagery ability assessed physiologically as opposed to subjectively was expected to be more predictive of reactivity during narrative imagery.
 - If, in fact, sensory imagery predicts emotional imagery, individuals demonstrating greater differentiation between low and moderate sensory-motor imagery responses were expected during narrative imagery to show both greater affective differentiation among contents (i.e., more reliable valence effects) and larger magnitude responses.

CHAPTER 2 EXPERIMENT 1: NARRATIVE IMAGERY

Method

Participants

Fifty-seven students (30 women; 27 men) from the University of Florida introductory psychology class participated in two studies in exchange for course credit. Study 1 entailed the completion of an experimental psychophysiological assessment of emotional narrative imagery.

Materials and Design

Text depicting twenty-four emotional and neutral experiences were devised (Table 2-1) to comprise three superordinate valence categories (pleasant, neutral, unpleasant) with seven different content categories. The content categories included: *panic*, *contamination*, *social fear*, *attack/danger*, *neutral*, *social reinforcement*, *high arousal pleasant*. Each of the seven content categories included three different text exemplars, except for neutral, which included six exemplars for added reliability. The scenes were 20–25 words long and reflected action and participation in the ongoing scene as opposed to bystander observation. Sentences were written to reveal the affective tone within the first three to four words. Words explicitly denoting emotional states (e.g., fear, sadness, anger) or semantic interpretations of the scene (e.g., dangerous, unpredictable) were excluded. An additional two scenes were written to serve as stimuli for demonstration trials.

The sentences were digitized into 10–12 second audio files. A female with instructions to use minimal prosody recorded all sentences. Sentences were recorded in stereo at a sampling rate and size of 44.1 kHz and 16-bit. The audio scripts, along with tones of uniform intensity, were played via Neurobehavioral Systems Presentation program commands from a SoundBlaster AWE 64 Gold sound card, connected to a 12 Volt power supply and gated by a Coulbourn

Audio-Mixer Amplifier (S82-24; Coulbourn Instruments, Allentown, PA). All auditory stimuli were presented to the participant over matched Telephonics TDH-49 headphones (Telephonics Corporation, Huntington, NY).

Trials were presented in 8 orders across subjects so that no more than 2 stimuli of the same hedonic valence, and no 2 stimuli in the same content category were presented consecutively. Specific exemplars were pseudo-randomized into the category sequence stipulated by each order.

A single trial consisted of an initial 3-second baseline, followed by the onset of a 12-second auditory script describing an ongoing emotional or neutral scene, followed by 12 seconds of imagery, and finally a tone-cued return to relaxation (Figure 2-1). After a brief recovery period a series of numbers were presented over the earphones and the participant was instructed to press a button when a given target number was heard. Startle probes were presented 4–5 and 10–11 seconds into each imagery period and 3–4 seconds into the intertrial interval on 50% of trials.

The acoustic startle stimulus consisted of a 50-ms presentation, 95 dB(A) burst of white noise with instantaneous rise time generated by a Coulbourn S81-02 white noise generator and presented over matched Telephonics TDH-49 headphones.

Procedure

The participant was seated in a recliner in a sound-attenuated, dimly lit room. Following completion of consent procedures sensor placement and introduction to the protocol commenced. The participant first read the upcoming imagery prompts and rated each in terms of pleasantness and arousal using the Self-Assessment Manikin (SAM; Lang, 1980; Bradley & Lang, 1994).

At the completion of ratings, the participant was instructed to carefully attend to the acoustic scripts when presented. At stimulus offset the subject was to vividly imagine being actively involved, as a participant as opposed to an observer, in the situation suggested by the

script. The participant was told to maintain this active imagining until hearing the next tone, and then to relax. The participant was notified that a series of numbers would be read and to press the joystick if the target number (identified at this time) was heard. (The identified number was varied across participants. This number tracking task was intended to interfere with residual or ongoing imagining that might otherwise occur). The participant was instructed to keep eyes closed throughout the entire session and that brief noises (startles) heard over the headphones could simply be ignored. Following these instructions a demonstration program was run to present two practice trials. Next the experimenter reviewed with the participant the imagery task in regards to the demonstration trials, confirming comprehension of the instructions, and then began data collection.

Following completion of the experiment the participant was subsequently debriefed, paid credit, and thanked.

Physiological Response Measurement

As noted above, stimulus presentation, timing, and ratings data acquisition was accomplished using a PC-compatible computer running Neurobehavioral Systems Presentation software (Neurobehavioral Systems, 2005). Acquisition of blink magnitude, facial electromyography, and autonomic measures was accomplished using a PC-compatible computer running VPM software (Version 11.2, Cook, 2000). Physiological signals were continuously sampled at 20 Hz for the duration of the experiment. Integrated electromyographic potentials were recorded from the corrugator (left brow), zygomatic (left cheek), and orbicularis (left eye) regions with Sensormedics miniature electrodes (Sensormedics, Yorba Linda, CA), using the placement recommended by Fridlund and Cacioppo (1986). The raw corrugator and zygomatic EMG signals were amplified by 10000, and frequencies below 13 Hz and above 1000 Hz were

filtered, using a Coulbourn S75-01 bioamplifier. The raw signals were rectified and integrated using a Coulbourn S76-23A contour following integrator, with a time constant of 500 ms.

Skin conductance electrodes were placed adjacently on the hypothenar eminence of the left palmar surface using Sensormedics standard electrodes filled with 0.05-m NaCl Unibase paste. The signal was acquired with a Coulbourn S71-23 skin conductance coupler and calibrated prior to each session to detect activity in the range from 0–40 μ Siemens.

The electrocardiogram was recorded from the left and right forearms, using large Sensormedics electrodes filled with electrolyte paste. The signal was filtered using a Coulbourn S75-04 bioamplifier, and a Schmitt trigger interrupted the computer each time the R component of the cardiac waveform was detected. Using VPM software (Cook, 2000) interbeat intervals were recorded to the nearest millisecond.

The eyeblink component of the startle response was measured by recording EMG activity over the orbicularis oculi muscle of the left eye. For continuous measurement of the orbicularis EMG, the raw signal was amplified (5000), and frequencies below 28 Hz and above 500 Hz were filtered, using a Coulbourn S75-48 bioamplifier. The raw signal was rectified and integrated using a Coulbourn S76-23A contour following integrator, with an actual time constant of 20 ms. To index the eyeblink to the startle reflex, activity in the orbicularis oculi muscle was sampled at 20 Hz with the exception of an increase in sampling rate to 1000 Hz for 50 ms prior to and 250 ms following startle probe onset.

EEG was recorded from 129 electrodes using an Electrodesics Inc. (EGI) high-density EEG system and digitized at a rate of 250 Hz using Cz as a recording reference. Impedances were maintained below 50 kOhm as recommended for the Electrical Geodesics high-input impedance amplifiers. A subset of EGI electrodes located at the outer canthi and below the right

eye were used to determine horizontal and vertical electrooculogram (EOG). All channels were processed on-line with 0.1 Hz high-pass and 100 Hz low-pass filtering.

Data Reduction

Using VPM software (Cook, 2000) corrugator, zygomatic, and orbicularis oculi EMG, and skin conductance were reduced off-line into half-second bins. Following the suggestions of Graham (1978) interbeat intervals were reduced to rates and then to weighted averages representing heart rate in beats per minute in half-second bins. Reactions in each measure were determined by subtracting activity in the 1 s prior to script presentation from that occurring at each half-second following onset. For all measures, response averages were calculated for the 12-second imagery periods. For skin conductance level log transformation ($\log[SCL+1]$) was performed to normalize the data. Further, range correction was performed to control for individual differences in SCL (Lykken, Rose, & Luther, 1966). Specifically, within-subject the average for each trial was expressed as a proportion of the participant's total range of variation across trials ($\text{range corrected SCL} = (\text{trial SCL} - \text{minimum SCL})/(\text{maximum SCL} - \text{minimum SCL})$).

The eye blink data was reduced off-line using a program (Balaban, Losito, Simons, & Graham, 1986) that scores the maximum excursion in analog to digital units from the level immediately preceding response onset. Trials with clear artifacts were rejected, while trials with no responses were scored as zero magnitude blinks. For all trials the blink magnitude to each of the two startle probes delivered during an imagery epoch were standardized within-subject in relation to the mean and standard deviation of the probe responses elicited during the inter-trial interval. The standardized values provide a measure of each participant's responsivity during imagery compared to a rest condition.

For assessing skin conductance responses (SCRs) to the acoustic startle probe during narrative imagery the procedure outlined by Bradley, Silakowski, & Lang (2007) was implemented. The skin conductance level at each half-second following the probe presentation during imagery was deviated from the average of the two half-seconds prior to probe presentation. The peak change that occurred from one to five seconds following the probe was scored as the skin conductance response. Hence, change scores reflected increase or decrease relative to the pre-startle baseline.

Brain Electrical Source Analysis was used for EEG data reduction (BESA; MEGIS Software, Inc., Gräfelfing, Munich). After transformation to the average reference, data was digitally filtered at 0.1 to 30 Hz, corrected for ocular artifacts and averaged by condition. Reasonable sensor groupings for ANOVAs were determined by inspection of topographical maps of scalp voltage. Eleven centro-parietal sensors were selected for analysis (Sensors: 53, 54, 61, 62, 67, 68, 73, 78, 79, 80, 87). To extract the startle probe P300, artifact-free segments in the EEG were averaged and the P300 component to the startle probe was identified as the mean amplitude between 260 and 340 ms after probe onset. The P300 amplitude was measured relative to the mean of the 100 ms prior to probe onset.

Data Analysis

Analyses of each ERP, physiological, and reflex measure were conducted to assess the effects of stimulus content on imagery. In general, repeated measures analyses of variance (ANOVA) were employed using content as within subjects factors. Statistical analyses were accomplished using the SPSS package (Version 11.0, 2002). First, valence (pleasant, neutral, unpleasant) was the repeated-subject variate and linear and quadratic trend components as well as follow-up planned comparison (e.g., unpleasant v. neutral) were used to delineate valence response patterns. To explore specific category effects, content categories were then each

contrasted with reactivity during neutral imagery (e.g., neutral v. social reinforcement). Due to signal to noise ratio limitations, probe P300 data were not analyzed by content categories.

For all analyses that involved repeated measures with more than two levels, the multivariate test statistic (Wilks' lambda) was employed to avoid potential sphericity issues (Vasey & Thayer, 1987).

Results

Participant Characteristics

Fifty-seven students (30 women; 27 men) from the University of Florida introductory psychology class participated in two studies in exchange for course credit. The self-reported racial status of the participants was as follows: white (70%), black (12%), Hispanic (9%), Asian (4%), multiracial (2%), and other (3%). The participants reported first languages as follows: English (85%), Spanish (5%), Korean (2%), Creole (2%), both English and Spanish (3%) and other (2%). The mean age of participants was 19.45 years (SD = 2.30). Eighty-nine percent of participants were right-handed, 4% left-handed, 5% ambidextrous, and 2% unreported.

Narrative Imagery: Evaluative Judgments

Listed in Table 2-2 are the means and standard deviations for ratings of pleasantness and arousal for the imagery scripts averaged according to superordinate valence categories. As expected, valence categories affected ratings of pleasantness, $F(2, 55) = 594.97, p < .001$, with the previously defined pleasant scripts evoking the highest pleasantness ratings followed by neutral and lastly unpleasant scripts, *linear trend*, $F(1, 56) = 1208.62, p < .001$ (Figure 2-2A). Further as expected, compared to neutral scripts, ratings of pleasure were greater for pleasant imagery, $F(1, 56) = 265.96, p < .001$, and less for unpleasant imagery, $F(1, 56) = 663.85, p < .001$.

The a priori valence categories reliably affected ratings of arousal, $F(2, 55) = 216.13, p < .001$ (Figure 2-2B). Although not different from one another, $F(1, 56) = 0.12, ns$, arousal ratings were greater for both pleasant, $F(1, 56) = 437.08, p < .001$, and unpleasant, $F(1, 56) = 237.98, p < .001$, compared to neutral imagery.

To address evaluative differences within valence category, the subordinate pleasant and unpleasant content categories were next analyzed within-valence, as well as in relation to ratings for neutral contents. The ratings averaged by content are presented in Table 2-3. Concerning the pleasant categories, both social reinforcement, $F(1, 56) = 265.14, p < .001$, and pleasant arousing, $F(1, 56) = 186.58, p < .001$, were rated more pleasant than neutral scripts, while not differing from one another, $F(1, 56) = 0.12, ns$. Similarly in terms of arousal, both social reinforcement, $F(1, 56) = 335.04, p < .001$, and pleasant arousing, $F(1, 56) = 416.64, p < .001$, were rated more pleasant than neutral scripts. In contrast to commensurate levels of pleasantness, pleasant arousing contents were rated as more arousing than social reinforcement contents, $F(1, 56) = 24.05, p < .001$. The content categories in order of mean valence are illustrated in Figure 2-3A and in order of mean arousal in Figure 2-3B

In considering the ratings of specific unpleasant contents, contamination scenes were rated the least pleasant followed by attack/danger, panic, and lastly social threat, all of which were less pleasant than neutral scenes, *all comparisons to neutral, p < .001*. Contamination, attack, and panic scenes were rated as similarly unpleasant, whereas social threat was rated the least unpleasant content, *all comparisons to social threat, p < .001*. All four unpleasant contents were rated as more arousing than neutral, *all comparisons to neutral, p < .001*. Attack/danger scripts were rated as the most arousing followed by panic, contamination and social threat. Among the

unpleasant categories all conditions except contamination and social threat, $F(1, 56) = 0.19$, *ns*, were reliably different in rated arousal, *all comparisons*, $p < .001$.

Affect communication through facial action

Corrugator EMG activity. Figure 2-4A illustrates the half-second changes in corrugator EMG activity during the course of listen, imagery and recovery averaged by valence. Focusing on the average of the 12-second imagery period (Figure 2-4B) the valence of the scene affected corrugator activity, $F(2, 49) = 10.39$, $p < .001$, with greater tension elicited during imagining of unpleasant, compared to neutral, $F(1, 50) = 5.60$, $p < .05$, and pleasant scenes, $F(1, 50) = 21.07$, $p < .001$ (Table 2-2). In addition, pleasant imagery evoked a relative relaxation compared to neutral, $F(1, 56) = 11.22$, $p < .01$.

Regarding pleasant contents, both social reinforcement, $F(1, 56) = 8.07$, $p < .01$, and pleasant arousing scripts, $F(1, 56) = 6.37$, $p < .05$, elicited a reduction in corrugator EMG activity compared to neutral imagery (Table 2-3; Figure 2-5). The two pleasant contents resulted in similar lower levels of corrugator activity, $F(1, 56) = 1.67$, *ns*. Of the four unpleasant contents, the two rated most unpleasant, attack, $F(1, 56) = 6.22$, $p < .05$, and contamination, $F(1, 56) = 6.68$, $p < .05$, demonstrated increased corrugator activity compared to neutral. Posthoc analyses aimed at further discriminating among the unpleasant contents revealed that similarly, processing of attack, $F(1, 56) = 3.72$, $p < .05$, and contamination, $F(1, 56) = 5.52$, $p < .05$, imagery was marked by increased activity compared to the least unpleasant content, social threat imagery.

Zygomatic EMG activity. Figure 2-6A illustrates the half-second changes in zygomatic EMG activity during the course of listen, imagery and recovery averaged by valence, reflecting that this measure is primarily sensitive to pleasant contents. Focusing on the average of the 12-second imagery period (Figure 2-6B) no main effect of valence emerged, $F(2, 51) = 1.79$, *ns* (Table 2-2). However, planned follow-up tests revealed a significant increase during pleasant

compared to unpleasant imagery, $F(1, 52) = 3.64, p < .05^*$, and a trend for increased activity compared to neutral imagery, *trend* $F(1, 52) = 2.39, p = .06^*$.

Finer analyses revealed that social reinforcement elicited greater zygomatic activity than all other conditions, all comparisons, $p < .05$, and, furthermore, was the only condition to differ from neutral, $F(1, 52) = 3.64, p < .05$.

Orbicularis EMG activity. Figure 2-7A illustrates the half-second changes in orbicularis EMG activity during the course of listen, imagery and recovery averaged by valence. A main effect of valence did not emerge during the imagery period, $F(2, 47) = 2.04, ns$, although a quadratic trend was evident, $F(1, 48) = 4.18, p < .05$, (Figure 2-7B). Planned comparisons demonstrated that both pleasant, $F(1, 48) = 3.32, p < .05^*$, and unpleasant, $F(1, 49) = 3.26, p < .05^*$, imagery evoked increased orbicularis tension compared to neutral imagery.

Regarding the specific content differences from neutral, imagery of contamination, $F(1, 48) = 3.92, p < .05^*$, as well as social reinforcement, $F(1, 48) = 3.18, p < .05^*$, scenes elicited significantly more orbicularis activity, $F(1, 48) = 3.09, p < .05^*$ (Figure 2-8). A trend also emerged for elevated activity during pleasant arousing imagery, $F(1, 48) = 2.46, p = .06^*$.

Autonomic mobilization

Heart rate. Figure 2-9A illustrates the waveforms by valence obtained from averaging heart rate changes over half-second periods during listening, imagery, and recovery. A pronounced increase in heart rate was evident during listening to the scripts, followed by a gradual reduction in heart rate during the subsequent imagery and recovery periods. During imagery, stimulus valence affected heart rate, $F(2, 49) = 8.68, p < .05$, in that unpleasant, $F(1,$

* One-tailed test

50) = 17.64, $p < .01$, and pleasant, $F(1, 50) = 4.0$, $p < .01^*$, processing elicited more sustained heart rate change than the neutral condition (Figure 2-9B).

Content specific analyses revealed that of the pleasant contents social reinforcement, $F(1, 50) = 5.92$, $p < .05$, resulted in more sustained heart rate increase compared to neutral. All of the unpleasant contents showed increased heart rate change compared to neutral (social threat $F(1, 50) = 11.34$, $p < .01$; panic, $F(1, 50) = 12.40$, $p < .01$; contamination, $F(1, 50) = 13.17$, $p < .05$; attack; $F(1, 50) = 2.94$, $p < .05^*$).

Skin conductance level. During imagery, stimulus valence did not affect change in skin conductance level, $F(2, 50) = 1.17$, *ns*, and in follow-up pairwise comparisons, neither emotional content differed from neutral. Specific emotional contents similarly failed to evoke a reliable increase in skin conductance compared to neutral imagery. Post hoc analyses revealed that only 30 of the 52 (58%) participants evinced more reactivity to emotional than neutral contents. For this subset of the participants, valence influenced skin conductance level, $F(2,28) = 6.82$, $p < .01$, with pleasant, $F(1, 29) = 8.45$, $p < .01$, and unpleasant, $F(1, 29) = 5.53$, $p < .05$, contents eliciting more prolonged sympathetic activity than neutral imagery. Furthermore, among these sympathetic responders, contamination, $F(1, 29) = 5.59$, $p < .05$, panic, $F(1, 29) = 3.59$, $p < .05^*$, and social reinforcement, $F(1, 29) = 12.74$, $p < .01$, imagery resulted in more sustained skin conductance responding than neutral imagery.

Action readiness: The probe startle response

Startle reflex. The blink magnitude in response to the startle probe differed as a function of imagery valence, main effect, $F(2,47) = 5.91$, $p < .01$, with reliably augmented reflexes resulting during unpleasant compared to neutral imagining, $F(1, 48) = 9.05$, $p < .01$ (Figure 2-

* One-tailed test

10A). A trend emerged for elevated responding during pleasant compared to neutral imagining, $F(1, 48) = 1.97, p = .08^*$. Probe times (i.e., 4–5 seconds or 10–11 seconds) did not affect response magnitude (main effect of time, *ns*) nor did valence modulation differ by probe position (valence x time effect, *ns*). Content specific analyses revealed that in comparison to neutral imagining attack, $F(1, 48) = 4.16, p < .05$, panic, $F(1, 48) = 4.87, p < .05$, and contamination, $F(1, 48) = 8.96, p < .05$, scenes resulted in startle potentiation (Figure 2-10B). A trend also emerged for pleasant arousing imagery to prompt larger probe responses than neutral imagery, $F(1, 48) = 2.20, p = .07^*$.

Skin conductance response. Figure 2-11 illustrates the mean responses in skin conductance secondary to the startle probes averaged by valence. A main effect of valence emerged, $F(2, 48) = 3.40, p < .05$, primarily owing to a greater skin conductance response subsequent to the probes delivered during unpleasant compared to neutral imagery, $F(1, 49) = 6.77, p < .05$. Probe times (i.e., 4–5 seconds or 10–11 seconds) did not affect response magnitude (main effect of time, *ns*) nor did valence modulation differ by probe position (valence x time effect, *ns*). Thus the autonomic reaction to the probe was similar to the blink response, but varied in content emphasis.

Content specific analyses revealed that contamination, $F(1, 49) = 3.69, p < .05^*$, and social threat, $F(1, 49) = 4.79, p < .05$, imagining resulted in larger post-probe skin conductance responses than neutral imagining.

Attentional engagement: P300 to the probe

The event-related averages at Cz and Pz by valence are shown in Figure 2-12 illustrating the effect of imagery engagement on later probe processing, $F(2, 90) = 8.22, p < .001$, with both

* One-tailed test

pleasant, $F(1, 45) = 11.49, p < .01$, and unpleasant contents, $F(1, 45) = 9.53, p < .01$, compared to neutral evoking less positive deflections 260 to 340 ms after the startle probe. This pattern is the inverse of that recorded for the blink response indicating reduced attentional allocation to the probe during emotional processing.

Discussion: Narrative Imagery

Affect Communication through Facial Action

Facial expressivity measures, corrugator and zygomatic EMG showed the expected covariation with valence, in that corrugator EMG demonstrated the largest increases for the most subjectively unpleasant (i.e., contamination) and the greatest relaxation for the most subjectively pleasant (i.e., social reinforcement) imagery. Zygomatic EMG was elevated for pleasant imagery, and more specifically those scenes denoting positive social interaction (i.e., social reinforcement). Although the winning and victory scenes depicted in the pleasant arousing category were rated commensurate to social reinforcement scenes in terms of pleasantness, the scenes describing direct positive reinforcement from superiors and friends elicited more facial motor activity, likely reflecting subovert smiling behavior.

Orbicularis EMG activity showed commensurate increases during both pleasant and unpleasant compared to neutral imagery, consistent with previous imagery studies. Interestingly, however content analyses revealed that orbicularis activity covaried more closely with valence than arousal. In particular, the most pleasant (social reinforcement) and unpleasant (contamination) contents elicited the most increase similar to content specificity demonstrated during emotional picture viewing (Bradley, Codispoti, Cuthbert, & Lang, 2001). The coincident increases in zygomatic and orbicularis EMG for highly pleasant materials, as observed here to social reinforcement scripts is typically considered a measure of the authentic or genuine Duchenne smile (Ekman, Davidson, & Friesen, 1990), in contrast to the unfelt, social smile

recruiting only zygomaticus major (Bradley et al., 2001). Further, the marked increase in orbicularis during contamination imagery possibly reflects grimacing (Bradley et al., 2001). Taken together the three facial action measures showed strong correspondence to social communication behavior implied in the imagery scenes.

Autonomic Mobilization

Consistent with prior studies (e.g., Witvliet & Vrana, 2000) and as expected, pleasant and unpleasant narrative imagery compared to neutral prompted increased autonomic reactivity as captured in heart rate. All unpleasant scenes showed increases relative to neutral whereas social reinforcement, but not pleasant arousing scripts showed increases. Somewhat unexpectedly, heart rate increase was not as closely coupled to rated arousal as demonstrated in previous studies (e.g., Bradley et al., 1995). Rather, contamination, showed the greatest heart rate increase among unpleasant contents and social reinforcement among pleasant contents.

Contrary to expectations changes in skin conductance level did not systematically vary with emotion. However, although these two output systems often show similar sensitivity to emotional arousal, particularly during discrete, external stimulation such as affective picture presentation (e.g., Bradley et al., 2001), the weak effects in electrodermal responding seen here are not surprising and have been demonstrated during prior investigations of narrative imagery (Bauer & Craighead, 1979; Carroll, Marzillier, & Merian, 1982; Lang et al., 1980; Lang et al., 1983; Vrana, 1993, 1994; Witvliet & Vrana 1995). In reference to these intermittent null effects Lang et al. (1983) previously conjectured that the purposeful disattention to external stimulation requisite in mental imagery, in part functions to attenuate skin conductance reactivity by “tuning out” the modality to which it is most sensitive. He cautioned that to consistently detect changes during imagery samples would need to be of sufficient size and/or visual media should be employed to prompt subsequent imaging. Interestingly, in the current study the phasic skin

conductance responses to the acoustic probes showed evidence of reliable modulation by emotion indicating that theme-relevant processing is in fact coded in the electrodermal system and that abrupt external stimulation provides a useful window through which to assess activation.

Action Readiness: The Probe Startle Response

In addition to the reliable modulation of the skin conductance response, blink magnitude to the startle probe differed as a function of valence with reliably augmented reflexes resulting during unpleasant compared to neutral imagining. Although not an overwhelming effect, the data were also suggestive of augmented startle responding during pleasant imagery. In particular, probes delivered during attack, panic, and contamination imagery prompted larger startles than neutral imagery. Further, the pattern of modulation was suggestive of increased blink magnitude during highly arousing pleasant imagery.

Importantly, in both blink magnitude and skin conductance response to the startle stimulus probe position (middle or late in the imagery period) did not influence overall magnitude or the pattern of affective modulation, suggesting sustained motivational processing throughout the entire imagery period.

Attentional Engagement: P300 to the Probe

A primary aim of this study was to assess whether—similar to picture viewing paradigms in which probe P300 amplitude was reduced during more emotionally arousing pictures (e.g., Schupp et al., 1997)—more emotionally arousing narrative imagery would attenuate the P300 response. Findings revealed that, in fact, affective modulation of the P300 was present during emotional imagery with both pleasant and unpleasant contents compared to neutral evoking less positive deflections after the startle probe. Reduced P300 responses to probes delivered amidst competing non-affective cognitive tasks have been consistent across studies and interpreted as reflecting attentional resource allocation to the foreground task (Polich, 2007). In the context of

emotional picture viewing, diminished probe P300 responding has been conceptualized as an index of *natural selective attention* or processes activated to subserve motivational mobilization (Lang et al., 1998; Schupp et al., 1997). In the current investigation, attentional processes have been preferentially engaged in the generation of emotionally arousing as compared to neutral imagining. These findings are particularly compelling in that a task requiring effortful mental elaboration grabs attention similar to prominent external stimuli resulting in less resources for processing the probe interruption.

Conclusions

In conclusion these findings were largely consistent with hypotheses concerning patterns of expected modulation in the different response systems. However, one finding—the prominence of contamination in the defensive profile—was interesting in that even measures typically more reflective of emotional arousal as opposed to valence, showed the most reactivity to this category (e.g., SCR, blink magnitude, heart rate, orbicularis EMG). Contamination was rated the most unpleasant content, and although more arousing than neutral, it was rated significantly less arousing than panic and attack/danger imagery. The consistency of preferential processing of contamination as the most unpleasant, but moderately arousing category prompts the question of whether future investigations might productively implement a combined measure of valence and arousal, an affective vector of sorts that would enable the simultaneous examination of these dimensions in determining physiological response.

In total, these findings suggest that probe P300 responding in conjunction with autonomic, somatic, and reflexive recording provide informative, multi-modal assessment of attentional allocation, expressive dispositions, and somatomotor readiness during narrative imagery.

Table 2-1. Text of scripts for psychophysiological examination of affective narrative imagery

Valence category	Content category	Exemplar	Sentence
Unpleasant	Panic	Exemplar 1	Panic comes out of the blue. No warning. Your heart’s racing. You can’t get your breath. Thoughts whirl: “I’m going crazy? Am I going to die?”
		Exemplar 2	“People are all around you, pressing closer. It’s hard to breathe. You’re flushed, sweaty, dizzy—confused. You realize it’s another attack and this time, you think, “I will die.”
		Exemplar 3	You’ve waited endlessly at the check-out counter. Trapped. Others crowd against you. There’s a sudden rushing in your head. You gasp for breath, chest tight, temples throbbing. Is it a heart attack?
	Contamination	Exemplar 1	You are leaving the concert. (when) A drunk, smelling of smoke and alcohol, stumbles into you and throws up on your jacket. You retch as vomit drips onto your hand.
		Exemplar 2	You bite hungrily into the hamburger, and abruptly catch the putrid smell of spoiled meat. You spit out, and a greasy piece falls.
		Exemplar 3	You gag, seeing a roach moving slowly over the surface of the pizza. You knock the pie on the floor. Warm cheese spatters on your shoes.
	Social fear	Exemplar 1	It’s your turn to speak to the group. They’re all looking at you. Your mouth’s dry and you can’t get the words out. Your heart pounds in the silent room. Someone laughs.
		Exemplar 2	Everyone’s talking, laughing together at the party. You’re alone—tense, sweaty. People glance at you and quickly look away. When asked your name: Throat dry, you croak an answer.
		Exemplar 3	Everyone’s staring at you, waiting for your presentation. You’ve misplaced all your notes, graphics—everything’s lost! What will you say? They see you shaking, sweating—mumbling stupidly.
	Attack/danger	Exemplar 1	You’re alone in the alley in a bad part of the city. A street gang slowly surrounds you, knives out, laughing with menace. Your heart pounds as they close in.
		Exemplar 2	Without thinking, you stepped off the curb into traffic. Brakes screech. You look up, frozen, heart jumping in your chest. A truck is skidding, hurtling towards you.
		Exemplar 3	It’s late at night in a poorly lit parking lot. You tense, clutching the keys. Your car stands alone in the distance, when footsteps sound behind you.

Table 2-1. Continued

Valence category	Content category	Exemplar	Sentence	
Neutral	Neutral	Exemplar 1	You are sitting at the kitchen table with yesterday’s newspaper in front of you. You push back the chair when you hear the coffee maker slow to a stop.	
		Exemplar 2	It’s good to be able to do nothing and just stretch out on the couch. The television is on with the sound off. You can hear the low rumble of traffic in the distance.	
		Exemplar 3	You run the comb through your hair, straighten your collar, smooth out the shirt’s wrinkles. Water is running in the sink. You turn it off and leave.	
		Exemplar 4	You unfold the map, spread it out on the table, and with your finger trace a route south towards the beach. You refold the map, pick up your bag, and leave.	
		Exemplar 5	It’s a quiet day without much to do. You’re sitting around your place, resting, reading, and looking out the window—where leaves swirl gently in the wind.	
		Exemplar 6	You are relaxing on a lawn chair, looking out into the garden. A child’s tricycle is abandoned on the grass. You hear the low buzz of a lawn mower in the distance.	
	Social reinforcement	Exemplar 1	You’ve successfully completed a difficult assignment. Your friends are enormously pleased for you—with pats on the back and welcome praise. Your face is warm. You can’t help smiling.	
		Exemplar 2	She really likes your gift. As soon she saw it, she screamed with joy: “Thank you. It’s just perfect, fantastic.” Your heart beats with pleasure, when she leaps up and hugs you.	
		Exemplar 3	The boss smiles and shakes your hand. “You’ll receive a very big raise in pay. Good work!” he says. Your heart skips a beat. Someone shouts congratulations. You smile back.	
		High arousal pleasant	Exemplar 1	The registered letter says that “You have just won ten million dollars!” It’s amazing—You bought the winning ticket in the lottery. You cry, scream, jump with joy!
			Exemplar 2	It’s the last few minutes of the big game and it’s close. The crowd explodes in a deafening roar. You jump up, cheering. Your team has come from behind to win.
			Exemplar 3	You won a free pass to the whole carnival. Like kids again, you all jump on the merry-go-round, laughing as it turns, singing along with the music: “What a wonderful day!”

Table 2-2. Narrative imagery: Mean response (standard deviation) across measures averaged by valence category

Dependent Measure	N	Pleasant		Neutral		Unpleasant		Valence main effect
		M	SD	M	SD	M	SD	
Affect communication								
Corrugator EMG Δ (μ V)	51	-0.46	(1.25)	0.03	(0.96)	0.35	(1.48)	$F(2, 49) = 10.39, p < .001^{a,b,c}$
Zygomaticus EMG Δ (μ V)	53	0.12	(0.62)	-0.03	(0.42)	-0.05	(0.18)	$F(2, 51) = 1.78, ns^{a,b}$
Orbicularis EMG Δ (μ V)	50	0.63	(1.41)	0.28	(1.01)	0.55	(0.79)	$F(2, 47) = 2.04, ns^c$
Autonomic mobilization								
Heart rate Δ (bpm)	50	-0.70	(4.46)	-2.02	(3.41)	0.15	(2.91)	$F(2, 49) = 8.68, p < .01^{a,c}$
SCL Δ (log (μ S + 1))	52	-0.03	(0.08)	-0.03	(0.06)	-0.03	(0.05)	$F(2, 50) = 0.77, ns$
Action readiness								
Startle (T-score)	49	57.23	(27.05)	52.46	(6.38)	55.97	(11.01)	$F(2, 47) = 5.91, p < .01^c$
SCR (μ S)	51	0.05	(0.08)	0.03	(0.08)	0.05	(0.12)	$F(2, 49) = 3.40, p < .05^c$
Attentional engagement								
P300 (μ V)	48	4.24	(2.64)	5.51	(2.90)	4.63	(2.82)	$F(2, 90) = 8.22, p < .001^{a,c}$
Evaluative ratings								
Pleasure (1-9)	57	8.20	(0.73)	6.18	(0.79)	2.21	(0.72)	$F(2, 55) = 594.97, p < .001^{a,b,c}$
Arousal (1-9)	57	7.07	(1.07)	3.40	(1.24)	7.14	(1.10)	$F(2, 55) = 216.13, p < .001^{a,c}$

Note. Δ = change; EMG = electromyographic; SCL = skin conductance level; SCR = skin conductance response; bpm = beats per minute; μ V = microvolt; μ S = microsiemen; ^a = Comparison of pleasant versus neutral conditions is significant at $p < .05$; ^b = Comparison of pleasant versus unpleasant conditions is significant at $p < .05$; ^c = Comparison of unpleasant versus neutral condition is significant at $p < .05$.

Table 2-3. Narrative imagery: Mean response (standard deviation) across measures averaged by content category

	Pleasant arousing		Social reinforcement		Neutral		Social threat		Panic		Attack		Contamination	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Affect communication														
Corrugator EMG Δ (μ V)	-0.31	(1.66)*	-0.61	(2.02)*	0.04	(1.18)	0.04	(1.66)	0.28	(2.52)	0.44	(1.53)*	0.67	(2.53)*
Zygomatic EMG Δ (μ V)	-0.01	(0.67)	-0.24	(0.85)*	-0.03	(0.42)	-0.01	(0.42)	-0.07	(0.40)	-0.03	(0.32)	-0.07	(0.39)
Orbicularis EMG Δ (μ V)	0.64	(1.74)	0.62	(1.29)*	0.28	(1.01)	0.37	(1.21)	0.48	(0.91)	0.45	(1.45)	0.89	(2.07)*
Autonomic mobilization														
Heart Rate Δ (bpm)	-1.21	(5.86)	-0.20	(4.81)*	-2.02	(3.41)	0.39	(4.80)*	0.52	(4.02)*	-0.96	(3.85)*	0.66	(5.04)*
SCL Δ (log (μ S + 1))	-0.05	(0.13)	-0.02	(0.08)	-0.03	(0.06)	-0.02	(0.06)	-0.02	(0.08)	-0.05	(0.10)	-0.03	(0.07)
Action readiness														
Startle (T-score)	55.84	(36.09)	58.71	(14.26)	52.46	(6.38)	54.15	(9.67)	55.44	(18.76)*	55.35	(18.49)*	58.86	(10.62)*
SCR (μ S)	0.05	(0.17)	0.04	(0.12)	0.03	(0.08)	0.06	(0.15)*	0.06	(0.15)	0.04	(0.13)	0.05	(0.12)*
Evaluative ratings														
Pleasure (1-9)	8.22	(0.80)*	8.19	(0.63)*	6.18	(1.24)	2.67	(0.91)*	2.18	(0.62)*	2.04	(0.77)*	1.95	(0.89)*
Arousal (1-9)	7.42	(1.53)*	6.73	(1.12)*	3.40	(1.61)	6.62	(1.24)*	7.33	(0.76)*	7.95	(0.82)*	6.64	(1.04)*

Note. Δ = change; EMG = electromyographic; SCL = skin conductance level; SCR = skin conductance response; bpm = beats per minute; μ V = microvolt; μ S = microsiemen; * = Comparison versus neutral condition is significant at $p < .05$.

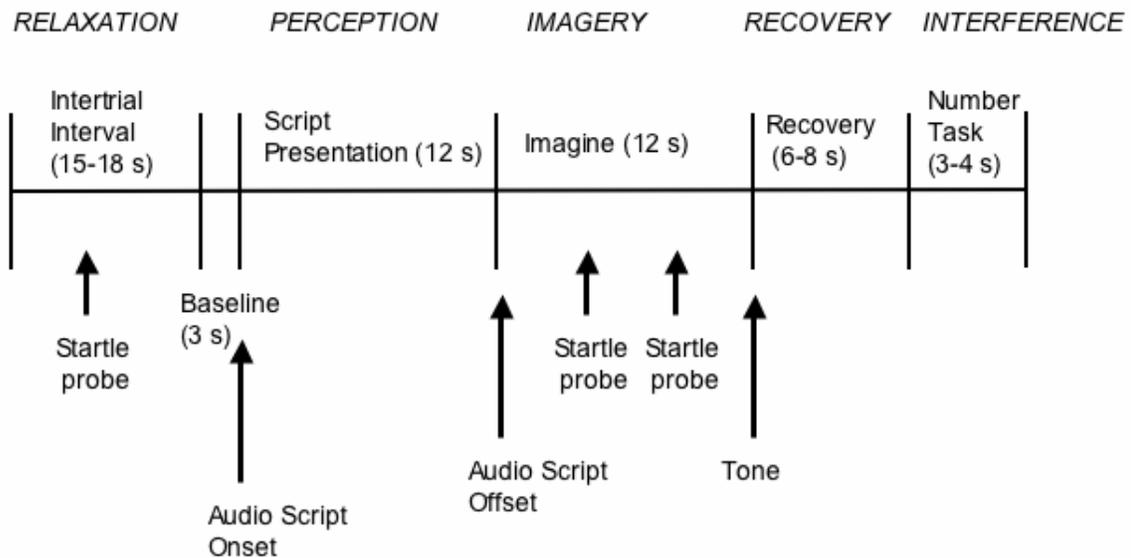


Figure 2-1. Trial structure for narrative imagery. A single trial consisted of an initial 3-second baseline, followed by the onset of a 12-second auditory script describing an ongoing emotional or neutral scene, followed by 12 seconds of imagery, and finally a tone-cued return to relaxation. After a brief recovery period, a series of numbers were presented over the earphones and the participant was instructed to press a button when a given target number was heard. Startle probes were presented 4–5 and 10–11 seconds into each imagery period and 3–4 seconds into the intertrial interval on 50% of trials.

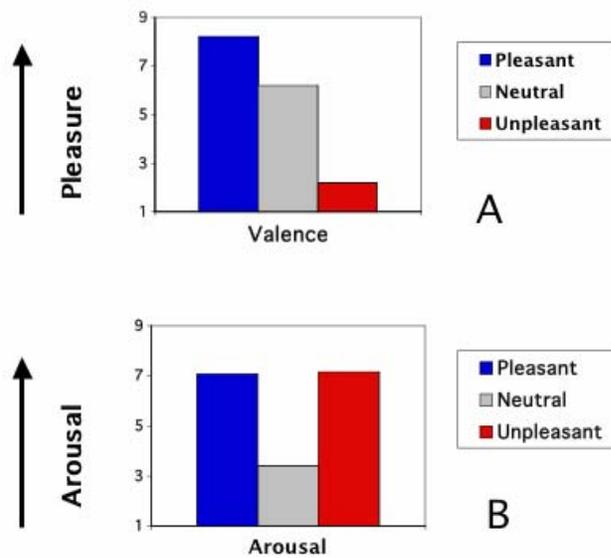


Figure 2-2. Mean ratings of pleasure and arousal as prompted by pleasant, neutral, and unpleasant scripts measured with the Self-Assessment Manikin. A) Pleasantness ratings. B) Arousal ratings.

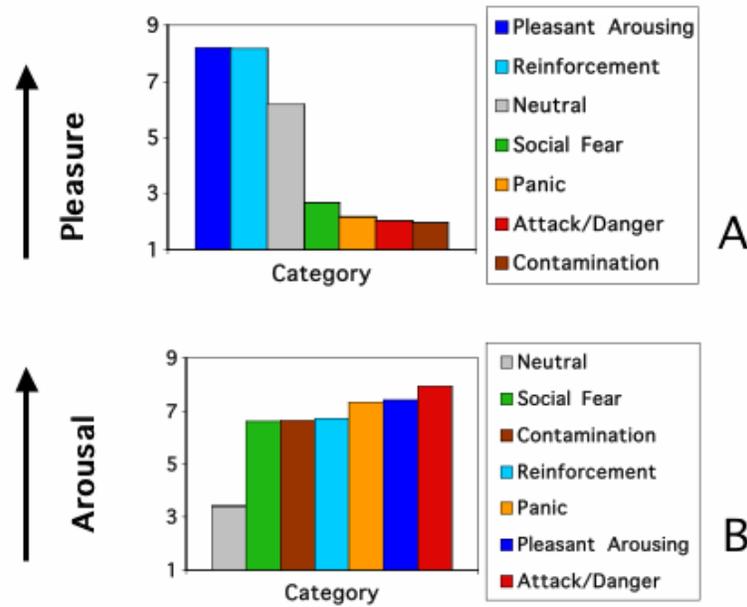


Figure 2-3. Mean ratings of pleasure and arousal by narrative imagery content category as measured with the Self-Assessment Manikin. A) Pleasantness ratings. B) Arousal ratings.

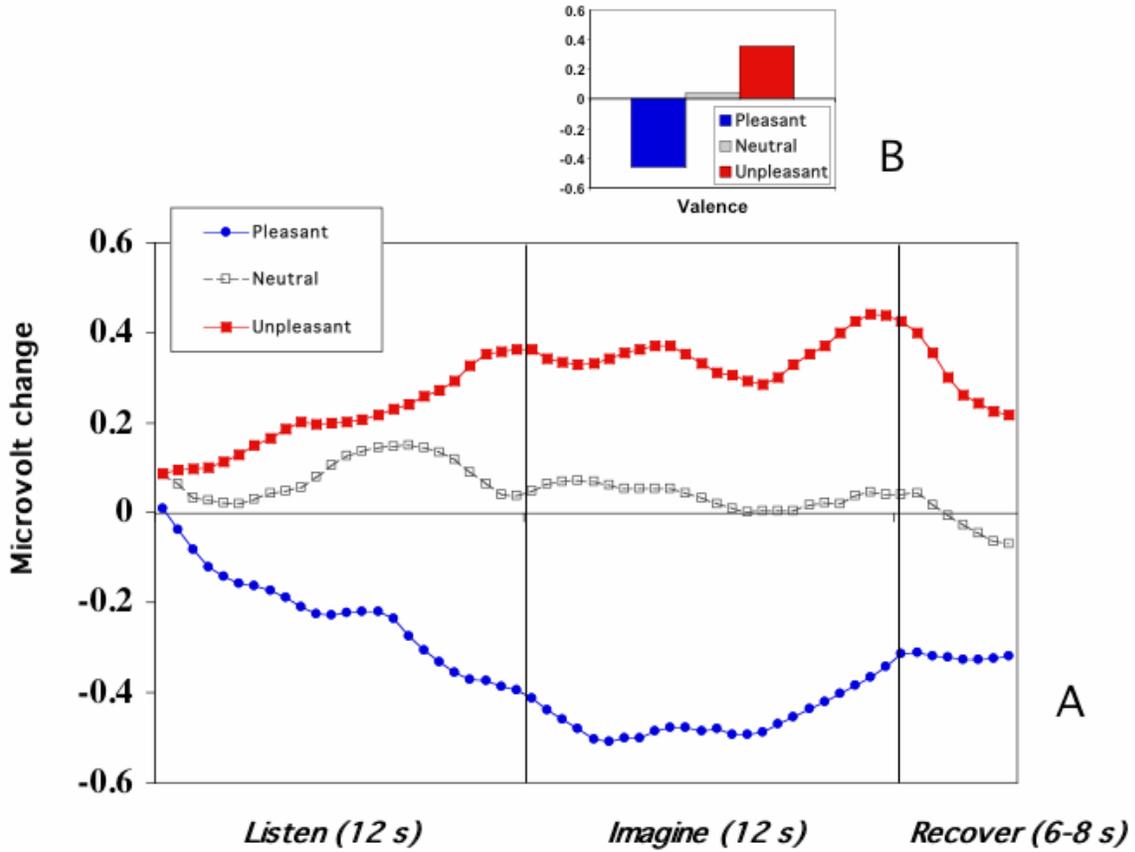


Figure 2-4. Average change in corrugator EMG activity by valence of imagined prompt. A) Smoothed, half-second averages during listen, imagine, and recover. B) 12-second averages during imagine.

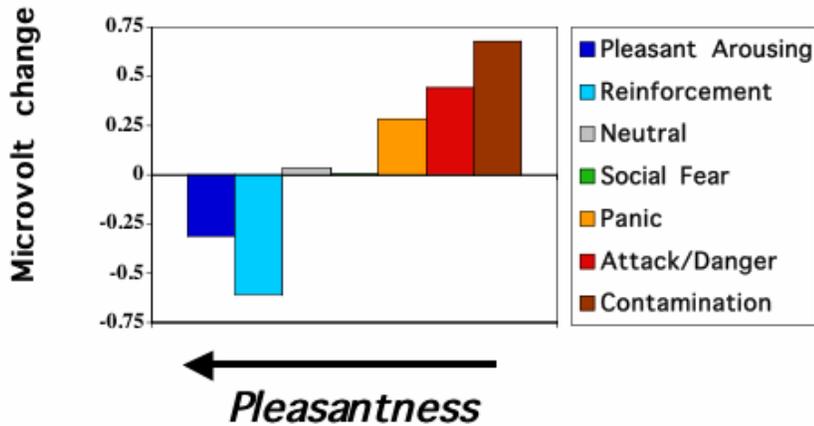


Figure 2-5. Average 12-second change in corrugator EMG activity during imagery by category of imagined prompt. Categories on the x-axis are arranged according to rated pleasantness.

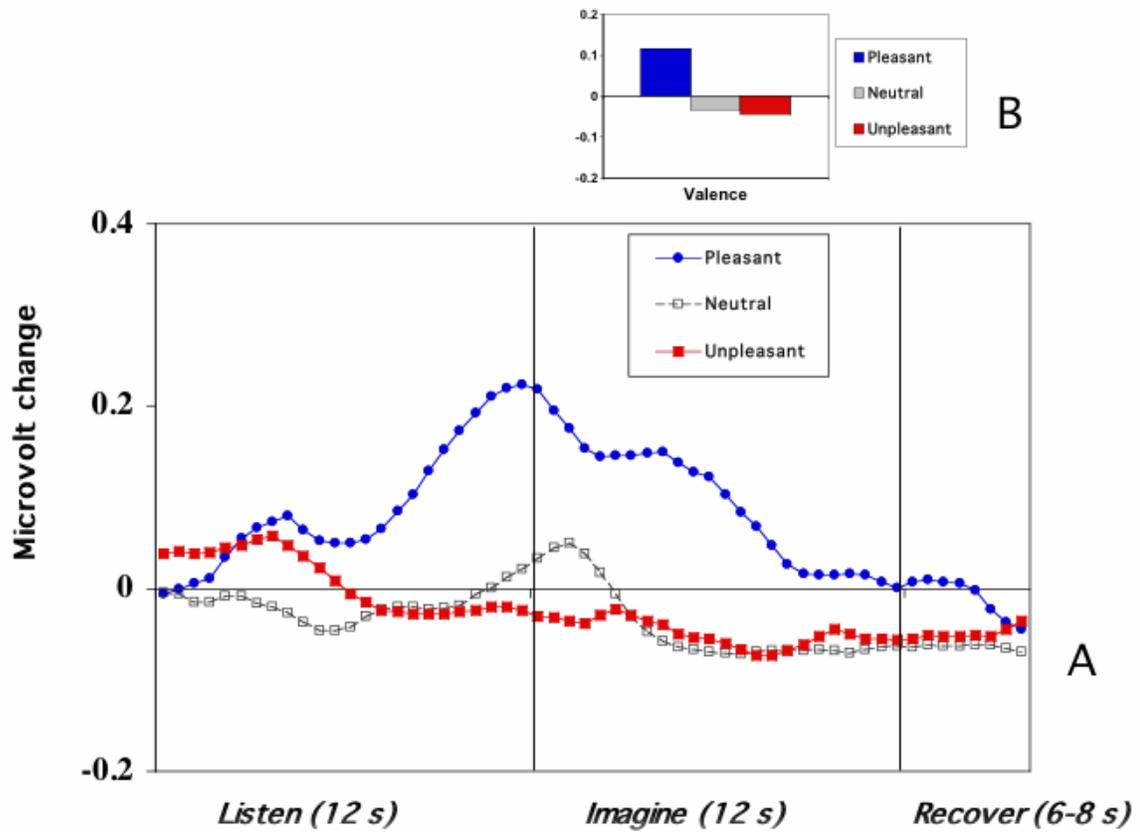


Figure 2-6. Average change in zygomatic EMG activity by valence of imagined prompt. A) Smoothed, half-second averages during listen, imagine, and recover. B) 12-second averages during imagine.

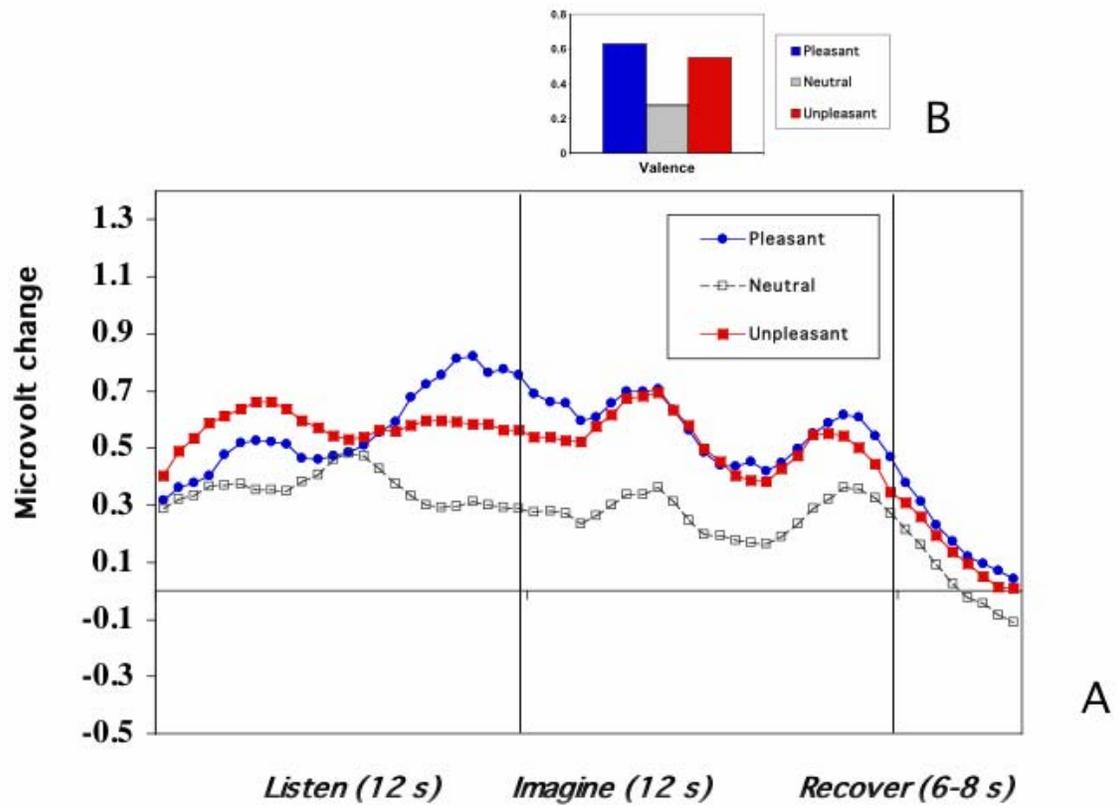


Figure 2-7. Average change in orbicularis EMG activity by valence of imagined prompt. A) Smoothed, half-second averages during listen, imagine, and recover. B) 12-second averages during imagine.

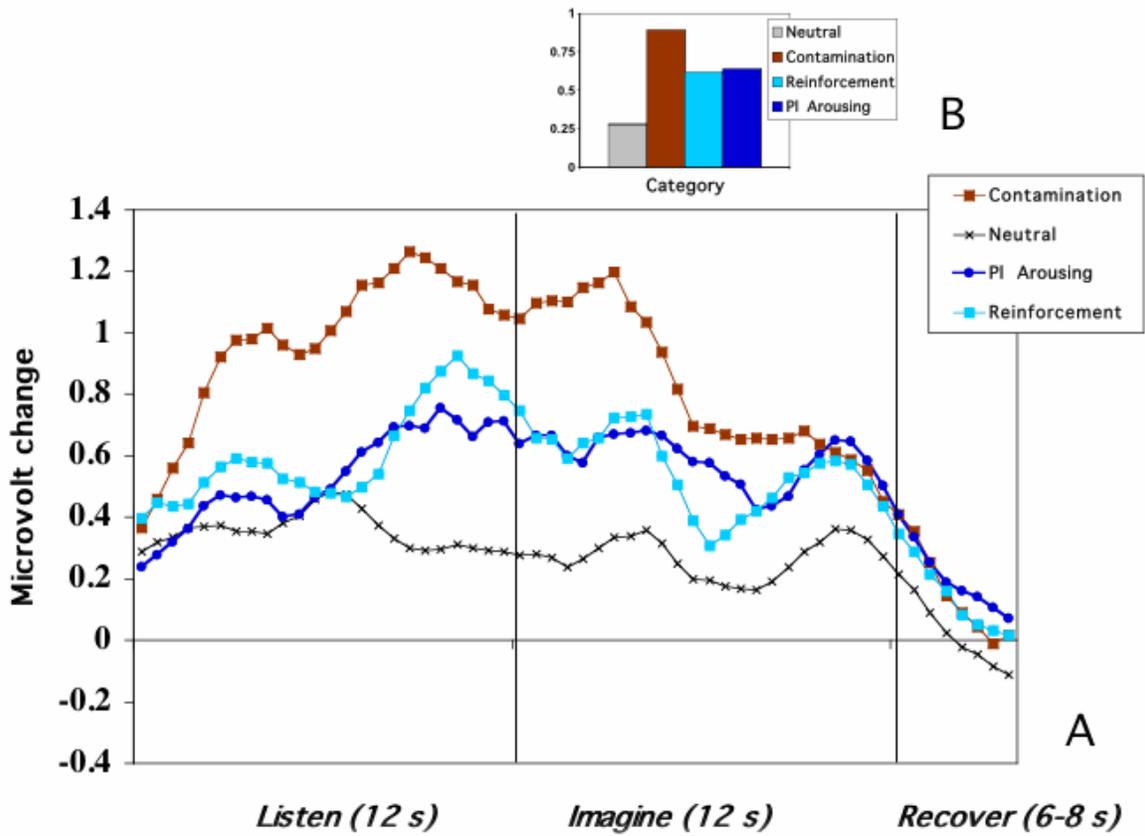


Figure 2-8. Average change in orbicularis EMG activity during neutral scenes and those emotional scenes that during narrative imagery evoked significant increases compared to neutral. A). Smoothed, half-second averages of orbicularis EMG activity during listen, imagine, and recover prompted by neutral, pleasant arousing, social reinforcement, and contamination imagery. B) 12-second averages during imagine.

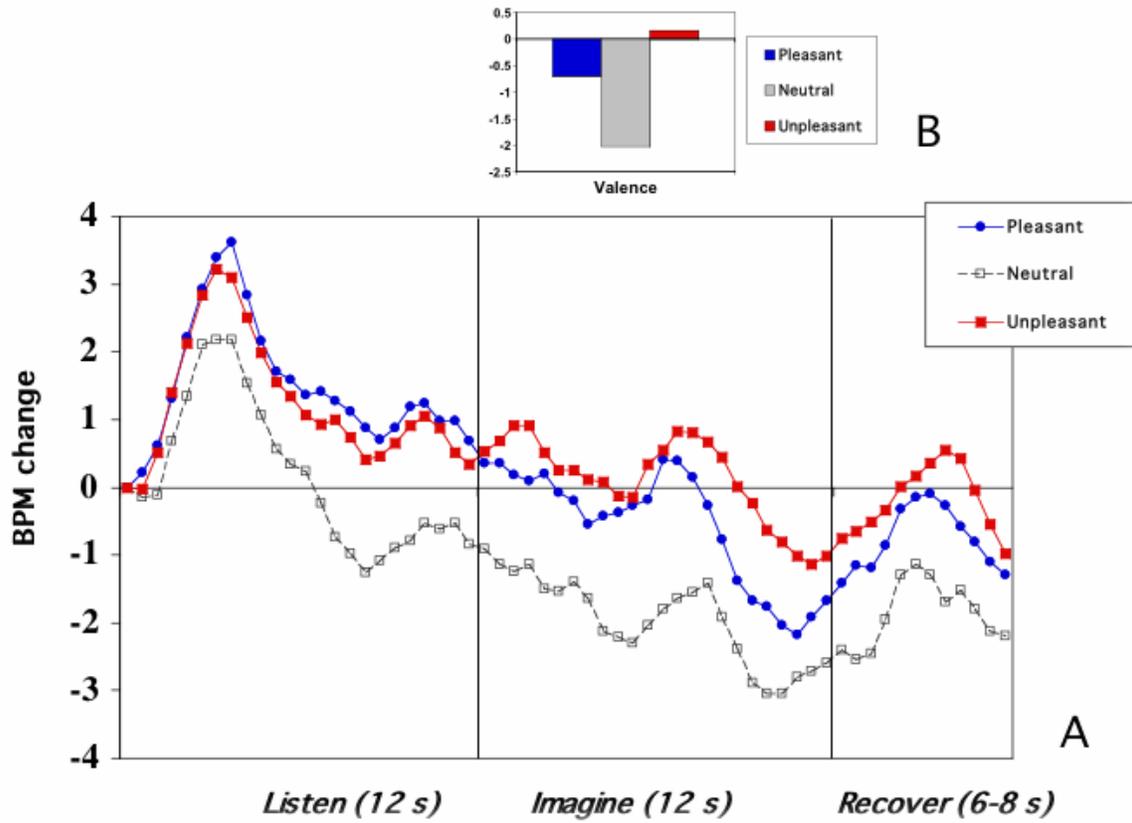


Figure 2-9. Average change in heart rate by valence of imagined prompt. A) Half-second averages during listen, imagine, and recover. B) 12-second averages during imagine.

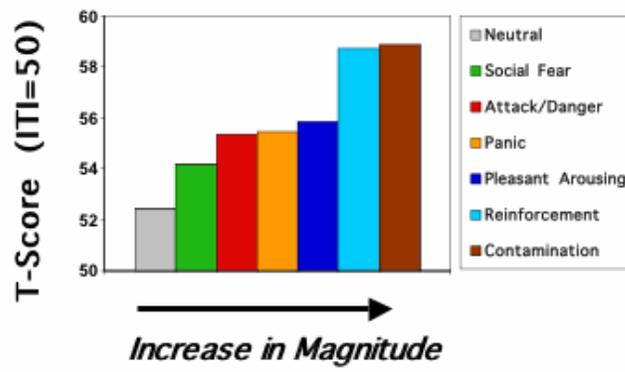
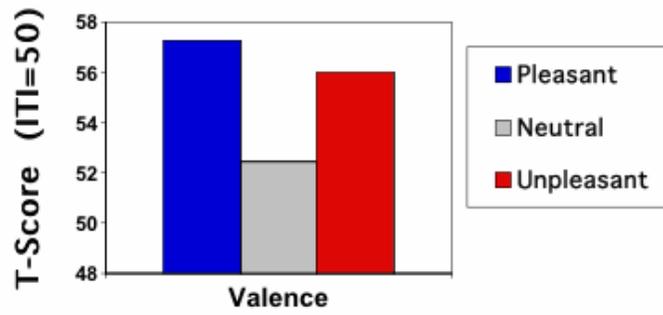


Figure 2-10. Mean blink magnitude to the startle probe during narrative imagery. A) By valence category. B) By content category arranged on the x-axis in order of increasing mean response magnitude.

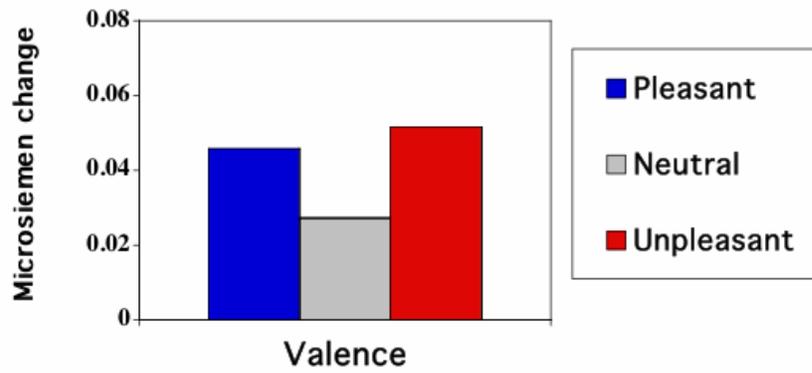


Figure 2-11. Mean peak skin conductance response to the startle probe during narrative imagery by valence of imagined prompt.

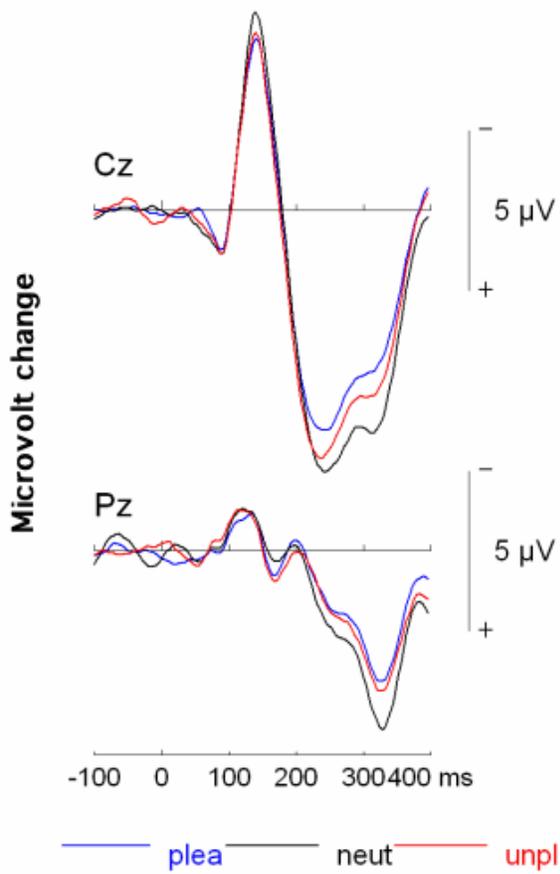


Figure 2-12. Event-related averages to the startle probe at electrodes Cz and Pz 100 ms pre- to 400 ms post-probe by valence of imagined prompt.

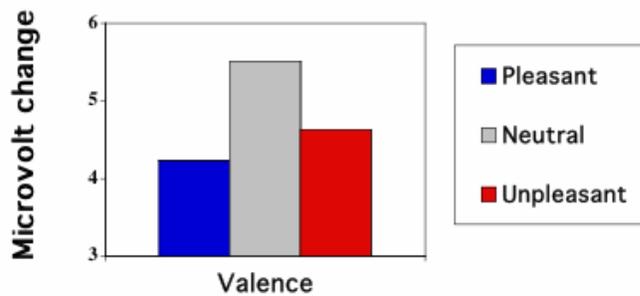


Figure 2-13. Scalp potential at 11 centro-parietal sensors 260-340 ms after the startle probe by valence of imagined prompt.

CHAPTER 3
EXPERIMENT 2: SENSORIMOTOR IMAGERY

Method

Participants

Fifty-seven students (30 women; 27 men) from the University of Florida introductory psychology class participated in two studies in exchange for course credit. At a preceding session the same participants in the narrative imagery protocol completed both an experimental psychophysiological assessment and self-report measure of imagery vividness/ability

Materials and Design

Text depicting fourteen common sensory experiences were devised (Table 3-1) to parallel the items of the QMI (Betts, 1909; Sheehan, 1967). The QMI (*Cronbach's alpha* = 0.77) is a 35-item self-report measure of individual differences in imagery ability. Items relate to imaginal vividness of stimuli in seven sensory modalities (visual, auditory, olfactory, cutaneous, kinesthetic, gustatory, and interoceptive/organic). Instructions and sample items include

Think of [perceiving] the following, considering carefully the picture which comes before your mind's eye. Classify the image suggested by the following question as indicated by the degrees of clearness and vividness specified on the Rating Scale (1 = As vivid as the actual experience; 9 = No image at all. You are only thinking about it).

Sample rating items include: "The sun as it is sinking below the horizon"; "The whistle of a locomotive"; "Sand"; "Running upstairs"; "Salt". Scores are summed to obtain a total score, such that a low total score implies high self-reported imagery ability. For the psychophysiological test of imagery vividness two text prompts (one low and one moderate sensory-motor intensity) were generated to correspond to each of the seven sensory-motor modalities represented in the QMI, resulting in seven low and seven moderate intensity prompts.

Text prompts of 1.9 to 4 s in duration were digitized in the same procedure outlined in Study 1. Script exemplars were presented such that low and moderate sensory-motor intensity

trials alternated. Two orders were presented to ensure that low and moderate sensory-motor trials were equally often presented at each position during the protocol, counterbalanced across participants. For example, one order would proceed for 14 trials: Low–Moderate–Low–Moderate and so forth. The alternative order would be Moderate–Low–Moderate–Low and so forth. The specific exemplars were pseudo-randomly assigned to the two category positions.

A single trial consisted of an initial 3-second baseline, followed by the onset of a brief auditory script describing a common daily activity with sensory and motor prompts, followed by 12 seconds of imagery, and finally a tone-cued return to relaxation and a rating of imagery vividness. Startle probes were presented 8–10 seconds into each imagery period and 4–6 seconds into the intertrial interval on 50% of trials (Figure 3-1). Participants received a total of 23 startle probes.

Stimulus presentation, timing, and physiological and ratings data acquisition were accomplished with the same parameters and equipment outlined for Study 1.

Procedure

The participant sat in a recliner in a sound-attenuated, dimly lit room. Following consent procedures sensors were placed on the participant. The participant then received instructions regarding the parameters for imagining the imagery prompts:

This next test is designed to assess your mental imagery, how vividly you can call back to mind memories of common experiences. For example: Close your eyes, and relax. Now consider a red apple in your mind's eye. Compose a vivid image of the apple, its color, the shine of the skin. Is there a stem on top? Now imagine that you pick up the apple, feeling its heft, round shape and smooth skin, as you hold the apple in your hand. Now bite into the apple, taste the ripe fruit, smell its freshness. (Pause).

I'll bet you had a good image in your mind's eye? How vivid was it? —as you think of vivid memory images that you have had in the past. What rating would you give your apple image on a scale from 1 to 9—with 1 meaning no image at all, and 9 meaning it was perfectly vivid and clear, the same as if you were experiencing a real apple?

Now, continue relaxing with your eyes closed. You are going to hear a series of different common events—like eating an apple—for you to imagine in the same way, as vivid mental experiences. Think about each event, and hold your image and reactions in your mind for several seconds. When you hear the tone, rate the image for its clarity and vividness—remember, 1 to 9. Rate how much it was as if you were actually seeing, feeling, or doing something.

The participant was further instructed to keep his/her eyes closed during imagery and that brief noises heard over the headphones could simply be ignored.

Following the completion of the imagery protocol, the participant completed the Questionnaire Upon Mental Imagery (QMI) and then was debriefed, granted credit, and thanked.

Data Reduction

Data reduction procedures were similar for the two studies with the exception that due to a programming error the first eight rather than 12 seconds of continuous data were recorded during sensorimotor imagery. Consequently averages for imagery periods during the sensorimotor task represent the half-second averages over eight seconds. Additionally, due to the previously described programming error, data is unavailable for SCRs during sensorimotor imagery.

Data Analysis

Analyses of each ERP, physiological, and reflex measure were conducted to assess the effects of stimulus content on imagery. In general, repeated measures analyses of variance (ANOVA) were employed using content as within subjects factors. Statistical analyses were accomplished using the SPSS package (Version 11.0, 2002). Influences of intensity and sensory modality were entered as within-subjects repeated measures (2 (Low, Moderate) x 7 (Gustatory, Olfactory, Cutaneous, Interoceptive, Acoustic, Visual, Kinesthetic)) to assess main effects and interactions

In separate analyses, using mixed-model repeated measures ANOVA individuals identified as “good” and “poor” subjective imagers on the QMI measure of imagery vividness were

compared in terms of emotional reactivity during narrative imagery. The same analysis was then repeated for individuals identified as “good” and “poor” imagers defined by magnitude and consistency of physiological differentiation between low and moderate intensity sensorimotor imagery.

For all analyses that involved repeated measures with more than two levels, the multivariate test statistic (Wilks' lambda) was employed to avoid potential sphericity issues (Vasey & Thayer, 1987).

Results

Participant Characteristics

Same as Study 1.

Physiological Effects of Prompt Intensity and Sensory Modality

Increased physiological reactivity was reliably demonstrated across modalities during moderate compared to low intensity prompts as indexed in orbicularis EMG activity, $F(1, 55) = 10.31, p < .01$, corrugator EMG, $F(1, 55) = 3.87, p < .05^*$, skin conductance level, $F(1, 55) = 9.05, p < .01$, and blink magnitude to the startle probe, $F(1,55) = 4.22, p < .05$ (see Figure 3-2; Table 3-2). No stimulus intensity differences emerged in measures of zygomatic EMG activity, $F(1, 55) = 1.54, ns$, heart rate change, $F(1, 55) = 0.50, ns$, or electrocortical probe responses as indexed by P300, $F(1, 47) = 2.63, ns$.

Concerning differences among sensory modalities, an additional main effect emerged in orbicularis EMG activity, $F(6,51) = 2.36, p < .05$, with the largest increase during imagery of acoustic prompts followed by visual, olfactory, cutaneous, kinesthetic, gustatory and interoceptive imagery (Figure 3-3). Posthoc analyses revealed that imagery of interoceptive

* One-tailed test

experience, resulted in less orbicularis activity than all other sensori-motor imagining, all comparisons, $p < .05$, although still yielded a reliable increase from baseline, $F(1, 56) = 5.49, p < .05$. Corrugator EMG activity was also affected by sensory modality, $F(6,51) = 5.00, p < .001$. As illustrated in Figure 3-4, imagery of cutaneous experience prompted the most increase followed by olfactory, visual, and acoustic imagery. Taken together, these contents elicited significantly increased activity compared to baseline, $F(1, 56) = 11.10, p < .05$. Relaxation below baseline was evident during gustatory, kinesthetic, and interoceptive imagining, $F(1, 56) = 3.81, p < .05^*$.

An interaction between intensity and sensory modality emerged only in terms of orbicularis EMG activity, $F(6,50) = 4.33, p < .001$. Follow-up analyses demonstrated that olfactory, $F(1, 55) = 3.11, p < .05^*$, acoustic, $F(1, 55) = 10.60, p < .01$, and gustatory, $F(1, 55) = 13.49, p < .01$, imagining prompted reliable increases during moderate compared to low intensity prompts, whereas no such difference emerged for cutaneous, kinesthetic, and interoceptive imagery.

Subjective Report of Imagery Vividness During Sensorimotor Imagery

Contrary to expectations, rated vividness of sensorimotor imagery was unrelated to the intensity of the prompts, $F(1, 55) = 0.64, ns$. Sensory modality reliably affected ratings, $F(6, 50) = 17.59, p < .001$. As represented in Figure 3-5, imagery of interoceptive experience was rated as most vivid followed by kinesthetic, visual, acoustic, gustatory, olfactory and finally cutaneous scenes. The relationship between vividness and intensity varied within sense (*interaction*, $F(6, 50) = 9.20, p < .001$) with visual and acoustic prompts yielding higher vividness ratings while the

* One-tailed test

opposite pattern emerged for olfactory and kinesthetic prompts. Cutaneous, interoceptive and gustatory high and low intensity prompts resulted in commensurate levels of imaginal clarity.

Subjective Report of Imagery Vividness: QMI Scores

The sum of ratings of imagery vividness during the sensorimotor task was correlated with imagery vividness and clarity as indexed in the QMI Total score ($r = 0.52, p < .001$). Sensory modality similarly affected rated vividness, $F(6, 49) = 12.81, p < .001$, with interoceptive experiences again rated as most vivid followed by kinesthetic, visual, gustatory, cutaneous, acoustic and finally olfactory scenes (Figure 3-6). Taken together, the experimental vividness and QMI ratings suggest that interoceptive and kinesthetic experiences are imagined with the most subjective vividness whereas olfactory and cutaneous experiences are conjured with less clarity.

“Good” and “Poor” Imagers: QMI Score as a Predictor of Sensorimotor Imagery

Did individuals reporting high subjective clarity of their mental images on the QMI show more pronounced physiological differences between moderate and low intensity sensorimotor imagery? Participants were defined as “good” and “poor” imagers based on subjective reports of imagery vividness on the QMI. Specifically, individuals in the lower quartile of QMI vividness scores (i.e., higher vividness) were defined as “good” imagers ($n = 13$; QMI Mean score = 56.15; $SD = 19.77$) and those in the upper quartile as “poor” imagers ($n = 13$; QMI Mean score = 117.77; $SD = 19.77$). The upper and lower quartiles were selected to maximize detection of potential individual differences and to approximate group means found in previous studies that selected on imagery ability (e.g., Arabian & Furedy, 1983; Miller et al., 1987). Next, a series of 2 x 2 repeated measures ANOVAs were performed assessing good versus poor imager status as the between subjects factor and sensory intensity as the within subjects factor. No significant main effects or interactions emerged in the following physiological measures: orbicularis, zygomatic,

and corrugator EMG, SCL, heart rate, and probe responses in blink magnitude and P300 event-related potentials. The only reliable difference emerged in terms of experimental vividness ratings in that, not surprisingly, those individuals defined as “good” imagers on the QMI rated the imagined sensorimotor experiences as more vivid, $F(1, 24) = 28.17, p < .001$.

“Good” and “Poor” Imagers: QMI Score as a Predictor of Narrative Imagery

Next imagery vividness, again defined subjectively was related to patterns of affective responding during narrative imagery. First, the analytical scheme applied to predict sensorimotor imagery (i.e., upper and lower quartiles on the QMI as criteria for poor and good imagers respectively) was implemented to predict physiological responding during narrative imagery. Again the upper and lower quartiles were selected to maximize detection of potential individual differences and facilitate comparability to prior studies (e.g., Miller et al., 1987). A series of 2 (imager status) x 3 (valence) repeated measures ANOVAs were performed on each of the physiological dependent measures. No significant main effects or interactions emerged in the following physiological measures: orbicularis, zygomatic, and corrugator EMG, SCL, heart rate, and probe responses in blink magnitude and P300 event-related potentials.

“Good” and “Poor” Imagers: “Psychophysiological” QMI as a Predictor of Narrative Imagery

Next imagery vividness was operationalized as more robust discrimination between low and moderate sensorimotor imagery. Specifically, for those measures predicted to discriminate intensity (i.e., SCL, heart rate, orbicularis EMG, and blink magnitude to the startle probe), the difference scores between low and moderate imagery were subjected to unrotated principal components analysis to yield a linear composite. Participants were next divided according to the upper and lower quartile on this vector, with those individuals showing the highest loadings purported to be good physiological imagers and those with the lowest loadings as poor

physiological imagers. Imager status was then related to patterns of affective responding during narrative imagery. A series of 2 (sensorimotor imager status) x 3 (valence) repeated measures ANOVAs were performed on each of the physiological dependent measures.

“Consistent” and “Inconsistent” Imagers: Consistency of Reactivity During Sensorimotor Imagery as a Predictor of Narrative Imagery

In light of the failure to predict narrative responding from magnitude of reactivity during sensorimotor imagery, posthoc analyses were next performed to assess whether *consistency* of physiological differentiation between low and moderate intensity sensorimotor imagery across measures might better predict emotional reactivity. Specifically individuals who showed increased reactivity in four of the five measures predicted to differentiate intensity (i.e., blink magnitude, orbicularis EMG, corrugator EMG, heart rate, and skin conductance) were categorized as “consistent” responders across measures (n = 15; 47% female). In contrast, individuals showing increased reactivity during moderate compared to low reactivity in two or less physiological systems were categorized as “inconsistent” responders (n = 15; 53% female). A series of 2 (consistency status) x 3 (valence) repeated measures ANOVAs were performed on each of the narrative imagery physiological dependent measures.

Table 3-3 lists the main effects and interactions for each of the dependent measures. Consistent responders were expected to demonstrate more reliable affective modulation than inconsistent responders, resulting in a significant valence by group interaction. However, inspection of Table 3-3 reveals that only blink magnitude to the startle probe was suggestive of such a relationship. This trend was followed up by analysis of the separate groups, which demonstrated that consistent responders showed reliable affective modulation (valence main effect, $F(2, 11) = 4.59, p < .05$) whereas inconsistent responders showed no differentiation

among contents (Figure 3-7). A main effect of group also resulted from larger blink magnitude responses during unpleasant contents by consistent responders.

Discussion: Sensorimotor Imagery

Increased somatovisceral and reflex activity was demonstrated during moderate compared to low intensity sensorimotor prompts as indexed in orbicularis EMG, SCL, and blink magnitude to the startle probe. Modest but reliable increase was also evidenced in corrugator EMG. The finding that imagery of simple, context-free, sensory percepts results in discernible activation in efferent physiology and reflexes that covaries with experiential intensity suggests that more intense sensations may be coded in memory with stronger associated somatomotor response elements, which although not prompted explicitly by imagery scripts, are reliably activated during mental imagery.

Interestingly, effects of sensory modality emerged only in corrugator and orbicularis EMG. Overall the two measures showed little similarity in terms of sensitivity to specific imagined modalities. Although, for both measures interoceptive experience resulted in the least reactivity, and in the case of corrugator activity, the most relaxation. Perhaps the relative restriction of expressive facial activity reflected the primarily internally-oriented process of interoception. In contrast the largest response in orbicularis EMG was evinced during acoustic imagery while corrugator tension was the largest during cutaneous imagery, both more externally-oriented experiences. Most investigations of sensory imagery focus on a single modality, however, these preliminary results suggest that comparison of modalities might further elucidate mechanisms of imagined experience.

The reliable physiological differentiation of imagined sensation demonstrated here complements neuroimaging findings on imagined perception showing brain activation patterns akin to in vivo experience. For example, Kosslyn and colleagues (e.g., Kosslyn et al., 2001;

Kosslyn & Thompson, 2003; Kosslyn, Thompson, Kim, Rausch, & Alpert, 1995) have found that mental recreations or “depictions” of simple visual percepts activate neural structures similar to those recruited during perception, including striate and extrastriate cortex, and more recently demonstrating even retinotopically organized activation (Slotnick, Thompson & Kosslyn, 2005). This pattern of sense-specific cortical involvement during mental imagery has emerged for other modalities as well. Concerning kinesthetics, imagery of simple volitional motor movements activates somatotopically organized contralateral primary, premotor and supplementary motor areas (e.g., Binkofski et al., 2000; Ehrsson, Geyer, & Naito, 2003). Imagined gustation results in increased blood flow to both primary and secondary gustatory areas (Kobayashi et al., 2004; Kikuchi, Kubota, Nisijima, Washiya, & Kato, 2005) while imagined hearing reliably activates secondary auditory cortex (e.g., Halpern, Zatorre, Bouffard, & Johnson, 2004; Kraemer, Macrae, Green, & Kelly, 2005; Zatorre & Halpern, 2005). These demonstrated neural correlates of sensation imagery suggest processes that mimic actual experience and, perhaps, result in the efferent outflow exhibited in the current study. These conclusions are, however, necessarily tentative as little work exists in the efferent and reflex physiology of imagining sensory experiences such as taste, smell, touch, and interoception. Furthermore, compared to the previously mentioned neuroimaging studies, the cues employed in the present investigation were much more degraded. For example, in typical sensory imagery studies descriptions of the to-be-imagined percepts are often prompted repeatedly during imagery (e.g., Kobayashi et al., 2004), described with greater specificity at the outset (Slotnick et al., 2005), pre-exposed (Kraemer et al., 2005), exposed as detailed depictions in a separate modality (Kikuchi et al., 2005) and/or practiced (e.g., Ehrsson et al., 2003). Although the differences in the presentation of imagery prompts necessarily limit the comparability of the current to former findings, they

simultaneously suggest that the effects demonstrated here would very likely be more robust under typical presentation modes. Essentially, these results underscore the utility of physiological recording of imagery in assessing unobservable mental phenomena.

Taken together, these findings support efferent outflow as an effect of mental conjuring of simple sensation, which in turn covaries with the intensity of the sensory and motor experience denoted by prompts—presumably owing to stronger associated response elements.

Table 3-1. Text of scripts for psychophysiological experimental test of imagery ability

Sensory/motor system	Low intensity	Moderate intensity
Taste	Tasting mashed potatoes.	Biting into a raw lemon.
Smell	Smelling grass that has just been mowed.	Smelling meat that's spoiled.
Sight	Looking at a blue enameled bowl setting on a red table.	Looking into the sun, squinting to see something clearly.
Sound	Hearing the sound of traffic in the distance.	Hearing someone's nails scrape across a blackboard.
Cutaneous	Smoothing wrinkles in a wool sweater with your hand.	A pin sticking deep into your finger.
Interoception/"organic"	Relaxing in an easy chair.	Your heart pounding as you run upstairs.
Kinesthetic	Lying in bed just before falling asleep.	Pushing hard against a door that's stuck.

Table 3-2. Sensorimotor imagery: Mean response (standard deviation) across measures averaged by intensity

Dependent Measure	N	Low Intensity		Moderate Intensity		Intensity main effect
		M	SD	M	SD	
Sustained responses						
Corrugator EMG Δ (μ V)	56	0.06	(0.80)	0.30	(0.89)	$F(1, 55) = 3.87, p < .05$
Zygomaticus EMG Δ (μ V)	56	0.01	(0.22)	-0.07	(0.47)	$F(1, 55) = 1.54, ns$
Orbicularis EMG Δ (μ V)	56	0.98	(1.45)	1.54	(1.74)	$F(1, 55) = 10.31, p < .01$
Heart Rate Δ (bpm)	56	-0.33	(2.51)	-0.64	(2.86)	$F(1, 55) = 0.50, ns$
SCL Δ (log (μ S + 1))	56	-0.01	(0.02)	0.00	(0.02)	$F(1, 55) = 2.80, p = .05$
Probe responses						
Startle (T-score)	46	50.56	(9.13)	53.88	(8.78)	$F(1, 55) = 4.22, p < .05$
P300 (μ V)	47	2.93	(2.26)	3.49	(2.48)	$F(1, 46) = 2.63, ns$
Evaluative rating						
Vividness (1-9)	56	6.64	(0.91)	6.53	(0.96)	$F(1, 55) = 0.64, ns$

Note. Δ = change; EMG = electromyographic; SCL = skin conductance level; SCR = skin conductance response; bpm = beats per minute; μ V = microvolt; μ S = microsiemen.

Table 3-3. Effects of sensorimotor responder status and valence category on physiology and evaluative ratings of narrative imagery

Dependent measure	N	Valence main effect	Group main effect	Valence x group interaction
Affective communication				
Corrugator EMG Δ	27	$F(2, 26) = 7.16, p < .01$	$F(1, 27) = 9.93, p < .01^a$	$F(2, 26) = 3.90, ns$
Zygomaticus EMG Δ	30	$F(2, 27) = 2.19, ns$	$F(1, 28) = 1.01, ns$	$F(2, 27) = 1.99, ns$
Orbicularis EMG Δ	27	$F(2, 24) = 1.35, ns$	$F(1, 25) = 0.04, ns$	$F(2, 26) = 2.13, ns$
Autonomic mobilization				
Heart Rate Δ	27	$F(2, 25) = 11.35, p < .001$	$F(1, 26) = 0.21, ns$	$F(2, 25) = 1.34, ns$
SCL Δ	28	$F(2, 26) = 0.16, ns$	$F(2, 26) = 1.92, ns$	$F(1, 27) = 0.46, ns$
Action readiness				
Startle	27	$F(2, 24) = 4.56, p < .01$	$F(1, 25) = 2.91, p = .05^a$	$F(2, 24) = 3.08, p = .06$
SCR	26	$F(2, 24) = 2.49, ns$	$F(1, 25) = 1.07, ns$	$F(2, 24) = 0.96, ns$
Attentional engagement				
P300	26	$F(2, 24) = 1.04, ns$	$F(1, 25) = 0.50, ns$	$F(2, 24) = 0.65, ns$
Evaluative ratings				
Pleasure (1-9)	27	$F(2, 27) = 271.26, p < .001$	$F(1, 28) = 0.09, ns$	$F(2, 27) = 0.89, ns$
Arousal (1-9)	27	$F(2, 27) = 107.45, p < .001$	$F(1, 28) = 0.02, p = .05^a$	$F(2, 27) = 0.32, ns$

Note. Δ = change; EMG = electromyographic; SCL = skin conductance level; SCR = skin conductance response; bpm = beats per minute; ^a = Consistent responders demonstrated significantly larger responses than inconsistent responders at $p < .05$; ^b = Inconsistent responders demonstrated significantly larger responses than consistent responders at $p < .05$.

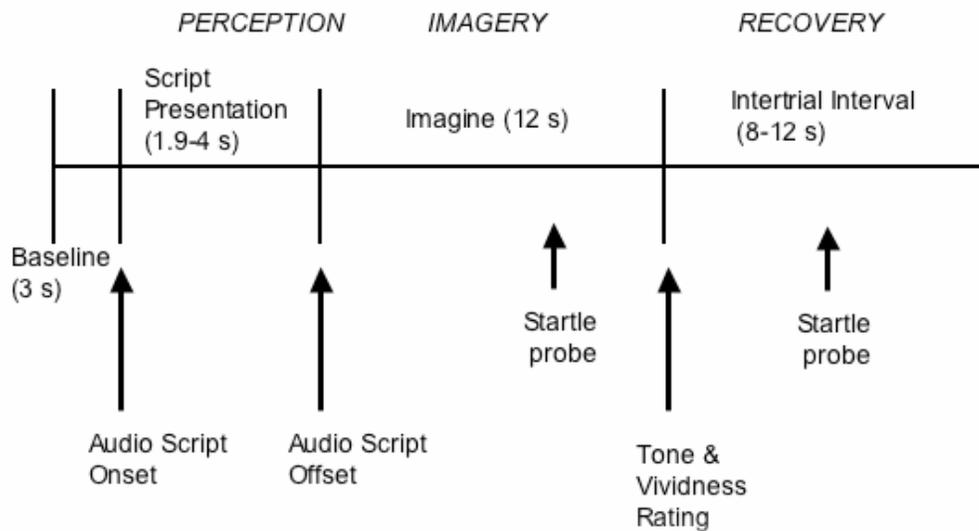


Figure 3-1. Trial structure for sensorimotor imagery. A single trial consisted of an initial 3-second baseline, followed by the onset of a brief auditory script describing a common daily activity with sensory-motor prompts, followed by 12 seconds of imagery, and finally a tone-cued return to relaxation and a rating of imagery vividness. Startle probes were presented 8–10 seconds into each imagery period and 4–6 seconds into the intertrial interval on 50% of trials.

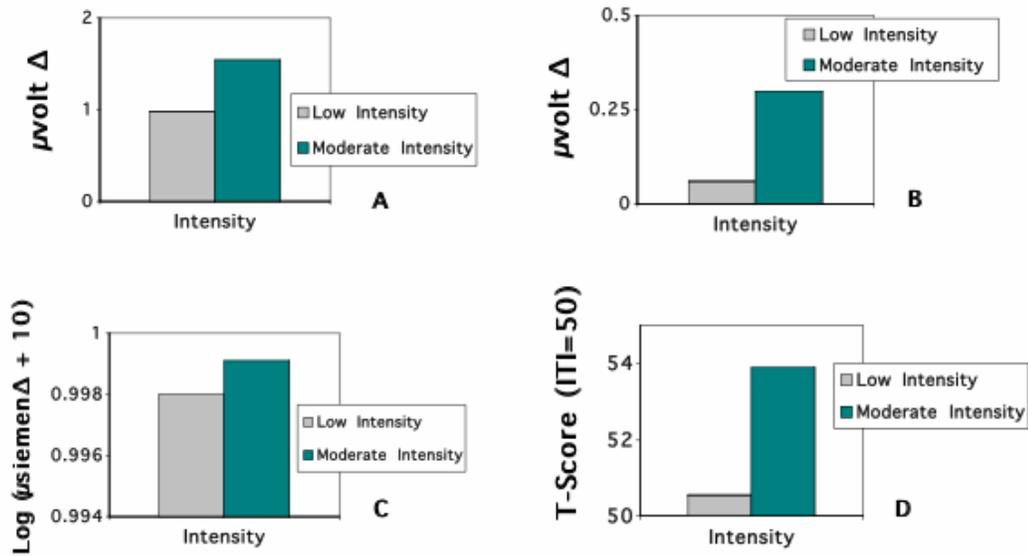


Figure 3-2. Average physiological change during low and moderate intensity sensorimotor imagery. A) Measured in orbicularis EMG ($\mu\text{volt } \Delta$ = microvolt change). B) Measured in corugator EMG ($\mu\text{volt } \Delta$ = microvolt change). C) Measured in SCL ($\mu\text{siemen } \Delta$ = microsiemen change). D) Indexed in blink magnitude to the startle probe.

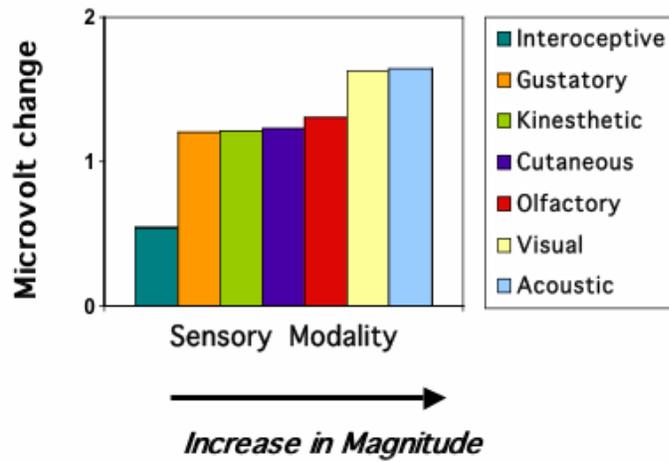


Figure 3-3. Average orbicularis EMG change during during sensorimotor imagery by sensory modality. Sensory modality means on the x-axis are ordered according to response magnitude.

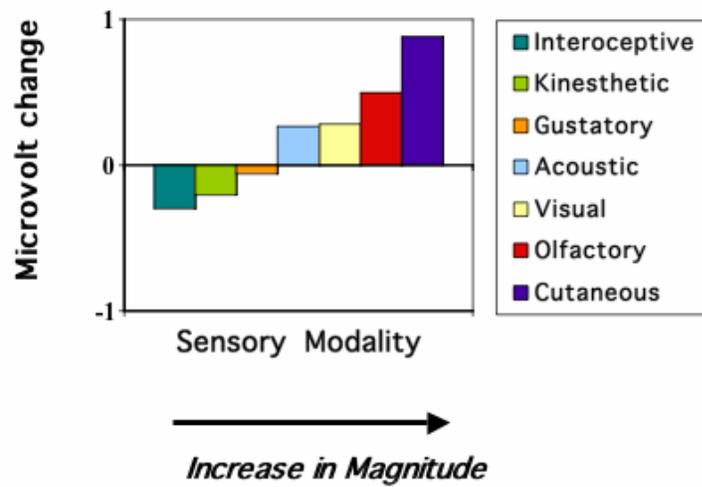


Figure 3-4. Average corrugator EMG change during during sensorimotor imagery by sensory modality. Sensory modality means on the x-axis are ordered according to response magnitude.

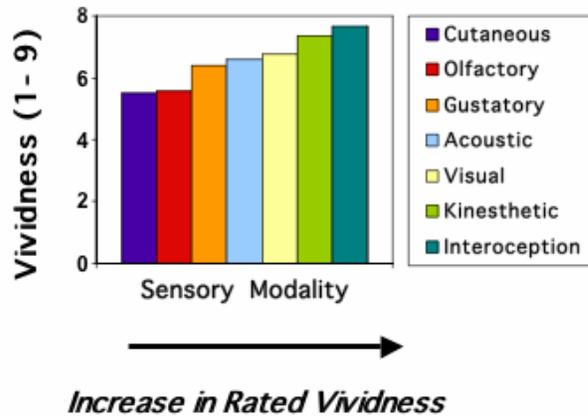


Figure 3-5. Average experimental ratings of imagery vividness by sensory modality. Increasing value indicates more subjective vividness. Sensory modality means on the x-axis are ordered according to increasing vividness.

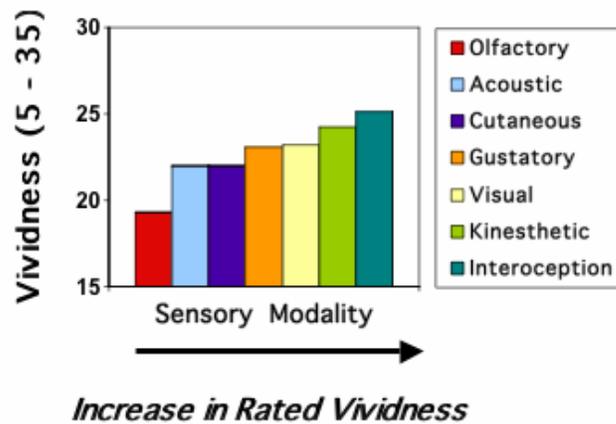


Figure 3-6. Imagery vividness as rated on the Questionnaire Upon Mental Imagery (QMI) averaged by sensory modality. Illustrated means are reverse-scored from the original values. Increasing value indicates more subjective vividness. Sensory modality means on the x-axis are ordered according to increasing vividness.

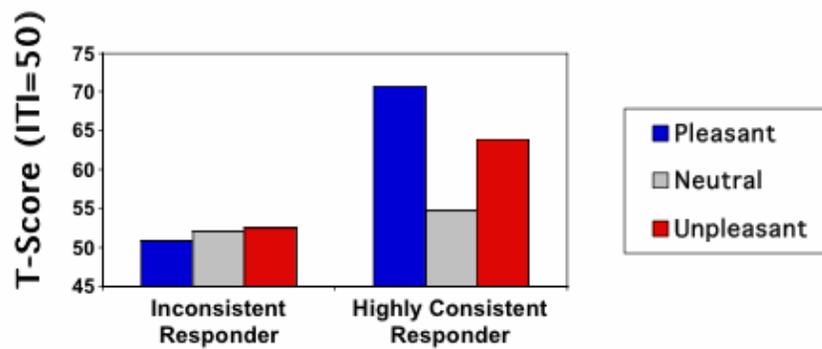


Figure 3-7. Mean blink magnitude to the startle probe during narrative imagery for individuals classified as inconsistent (n = 15) and consistent (n = 15) physiological responders during sensorimotor imagery.

CHAPTER 4 GENERAL DISCUSSION

Imagery Ability and Reactivity to Sensory and Emotional Imagery: Meaningful Associations?

Imagery vividness as rated during both the experimental sensorimotor task and Questionnaire Upon Mental Imagery (Betts, 1909; Sheehan, 1967) were positively correlated and in both sets of responses vividness varied by sensory modality. Across measures interoceptive and kinesthetic experiences were imagined with the most subjective vividness whereas olfactory and cutaneous experiences were conjured with less clarity.

In contrast to the high concordance between subjective measures of vividness (i.e., QMI and experimental ratings), neither measure predicted the extent of physiological reactivity during sensorimotor *or* emotional imagery. Similarly, “physiologically” vivid responders defined as large magnitude responders during sensorimotor imagery did not show more robust affective modulation during narrative imagery. Further, identification of individuals who showed consistent as opposed to inconsistent differentiation between low and moderate intensity sensorimotor imagery across physiological measures only slightly improved predictive power. Specifically, inconsistent responders failed to show valence-modulated startle responding in comparison to intact modulation among consistent responders. However, no other group differences emerged and the generalizability of this finding is clearly limited. Overall subjective imagery ability, reactivity during sensorimotor imagery, and reactivity during emotional imagery were not closely related in the current sample.

These results do not directly address the intended aim of providing an alternative “psychophysiological” Questionnaire Upon Mental Imagery that would more precisely predict the physiology of emotional imagery. However, as noted at the outset, these findings are not wholly unexpected and lead to compelling questions. If subjective imagery vividness, as

demonstrated here is consistent across self-report measures (i.e., QMI and experimental ratings) but does not predict physiological reactivity during imagery, how are respondents defining clarity? Should subjective sensory imagery be expected to predict engagement during more elaborate, multiply-determined images of emotional experience? Lang and colleagues (1980) emphasized that response propositions in emotional images are not limited to perceptual information and, in fact, the data here suggest that responders during percept imagery are *not* the same individuals showing robust affective modulation during narrative imagery.

Imagery Ability, Psychopathology, and Emotional Reactivity

While posing more questions than answering, these results indirectly promote confidence that the observed differences in patterns of emotional reactivity during imagery among fearful and anxious patients are attributable to characteristics central to the respective pathologies other than group differences in imagery ability. In a programmatic series of studies, Lang and colleagues have found that although nearly all anxiety patients report comparable fearfulness and symptoms of anxious arousal, not all anxiety diagnoses show an accompanying physiology of defense (Lang, 1985). While defensive reactions are strong in specific phobics when imagining encounters with fearful scenes, this has not always been true for other diagnoses, notably agoraphobia, panic disorder, and generalized anxiety disorder. The postulate that these differences might be due to imagery ability was raised secondary to Lang and colleagues' (Cook et al., 1988) findings that heart rate increases to fearful imagery were positively related to imagery ability among specific phobics but not for social phobics or agoraphobics. However, in more recent findings with patients the group differences have replicated in that those with circumscribed fearfulness show more pronounced defensive reactivity compared to the attenuated and unreliable responding of those with more diffuse and chronic apprehension and arousal (Cuthbert et al., 2003; Lang, McTeague, & Cuthbert, 2007; McNeil, Vrana, Melamed,

Cuthbert, & Lang, 1993). Whereas the main effect of fearfulness versus anxiety has persisted, the interaction with imagery ability has not (Cuthbert et al., 2003; Lang, McTeague, & Cuthbert, 2007).

Startle Reflex Modulation in Sensorimotor Imagery: Implications for Understanding Startle Reflex Facilitation during Narrative Imagery

Although not an intended aim in the current investigation, the within-subject data on blink magnitude to the startle probe and concurrent probe P300 during imagery of simple sensory experiences as well as more elaborate narratives inadvertently addressed the ongoing debate concerning the processes underlying facilitated startle reflexes during both pleasant and unpleasant imagery. Concerning attentional hypotheses, Panayiotou & Vrana (1998) assessed the effects of externally versus internally-focused attention by examining startle reflex magnitude and heart rate changes during an initial period of acoustically presented digits (perception) and a subsequent rehearsal period (internal elaboration) and found both potentiated startle and accelerated heart rate during rehearsal compared to listen. Furthermore, both startle magnitude and heart rate acceleration increased with the length of digit span to rehearse suggesting influence of cognitive effort or load. The authors concluded that these results, in conjunction with results on affective startle modulation during imagery, indicate that when attention is not engaged to a specific sensory modality, increasing the effortful demand on processing resources increases the startle response.

Miller and colleagues (2002) offered an alternative explanation that the parameters and associated processing demands of imagery versus picture processing yield the different startle patterns. Picture viewing is a passive, perceptual task requiring unimodal orienting to the external sensory environment. In contrast, imagery is a cognitive task requiring purposeful elaboration and disengagement from the external sensory environment. During picture viewing,

the acoustic startle probe is cross-modal and fewer resources are available for processing the stimulus, resulting in reflex attenuation. Conversely, attention is focused internally during imagery and the startle probe functions as an interrupt thereby potentiating responding. The authors further speculated that startle is potentiated proportionally to the extent of engagement in imagery and the degree of processing interruption and that this process is independent of valence-modulated startle.

Bradley and colleagues (1995) further refined the comparisons of internal and external processing influences on the acoustic startle reflex by comparing reactivity during narrative imagery and imagery of an immediately preceding picture. Narrative imagery evoked the expected pattern of commensurate elevations in startle reactivity during both pleasant and unpleasant contents compared to neutral. In contrast, imagery of visual percepts yielded increased startle during unpleasant compared to pleasant imagining, similar to the pattern evoked during viewing of the actual picture. These results suggest that facilitated acoustic startle responding during emotional versus non-emotional imagery is not primarily attributable to interruption of internally-oriented processing exaggerated by cross-modal stimulation. Rather, Bradley et al. (1995) suggested that similar to the interpretation of autonomic and somatic output during imagery and further consistent with the bioinformational model (Lang, 1979), patterns of startle facilitation during imagery of arousing narrative scenarios may be an aspect of the motor and response dispositions engaged during the reinstatement of personal experience and action.

In the current study of simple sensory imagery, startle probes elicited increased blink magnitude during moderate compared to low intensity imagery and no accompanying difference in P300 amplitude. In contrast, narrative imagery prompted increased blink magnitude during emotional (most reliably unpleasant) processing compared to neutral, and coincident reductions

in probe P300 responding. The dissociation in these patterns bears on the postulates of Miller et al. (2002) that startle is potentiated as a function of the extent to which internally-directed attention is interrupted by the intruding, external startle stimulus. In the present narrative imagery study the decreased probe P300 that resulted during emotional scenes (suggesting more attention to emotional imagery) and coincided with increased startle reflex responses are not inconsistent with the premise of Miller and colleagues (2002). However, the lack of differences in probe P300 responses during sensorimotor imagery (suggesting no differences in attentional engagement), in conjunction with the augmented startle during imagination of more intense sensory and motor experiences implicates, rather, the recruitment of stronger somatomotor response elements. Although more research is needed to disentangle this issue, these preliminary data suggest that startle facilitation during imagery cannot fully be explained by degree of attentional engagement. Furthermore these results provide tentative support for the hypothesis set forth by Bradley and colleagues (1995) that startle facilitation during arousing narrative scenarios reflects readiness for action as part of broader motivational mobilization.

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BIOGRAPHICAL SKETCH

Lisa M. McTeague is originally from Lincoln, NH and she received her Bachelor of Arts degree in psychology from Harvard College in Cambridge, MA in June 1998. She matriculated to the doctoral program in clinical psychology at the University of Florida to work with Peter J. Lang, Ph.D. and Margaret M. Bradley, Ph.D. in August 2000. She recently completed her predoctoral internship through the UF Department of Clinical and Health Psychology, focusing on the multimodal assessment and treatment of anxiety and mood disorders.

Lisa's research pursuits have been motivated by a desire to better understand emotional processing and the physiological substrates and concomitants of fear and anxiety. For the last seven years under the mentorship of Drs. Lang and Bradley she has been involved in a series of translational research investigations at the NIMH Center for the Study of Emotion and Attention. These studies have centered on the neuroscience and psychophysiology of emotion using multiple recording methodologies (e.g., startle reflex, autonomic measures, respiration, electromyography, high density EEG, fMRI, eye-tracking) in both unselected and anxiety and mood disorder patient populations. Most recently she spearheaded a program of experiments comparing the extent of defensive reactivity across the anxiety disorder spectrum. These studies, involving over 400 anxiety and mood disorder patients, were motivated by the presumption, on the basis of both current diagnostic nosology and animal models of fear, that all anxiety patients show defense system hyper-reactivity. However, findings to this point suggest a hierarchy of disorders defined by monotonically increasing comorbid psychopathology and negative affect, varying with the degree to which the principal complaint is circumscribed fear (i.e., specific phobia) versus generalized apprehension (i.e., GAD/panic). On multiple self-report measures of anxiety, depression, and functional interference, specific phobics report the least symptomatology followed by those with social phobia, panic disorder, PTSD, and lastly, GAD.

Paradoxically, this ascending hierarchy of self-reported distress is directly associated with a reciprocal reduction in physiological defensive reactivity. These findings echo a growing number of studies that prompt the question motivating much of Lisa's current research: Are anxiety spectrum disorders better represented as discrete diagnoses or a continuum of severity?

In addition to characterizing the comparative physiology and verbal report of anxiety disorder patients, Lisa has a pronounced interest in PTSD research that piqued in college while she worked as a domestic violence and rape crisis counselor. This curiosity spawned her senior honors thesis conducted under the mentorship of Richard J. McNally, Ph.D. at Harvard University. She developed a multivariate, lifespan model of PTSD in female Vietnam veterans applicable to the National Vietnam Veterans Readjustment Study (NVVRS) database. Eager for exposure to multimodal experimental investigation, upon graduation, Lisa began working as a research assistant with Brett Litz, Ph.D. and Mark Miller, Ph.D. at the National Center for PTSD at the Boston VA Medical Center on a parametric psychophysiological investigation of affective processing in Vietnam and Gulf War veterans. Together, these experiences were formative in influencing a lasting involvement in PTSD research. Lisa recently completed an investigation supported by a National Research Service Award (NRSA) Predoctoral Fellowship titled *Traumatic Exposure, PTSD, and Physiological Reactivity*, exploring the reliability and task generalizability of both appetitive and defensive processing deficits in PTSD.

In the future, Lisa intends to investigate means by which psychophysiological and neuroscience techniques can be applied to enhance characterization of symptom constellations, judgments of prognosis, treatment planning, and tracking of treatment progress. For example, if defensive (and/or appetitive) hyporeactivity demonstrated at assessment reflects a fundamental incapacity to engage in emotional processing, intervention specific to this deficit is warranted at

the outset of treatment, prior to exposure-based or similar treatment methods. In short, Lisa is excited about the potential for psychophysiology to augment conventional assessment and treatment methods. For the upcoming year Lisa will be pursuing these research interests as a postdoctoral research fellow at the NIMH Center for the Study of Emotion and Attention.