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Emotional Response to Auditory and Visual Stimuli

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Emotional Response to Auditory and Visual Stimuli

by

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Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree Master of Arts.

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ABSTRACT OF THE THESIS

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Emotion can be studied by measuring physiological, behavioral, and verbal responses to specific stimuli. In current research, it is most common to use visual stimuli to measure the emotional response. One of the most common sets of stimuli used for this purpose is the International Affective Picture Systems (IAPS). An additional set of stimuli, the International Affective Digital Sounds (IADS), was created to be an auditory equivalent of the IAPS. The present study sought to compare the emotional response (measured with Heart Rate, Skin Conductance, and a self report measure of emotion called the SAM) to sounds from the IADS and images from the IAPS. The self report measure has participants rate each stimulus for arousal, valence, dominance, and interestingness by using a nine point scale anchored at one end by calm, unpleasant, not in control, and boring and at the other by excited, pleasant, in full control, and riveting, respectively. The present study also looked at differences in emotional response to sounds and images when they were presented in a pure block (all images and then all sounds or reverse) compared to a mixed block (a block of sounds and images, followed by a block of sounds and images). There were a total of 40 participants (34 female, 4 male; mean age 27.08), all of whom were recruited from a local university. Results revealed a significant difference ($p < .05$) in the heart rate and skin conductance response to sounds versus images. There was also a significant ($p < .05$) difference in self-reported arousal and dominance to images and sounds. Furthermore, there was a significant difference ($p < .05$) between the Pure Stimulus and Mixed Stimulus groups for heart rate and self-reported arousal and dominance. Results from this study do not support the theory that auditory and visual stimuli evoke similar physiological and self-reported emotional responses. Results also suggest that stimulus presentation may play a role in the observed or perceived difference in emotional response.

Emotional Response to Stimuli

Emotion is a construct that everyone knows and can recognize but for which there is not one obvious definition. It has been generally agreed, though, that there is a physiological response that accompanies emotion. In an emotional situation the body reacts, the heart flutters, pounds, and drops, palms sweat, muscles tense and relax, faces flush, smile, and frown (Bradley, 2000). These physical and behavioral changes are experienced subjectively and can be used to differentiate one emotion from another. An individual experiences these physiological and behavioral changes subjectively by noticing, for example, when their heart beats faster or their breathing pattern changes in a situation. The physiological and behavioral changes that we experience ourselves we also notice in others and make assumptions based on these visible physiological states about others' emotional state.

The emotional response to external stimuli is generated automatically by the individual, and is evident through their physiological and behavioral reactions. These physiological responses vary with the type of situation; that is, there is not a universal physiological response to all external stimuli (Lang, 1994). In particular, responding may be described or characterized as occurring on two dimensions. An evoked response may have either a positive (pleasant) or a negative (unpleasant) valence and occurs with a high or low level of arousal (Lang, Bradley, & Cuthbert, 1990). Thus, as the stimulus is interpreted and represented in the brain, it evokes physiological responses and biases the organism towards certain behaviors. In this way, an emotion may be considered, functionally and adaptively, to be a response disposition.

Lang and Bradley (Bradley, 2000; Lang, 1994) theorized that pleasure and arousal are the two basic dimensions that together make up emotion. It has been observed in both animal and human motivational behavior that pleasant situations elicit approach behavior, and unpleasant situations elicit withdrawal behavior. That is, the world appears to be categorized by the valance of the momentary experience, and the extent to which an event promotes (pleasant) or threatens (unpleasant) the individual. Said another way, life can be organized into the behavior of withdrawal versus approach evaluations of each situation. This suggests that this is a foundational characteristic in human (and non-human) emotion (Bradley, 2000).

It has been recognized that motivational behavior in all organisms appears to consist of either approach or withdrawal actions (Schneirla, 1959), with pleasant events eliciting approach behavior and unpleasant events eliciting withdrawal behavior. Approach behaviors include activities that insured individual or species survival, such as finding food, shelter, and a mate. Withdrawal behaviors result in the protection of the individual, such as huddling or fleeing from the situation (Bradley, 2000). When there is a threatening situation, it has been found that both animals and humans may display a variety of responses that include approach, withdrawal, and freezing behavior. However, the specific behavior is dependent upon the individual's past experiences, the context of the threat, and the intensity of the stimuli being experienced (Lang, Bradley, & Cuthbert, 1992). If the organism had not had many experiences or was less evolved (that is, non-complex), Schneirla (1959) suggested that the intensity of the stimulus would be the primary factor determining whether approach and withdrawal behaviors were evoked.

Thus, low-intensity stimuli elicit approach and high-intensity stimuli elicit withdrawal behavior.

Approach and withdrawal behaviors are fundamental to protection and self-sustainment. It appears they are regulated through two separate neural systems that aggressively exert an influence on the probability that the individual will or will not respond with a particular behavior (Fowles, 1988). The appetitive system is specifically for situations eliciting approach motivations, while the aversive system is for situations eliciting withdrawal motivations. It is suggested that pleasant states are driven by the needs of the appetitive system, which include the alimentary, nurturing, and procreating needs of an individual (Lang, Bradley, & Cuthbert, 1992). In addition, the appetitive system is associated with the motivation to do these tasks, and is accompanied by a positive and pleasant internal state. Thus, the appetitive motivational system is a reward seeking (approach) system that responds to incentives (Fowles, 1988). The appetitive system may also be activated in situations that require active avoidance, such as avoiding a punishment, for example.

In contrast, the aversive system manages all protective and defensive functions, and is accompanied by an unpleasant internal state (Lang et al., 1992). The aversive system is activated in situations where it is evident that unpleasant consequences may occur, inhibiting behavior or activating withdrawal and escape responses as necessary (Fowles, 1988). The effect of the aversive or defense system appears as a facilitation of negative or defensive responses, including protective reflexes, with the activation of the withdrawal or negative valence motivational system (Lang et al., 1992).

The appetitive and the aversive systems counterbalance one another. Typically, an increase of activity in one system is associated with a decrease of activity in the other. The inhibition or activation of either the appetitive or aversive system disposes an individual towards taking one or another action and is the motivation behind this potential action. The motivational space is defined by the level of activity in the appetitive/pleasant system, the aversive/unpleasant system, and a third system called the arousal system (calming or excitatory) (Lang et al., 1992). Each of these is believed to reflect separate neural systems. The specific emotions (fear, anger, joy, sadness) experienced by an individual are located within this motivational space.

Before the experience of emotion, there is the presence of the stimulus that could be threatening. The presence of a threatening stimulus engages the brain in a series of responses which includes the pre-encounter phase, the post-encounter phase, and the circa strike phase (Fanselow, 1994). It is important to note that these phases do not always appear in order. In some situations it could be crucial for the organism to oscillate between phases to achieve the best chances at survival. Each phase can be considered through the example of a giraffe at a watering hole. During the pre-encounter phase, he will be taking in the surroundings and scanning for threats, but spend significant time drinking. When he notices the lion that just appeared across the watering hole from him, he observes and watches the lion as a possible threat. During this post-encounter phase, the giraffe may reorganize its behavior depending on the proximity of the lion; despite his thirst, continuing to drink may become less important as the proximity of the lion becomes closer. During the circa strike phase, the giraffe is likely to take action against behaviors by the lion that are sudden and in response to potentially dangerous contact with the lion. Thus, the giraffe will jump away, strike at the lion, or employ other forms of attack or defense such as fleeing (Fanselow, 1994).

During the pre encounter and circa-strike phases, the giraffe responds to the threat by observing, re-directing his attention, or becoming actively engaged in action or defense. With the successful resolution of a circa-strike event, a return to the post encounter phase allows the giraffe to process the reduction in the level of threat and serves as reinforcement of behaviors he may execute the next time there is a lion (Fanselow, 1994). Therefore, the circa-strike phase does not merely elicit a response, but rather it promotes learning of what behaviors worked in the situation and what things did not work (Timberlake, 1993). This could include focusing on the features and actions of the lion that distinguish it as a threat, such as the way he moved towards the giraffe crouched down and ready to attack, or non-threat, such as when the lion drank water and then left without looking at or moving towards the giraffe. All of this information will be used to help the giraffe determine features of animals that are a threat in the future, as well as what actions should be taken to best protect himself in these threatening situations (Timberlake, 1993).

Although exposing people to threatening situations analogous to a giraffe being attacked by a lion is not appropriate, it has been found that the evaluation of visual stimuli not only supports the theory that the dimensions of pleasure and arousal can be used to measure emotional reactions to presented stimuli, but that the specific patterns of response to negative pictures may reflect the pre-encounter, post-encounter, and circa-strike phases of the defense cascade (Bradley, 2000). This research has used pictures from the International Affective Picture System (IAPS), a standardized set of pictures that range in valance from very pleasant to very unpleasant. The research has looked at the relationship between physiological responses and subjective reports of pleasantness and arousal obtained after each picture was shown. It was found that there were consistent patterns of physiological reactivity in response associated with the valence and arousal of each picture. The consistency of these responses has allowed the development of the IAPS normative ratings (Lang, Bradley, & Cuthbert, 1997).

Studies have found that viewing highly arousing visual images, such as mutilations, sexual images, and dramatic action, elicits a similar action and physiological response to that which would be observed in response to a similar live encounter of the event (Bradley et. al, 1993). While viewing the pictures there is an observable change in heart rate, skin conductance, and facial electromyographic (EMG) activity (Lang, Bradley, & Cuthbert, 1990). Moreover, the change varies with the emotional content of the picture (Bradley et al., 1993). The relationship between the physiological response and the rated arousal and pleasure of the pictures allows for the evaluation of emotional responding in human participants (Bradley et. al, 1993). Using a startle probe to elicit the reflex eye blink, a relative increase in EMG response magnitude was observed when the probe was presented during negative as compared with positive pictures. It was concluded that the pictures being viewed activated the aversive system. This suggested that the response was emotional in nature, activating the individuals' core motivations to approach or avoid the situation depicted in the picture.

Subsequent to the development and norming of the IAPS, Bradley and Lang (2000) compared the self-reported arousal level to a set of naturally occurring sounds to that elicited by the IAPS. When doing this comparison, the self reported arousal level for the sounds was compared to the normative self-reported arousal levels for the IAPS. It should be noted that a between subjects design was used in the initial stages of forming the IADS. Results of this study indicated that there was a similar arousal response to the auditory stimuli as to the visual stimuli. It was also found that free recall was greater for emotionally arousing auditory stimuli as compared with non-arousing visual and auditory stimuli. In a second experiment, the researchers used a different set of participants and had them listen to the same set of sounds while also using a visual startle probe to measure the EMG response, heart rate, and skin conductance. When listening to unpleasant sounds versus pleasant sounds, a greater startle response was evoked, as evidenced by more EMG activity and an increase in heart rate. This replicated the pattern of response reported with visual images from the IAPS. The authors concluded from the two experiments that auditory stimuli activate the appetitive and aversive systems in a similar manner to the visual stimuli.

The study found that the IADS to be a comparable set of stimuli to the IAPS in that they both elicit a similar startle response modification as well as skin conductance and heart-rate responses. Although these studies were a part of the development of a normative dataset for the IADS auditory stimuli, Bradley and Lang did not include comparisons between an individual's own self reported and physiological experience to *both* the auditory *and* visual stimuli. That is, all of the comparisons were between individuals responding *only* to IAPS or *only* to IADS stimuli. This leaves open the question of whether or not an individual experiences a similar level of emotional arousal to, say, a picture that shows someone being shot as they do to the sound of a gun shot.

This study aimed to compare the individual's self reported and physiological response to *both* auditory and visual stimuli. Furthermore, this study aimed to examine the effect of stimuli ordering on emotional response, which is a methodological issue not addressed in previous research on emotional response. The current study design allows for within subject comparisons of differences in the emotional response to auditory and visual stimuli, as well as between groups comparisons of the effect of stimulus ordering on emotional responses to auditory and visual stimuli. It is expected that the results will help to bridge our understanding of the relationship between emotional responses generated within an individual's auditory and visual systems.

Hypotheses

Primary hypothesis 1. It was hypothesized that the response pattern to positive and negative valence stimuli will be parallel whether the stimuli are visual or auditory. Specifically, subjects would not differ in their measured skin conductance during the presentation of the visual stimuli compared with the auditory stimuli (Hypothesis 1A), nor would they differ in their valence or arousal ratings for the visual compared with the auditory stimuli (Hypothesis 1B). Finally, it was hypothesized that subjects would not differ in their heart rate response for the visual compared with the auditory stimuli (Hypothesis 1C).

Primary hypothesis 2. It was hypothesized that there would be no effect of stimulus ordering. Specifically, it was hypothesized that there would be no difference in responses for participants in the group that is exposed to separate blocks of auditory stimuli and visual stimuli as compared to those in the group exposed to blocks of mixed auditory and visual stimuli. Specifically, it was predicted that there would be no difference in skin conductance responses during the presentation of stimuli blocked by modality compared with auditory and visual stimuli mixed within blocks (Hypothesis 2A). Furthermore, it was hypothesized that there would be no difference in the valence or arousal ratings of stimuli presented blocked by modality compared with auditory and visual stimuli mixed within blocks (Hypothesis 2B). Finally, it was expected that there would be no found difference in the heart rate response to stimuli presented blocked by modality compared with auditory and visual stimuli mixed within blocks (Hypothesis 2C).

Methods

Participants

The sample consisted of 40 undergraduate psychology and sociology students from California State University at San Bernardino. Any participant who signed up for the study was allowed to participate as long as they were literate in English, had normal or corrected to normal vision, and normal hearing.

Participants ranged in age from 18-50 years (mean age = 27.08). Of these participants, three were left-handed and thirty-seven were right handed. There were 34 females and six males in the study. See Table 1 for demographic descriptive characteristics of participants.

Table 1

Demographic Descriptive of Participants

Demographic Characteristics	Percentage (Raw #)	Mean (SD)
Gender		
Female	85.0% (34)	
Male	15.0% (6)	
Age		27.08 (1.37)
Handedness		
Right Handed	92.5% (37)	
Left Handed	7.5% (3)	

Measures

Visual and auditory emotional stimuli. The visual stimuli came from the International Affective Picture System (IAPS) with each of three affective categories represented: positive, neutral, negative (Lang & Greenwald, 1988; Lang, Ohman, & Vaitl, 1988). Normative ratings from the system were used to define affective categories. Slide affect ratings have been validated in a number of independent samples (Lang, Bradley, & Cuthbert, 2005). Greenwald, as cited by Lang, Bradley, and Cuthbert (2005) validated the IAPS using the test and re-test form of validation, through self-reported expression of emotions. The reliability of the IAPS has been established across multiple groups using a self-report instrument known as the Self Assessment Manikin (SAM), which includes visual depictions of changes in valence, arousal, dominance, and interestingness. Veruschuere et al. (2001) found that when comparing groups, the reliability coefficients indicated that there was good internal consistency. This indicates that the IAPS is not only measuring what we think it is measuring, it is doing so across individuals and groups. The negative and positive slides were equivalent overall in rated arousal, and both of these affective categories were more arousing than the neutral category slides.

In the current study, each affective category included a total of 10 visual images for each valance (positive, negative, and neutral). The negative slides included mutilated bodies or faces, spiders, snakes, a gun, and a man receiving an injection. Neutral slides included common household objects, for example, a hair dryer, a book, and a fork. Positive slides included opposite-sex nudes, smiling children, cute animals, and appetizing food.

The auditory stimuli were selected from the International Affective Digital Sounds – 2nd Edition (IADS-2), (Bradley & Lang, 2007). The IADS is a standardized collection of sound clips that have good convergent validity that was established using the SAM. In parallel with the visual stimuli, there were 10 sounds presented for each valance category, which translates to a total of 30 sounds presented to each participant. A limitation of this study is that the reliability of the IADS-2 has not been as well validated as the IAPS. Only one other study appears to have previously used the IADS (Bradley & Lang, 2000).

When selecting the stimuli from the IADS and IAPS they were matched by valence and arousal ratings (Appendix B and C) based on the normative ratings. This meant that the ten stimuli from each valence category (negative, neutral, and positive) from the IADS and the IAPS were chosen in a matched fashion. When a T-test was run to compare the normative valence ratings for the IADS and IAPS for each of the valence groups, it was found that the chosen stimuli were not significantly different based on valence. When a T-test was run to compare the normative arousal rating for the IADS and IAPS for the valence groups it was found that the IAPS negative and neutral stimuli were rated as significantly more arousing than the IADS negative and neutral stimuli. This was despite the fact that the chosen stimuli were matched one for one based on the valence ratings. The results of this comparative analysis can be seen in Table 2.

Heart Rate. The recording of heart rate activity was accomplished by attaching a photoplethysmograph to the middle finger of one hand. This device allowed the measurement of pulse waves through the blood vessels of the finger. Inter beat intervals were recorded in milliseconds and then converted to heartbeats per minute for every half-second interval (or bin) beginning two seconds before the stimulus and continuing for a total of ten seconds. Change in heart rate was defined on a trial-by-trial basis as the bin-

Table 2

Equivalence of Normative Ratings for 100 individuals for arousal and valence for the IADS and IAPS

Normative Rating	IADS Mean(SD)	IAPS Mean(SD)	T (p-value)
Valence			
Negative	1.03 (1.52)	2.2 (1.5)	-0.77 (p>.05)
Neutral	4.92 (1.69)	5.01 (1.08)	-0.42 (p>.05)
Positive	7.35 (1.76)	7.41 (1.77)	-0.22 (p>.05)
Arousal			
Negative	7.41 (1.52)	6.72 (2.12)	2.48 (p<.05)
Neutral	4.86 (1.69)	3.79 (1.94)	4.14 (p<.05)
Positive	6.09 (1.76)	6.25 (2.26)	-0.56 (p>.05)

to-bin change referenced to the individual's baseline in the bin immediately preceding the stimulus presentation.

Skin Conductance. Skin conductance was measured from the distal phalanges of the first and third finger of one hand using 8-mm Ag-AgCI electrodes filled with conducting paste. Skin conductance was defined as the largest increase from the participant's baseline observed during the presentation of each stimulus, with the onset occurring between one and four seconds following the presentation of the visual or the auditory stimulus.

Stimulus ratings. Each participant was asked to rate each stimulus using a computerized ratings system with a 9 point scale for pleasure, arousal, and dominance (Lang, 1980) and interestingness. The first three are equivalent to the SAM self reported ratings described above. Interestingness has been added in the measure of emotional response to the SAM for a complete look at the individual's perspective. The SAM has good face validity, because it is a self-reported measure about how a stimulus made an individual feel or react. The SAM has also been found to have good internal consistency and reliability across groups (Backs, Silva, & Han, 2005). The SAM and similar self report measures of pleasure, arousal, dominance, and interestingness have been used in previous studies with the IAPS (e.g., Lang, Greenwald, Bradley & Hamm, 1993).

Procedure

Individuals were assigned to one of two groups in counterbalanced order of appearance in the lab. There were 20 participants in group A (pure stimulus group), and 20 participants in group B (mixed stimulus group). The gender and age of each participant was recorded. Due to some equipment malfunctions, Heart Rate and Skin Conductance data was collected for 37 participants (19 in group A, and 17 in group B).

After participants provided informed consent, they were seated in front of the computer and had electrodes and the photoplethysmograph placed on their right hand to measure heart rate and skin conductance. Participants were told that they would see pictures on the computer screen and hear sounds through the external computer speakers, that the pictures and sounds would range from pleasant to unpleasant, and were asked to attend to each stimulus for the entire time it was presented.

Each visual stimulus was presented for 6 seconds and each auditory stimulus for 3 seconds followed by an 18 to 24 second inter-stimulus interval (average ITI = 21 s). Participants in the pure stimulus group received blocks of all auditory stimuli and of all visual stimuli in counterbalanced order across participants (with some getting auditory first, and other getting visual stimuli first). The mixed stimulus group was exposed to two blocks containing both auditory and visual stimuli varying from trial to trial. Within blocks the auditory and visual stimuli were presented in a random order.

After all of the stimuli were presented once, the electrodes were removed and the participants were asked to go through each sound and picture individually again in the same order, and rate them on a nine point scale for arousal, valence, dominance, and interestingness. For arousal, the nine point scale was anchored at 1 by calm, and at 9 by excited. Valence was anchored at 1 by unpleasant, and at 9 by pleasant. Dominance was anchored at 1 by not in control, and at 9 by in control. Lastly, Interestingness was anchored at 1 with boring, and at 9 with riveting.

After the ratings were completed, the participants were asked if they had any questions or feedback about the study. Each participant was then informed that the study was looking at the physiological and self-reported emotional response, and whether this response was different to auditory and visual stimuli. They were also given the contact information of the researcher and told that results of the study would be provided to them at the conclusion if they were interested.

Design and Analysis

A power analysis was conducted *a posteriori* using G power 3 (Faul, Erdfelder, & Buchner, 2007), which showed that with a sample size of 40 using a repeated measures ANOVA mixed design, a power of 0.40 was obtained.

Design: The present study was a mixed, within subjects, and between groups experimental design. The between subjects variable was group membership, either pure stimulus group (auditory or visual stimuli followed by either auditory or visual stimuli) or mixed stimulus group (mixed blocks of visual and auditory stimuli). The independent variables examined within subjects were stimulus modality (auditory or visual), and the stimulus valence (positive, negative, or neutral). The study investigated the following dependent variables: individuals' self-report of valence, arousal, dominance, and interestingness, as well as the physiological responses of skin conductance and heart rate change.

The analyses included multiple within-between groups mixed design ANOVAs for each of the relevant dependent variables. The analyses included the between participants factors of group membership (Mixed stimulus design or Pure stimulus design) and repeated measures for image valence (neutral, negative, and positive) and the modality of the stimulus (auditory or visual stimulus). The dependent variables included heart rate (HR) and skin conductance response (SCR) response during exposure to the stimulus, and the self report measure SAM (Dominance, Valence, Interestingness, and Arousal).

In all cases of possible violation of the sphericity assumption, the conservative Greenhouse-Geisser correction has been used. In presenting the results, the uncorrected degrees of freedom are reported along with the corrected p-value and the ε correction factor.

Results

Heart rate generally decelerated after onset of the stimulus, reaching a nadir after about 5 seconds and recovered to baseline within 3 seconds of picture offset. There were no significant main effects found. Critically, this includes a non significant main effect of Heart Rate $F(14, 22) = 169.82$, $p = 13.5$ and a Modality x Heart Rate interaction, $F(14, 22) = 2.55$, $p = 0.024$, $\eta 2 = 0.81$. The significant Modality x Heart rate interaction had a quadratic effect p=0.01, which reflected a pattern of deeper deceleration for the images than for the sounds (the magnitude of change can be seen in Figure 1). Furthermore, a significant Valance x Modality x Group Membership interaction was found $F(2, 34) = 3.95$, $p= 0.03$, $\eta 2= 0.67$, reflecting a pattern for the mixed stimulus group in which negative stimuli produced deeper decelerations than neutral and positive stimuli for both sounds and images. The pure stimulus group presented a deeper deceleration for positive sounds, followed by less of a deceleration for negative sounds, and the least deceleration was for neutral sounds. For the same pure stimulus group, the images produced a deeper deceleration for negative, neutral, and then positive images. Critically, none of the other effects involving the Modality or Heart Rate factors were significant, F's < 9.54, p's > 3.61. No other main effect or interaction was significant.

There was a significant main effect of Modality on the skin conductance response $F(1, 8.1) = 8.11$, $p = 0.007$, partial $\eta 2 = 0.16$, $\varepsilon = 0.79$, with linear $F(1, 125) = 3.81$, $p = 0.05$, partial $\eta 2 = 0.03$, effects for Auditory and Visual Stimuli (the magnitude of change can be seen in Figure 2). There is also a significant main effect for valence $F(2, 6.37) = 6.28$, $p = 0.004$, partial $\eta 2 = 0.14$, $\varepsilon = 0.86$. Quadratic effects were found across valences, $F(1, 1) = 12.90$, $p = 0.001$, partial $\eta 2 = 0.25$. Inspection of means indicates that there is a similar skin conductance response to negative and positive sounds and pictures, and less of a skin conductance response for neutral sounds and pictures. Critically, there was not a main effect for Group Membership $F < 61.1$, $p > 0.35$, and there were no further significant interactions found for Modality, Valence, and Group Membership.

When looking at the Self Report of Perceived Valence, there was a significant main effect across Valence $F(2, 84.07) = 0.52$, $p = 0.001$, $\eta 2 = 0.52$.. Results reflected a linear pattern $F(1, 135) = 286.96$, $p = 0.001$, $\eta 2 = 0.87$, where for both auditory and visual stimuli the negative stimuli were rated as more negative, the neutral as being neutral, and the positive stimuli as being positive. Critically, there were no significant main effects or interactions for Modality or Group Membership factors, F's < 1.90, p's > 0.52.

When looking at the Self Report of Perceived arousal, there was a significant main effect found $F(2, 113.5) = 0.7$, $p = 0.001$, $\eta 2 = 0.88$ across Valence. Results reflected a linear and quadratic pattern $F(1, 113.5) = 286.96$, $p = 0.02$, $\eta 2 = 0.13$, and $F(1, 135) = 286.96$, $p = 0.001$, $\eta 2 = 0.81$, where for both auditory and visual stimuli the negative stimuli were rated as more arousing, the neutral as being neutrally arousing, and the positive stimuli as being more arousing than neutral but less arousing than the negative stimuli. A significant Valence x Group Membership interaction was found, $F(1, 10.43) = 3.46$, $p = 0.04$, $\eta 2 = 0.84$, with the individuals in the Mixed Stimulus Group reporting the Positive Auditory stimuli as more arousing than those in the Pure Stimulus Group. The participants in the Pure Stimulus Group reported the negative stimuli to be more arousing than the individuals in the Mixed Stimulus Group. A Modality x Valence interaction $F(1, 2.66) = 3.94$, $p = 0.02$, $\eta 2 = 0.94$ was found, which reflects a pattern of neutral pictures being rated as less arousing than neutral sounds. There were no other main effects or interactions F's < 3.54, p's > 0.069.

When looking at the Self Report of Perceived Interesting, there was a significant main effect across Valence $F(2, 275.53) = 79.26$, $p = 0.001$, $\eta 2 = 0.68$. A quadratic pattern was reflected in the ratings $F(1, 132.25) = 186.08$, $p = 0.001$, $\eta 2 = 0.83$, where for both auditory and visual stimuli the negative stimuli were rated as most interesting, then positive stimuli, and neutral stimuli as the least interesting. Critically, there were no significant main effects or interactions for Modality or Group Membership factors, F's < 2.16, p's > 0.12.

When looking at the Self Report of Perceived Dominance, there was a significant main effect across Valence $F(2, 14.89) = 0.45$, $p = 0.001$, $\eta 2 = 0.45$. Results reflected a linear pattern $F(1, 225.02) = 22.91$, $p = 0.001$, $\eta 2 = 0.38$, where for both auditory and visual stimuli the negative stimuli were rated as least dominate, then neutral stimuli, and positive stimuli as the most dominate. A significant Modality x Group Membership interaction $F(1, 10.43) = 5.01$, $p = 0.04$, $\eta 2 = 0.84$ and Modality x Valence interaction $F(1, 5.02) = 3.94$, $p = 0.03$, $\eta 2 = 0.12$ was found. Individuals reported different levels of dominance for neutral sounds as well as for negative images. There were no other significant main effects or interactions, F's < 3.50, p's > 0.07.

Discussion

The Emotional Response theory as outline by Bradley and Lang (2000) states that the emotional response as observed by physiological and self-reported data will be similar across stimulus modalities. This suggests that the Heart Rate, Skin Conductance, and Self report to emotional (Negative, Positive, and Neutral) sounds will be similar to emotional pictures. Furthermore, the theory states that the order of stimuli presented will not change the measured emotional response of the participant.

Hypothesis One

Hypothesis one states that the emotional response to valence (negative, neutral, positive) will be the same for the sounds and the images, as measured by Heart Rate, Skin Conductance, and the four Self Report Measures of the SAM (Valence, Arousal, Interestingness, and Dominance). This hypothesis was not completely supported, with difference across modalities found for Heart Rate, Skin Conductance, Self Reported arousal, and Self Reported Dominance. There were differences found for Skin Conductance, and all four Self Report measures of the SAM across the valence types for both the images and the sounds, in keeping with expectations and consistent with previously established normative data for both the IADS and the IAPS.

It was found that when individuals viewed the images there was more deceleration in Heart Rate than when they heard the sounds. This finding implies that images we view elicit more of an emotional response than the sounds we hear. This is further supported by the finding of a significantly greater skin conductance response to the images than to the sounds. This finding implies that the images elicit more of an emotional response than the sounds for the two primary physiological measures of emotional response.

There were also differences found for self report of Arousal and Dominance, however when looking at a comparison of the auditory and visual stimuli chosen for the study there were significant differences in the arousal ratings between them. It was found that the visual stimuli (based of normative ratings) were more arousing, which explains the self reported statistical findings for this study. Although these findings were significant, it appears to be a result of un-matched auditory and visual stimuli during the construction of the project and are duplications of what the normative data indicated should be found between the groups.

One of the limitations that should be noted for this hypothesis is the small and homogenous sample used. The observed power for the primary analyses ranged from 0.4 to 0.8, which indicates that there were fewer participants than needed to find a significant difference. Furthermore, the sample was predominantly female and entirely college students. This could limit the generalizability of the results found. Furthermore, it is important to note that the conditions in which the data were collected were artificial and contained. That is, the images and sounds used to elicit emotional response may realistically differ from those elicited by actual dangerous/threatening or pleasurable situations. Lastly, a limitation to this study was the lack of similarity in arousal ratings between the IADS and IAPS stimuli used in the study.

Hypothesis Two

Hypothesis two states that the response to valence (negative, neutral, positive) will be the same for the Pure Stimulus Group (a block of images followed by a block of sounds or reverse) and Mixed Stimulus Group (a block of sounds and images, followed by a block of sounds and images), across Heart Rate, Skin Conductance, and the four Self Report Measures of the SAM (Valence, Arousal, Interestingness, and Dominance). This hypothesis was supported party through difference found for Groups in Heart Rate response. It was found that for Heart Rate, individuals in the Mixed Stimulus group had the greatest deceleration for negative, then neutral, and then the least deceleration for positive images and sounds. A similar pattern of deceleration was found with the images for the Pure Stimulus Group, with the greatest deceleration for negative images, then neutral, and the least deceleration for positive images. However, for the Pure Stimulus Group it was found that the positive sounds produced the greatest deceleration, then the negative sounds, and lastly the neutral sounds. This indicates that the theory is not supported when comparing the Heart Rate response to sounds in a Mixed Stimulus Group to the Heart Rate response to the sounds in a Pure Stimulus Group.

The differences in emotional response to mixed stimuli presentation verses pure stimuli presentation is further supported by the self reported arousal and dominance ratings. Individuals in the Mixed Stimulus Group found the positive stimuli to be more arousing than those in the Pure Stimulus Group. The individuals in the Pure Stimulus Group rated the modalities significantly different than those in the Mixed Stimulus Group in regards to perceived dominance. Individuals in the Mixed Stimulus group rated the negative auditory stimuli as more dominate than the negative visual stimuli, while participants in the Separate Stimulus group did not rate the auditory and visual stimuli differently for dominance. This finding indicates that how the stimuli are presented affects the self-reported emotional response to the stimuli.

The primary limitation for this hypothesis is the sample size, as reflected in the observed power ranging from 0.1 to 0.4. With a greater number of participants, other between group differences might have been found. Furthermore, the sample is homogenous in regards to gender and population demographics.

The findings of this study show that individuals' automatic physiological response to emotional sounds and images are different than how they are cognitively responding. That is, there seems to be a disconnect between how we think we feel about emotionally provocative stimuli and how our body perceives the threat or safety of that situation. It becomes evident in these data that although individuals are perceiving that the sounds and images are similar in emotional content, the brain (as reflected by physiological responses) perceives that images are more emotional than sounds. This suggests that individuals could misjudge a situation if they are relying on their cognitive perceptions of a situation instead of their physiological response. It also suggests that as humans we perceive (at a physiological level) that visual stimuli are more emotionally stimulating than auditory stimuli.

In conclusion it appears that there are differences in how individuals respond to images verses how they respond to sounds in their environment. The pure fact that individuals are more surrounded my images through television, the computer, video games, and even cell phones led to the question of what if any difference could there be in someone who does not see. Since only sighted participants were used the findings in this study could be due to the un-familiarity to the sounds, or the possibility that images and sounds are categorized differently for the individual's brain. It is evident that there are differences in the way the body reacts and wants to respond to emotional stimuli, it is just not clear as to why the presentation order of stimuli or the nature of the modality affects not only perceived by physiological response.

Future Directions

Since the study was underpowered, it would be critical to do a study with a larger and more diverse sample. Furthermore, since the findings are contrary to the theory and other preliminary studies looking at the difference in emotional response to images and sounds (the IAPS and IADS), a follow up study to confirm the findings would be beneficial. This would allow for confirmation of the differences in emotional response to stimuli, and if the theory around this should be revisited or revised.

Since there were differences found in the emotional response to images and sounds, it would be interesting to examine whether these differences are consistent when examining the emotional response to sounds by blind individuals and the emotional response to images by sighted individuals. This would allow for further understanding of emotional responses to auditory and visual stimuli and the connection to a dominant/primary sense of sight.

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Appendix A

Copy of Consent Form

Informed Consent Document For

Emotional Response to Visual and Auditory Stimuli

Principal Investigator: Paul Haerich
Co-Investigator: Amy Pitchforth

Purpose

You are invited to participate in this research study to help us better understand the way people respond to different types of visual and auditory stimuli. This research study will investigate the way people respond by measuring physiological responses to and self-reported ratings of the stimuli presented. The pictures and sounds you will be viewing have been chosen to cover a variety of things individuals might encounter in their life.

Procedure

During this study, you will view a series of pictures and sounds. The pictures depict various subjects including (listed alphabetically): animals, guns, household objects, human nudes, nature scenes, mutilations, plants, rocks, snakes, spiders, sports scenes, etc. The sounds include a comparable subjects including (listed in alphabetic order): baby crying, gunshot, hair drier, laughter of children, running water, the wind etc.

This research study involves collecting information regarding physiological and self-reported responses to each stimulus. This will be done with two sensors that may be taped to two of the fingers of your non-dominant hand. These sensors will be used to measure small changes in the amount of sweat being produced – an indicator of small changes in the activity level of the sympathetic division of the autonomic nervous system. You may also have a small pulse meter placed on your middle finger to measure your heart rate. The configuration of sensors will be described in more detail by the experimenter.

During the study each picture or sound will be presented for a few seconds, followed by a short break, and then next picture or sound will be presented. You should continue to view each picture or listen to each sound for the entire time it is presented. There is no need for you to perform any task during the presentation of the pictures and the sounds. Just view or listen to each stimulus and allow yourself to respond to the content naturally. During the second portion of the study all of the pictures and sounds will be presented again and you will be asked to rate each one.

We encourage you to ask questions about the instructions or any aspect of the task(s).

You are free to discontinue your participation without negative consequences at any time simply by letting the experimenter know that you wish to do so. That is, you will receive full participation credit whether or not you complete the session.

It will take approximately 50 minutes to complete your participation in this study.

Risks

The pictures and sounds used in this study are intended to evoke a range of responses and may be perceived by some as disturbing. Given this range, you may feel uncomfortable while viewing and hearing some of the pictures and sounds.

None of the stimuli or procedures used in this research study poses a risk beyond that which may be expected in everyday life. Therefore, the committees at both CSU San Bernardino (Department of Psychology Institutional Review Board Sub-Committee) and Loma Linda University (Institutional Review Board) that review human studies have determined that participating in this study exposes you to minimal risk. The official stamp appearing on this form indicates this approval.

Benefits and Reimbursement

You should not expect to receive any direct benefit from your participation in this research study other than the educational experience of participating in a scientific psychological research project.

We anticipate that the results of this study will help advance our understanding of how people respond to emotional stimuli and the differences and commonalities among them. In particular, because these stimuli are commonly used in research, we hope that this study will help us better understand the results of other studies using them.

Compensation

Although not a benefit from the research study itself, you may receive extra credit for a course. If you are a student at CSUSB, you may receive extra credit points for your class, at your instructor's discretion. You will receive 4 credits via the SONA system after you finish the study.

Confidentiality

All of the information gathered during your participation in this research study is confidential and will be handled anonymously. That means that your name will not be attached to or stored with any of your responses or physiological data. The responses of individual participants will not be disclosed to anyone. The information you provide will be grouped with that of other participants. Any publications or presentations resulting from this study will refer only to the grouped results.

Third Party Contact & Questions

If at any time you have any other questions regarding your participation in this study, you should feel free to contact Paul Haerich, PhD at the Department of Psychology, Loma Linda University. (Phone: 909-558-4770).

If you wish to contact an impartial third party not associated with this study regarding any complaint about the study, you may contact the Office of Patient Relations, Loma Linda University Medical Center, Loma Linda, CA 92354 (phone: 909-558-4647), for information and assistance.

Participant's Rights

Participation in this study is voluntary. If, after signing this consent form, you decide to discontinue the session at any time, for any reason, you are free to do so. You will receive participation credit whether you complete the session or not. If you have any questions regarding this study, we will be happy to answer them.

Consent Statement

By writing my study ID number in the space below I acknowledge that I have been informed of, and that I have understand, the nature and purpose of this study, and I freely consent to participate. I have read the contents of the consent form and have been given the opportunity to ask questions concerning the study. I have been offered a copy of this form. I acknowledge that I am at least 18 years of age. I hereby give my voluntary consent to participate in this study. Signing this consent form does not waive my rights nor does it release the investigators or institution(s) from their responsibilities. I may call Paul Haerich, Ph.D. at (909) 558-4770 if I have additional questions or concerns.

Participant's Study ID: _______

Date: ___________

Appendix B

IAPS Image List with Valence and Arousal

Image Group	IAPS Number	Valence	Arousal
Negative	1019	3.95	5.77
Negative	1220	3.47	5.57
Negative	2811	2.17	6.9
Negative	3000	1.45	7.26
Negative	3010	1.71	7.16
Negative	3030	1.91	6.76
Negative	3530	1.8	6.82
Negative	6350	1.9	7.29
Negative	9410	1.51	7.07
Negative	9810	2.09	6.62
Neutral	1935	4.88	4.29
Neutral	2038	5.09	2.94
Neutral	2220	5.03	4.93
Neutral	2351	5.49	4.74
Neutral	2780	4.77	4.86
Neutral	7002	4.97	3.16
Neutral	7020	4.97	2.17
Neutral	7034	4.95	3.06
Neutral	7179	5.06	2.88
Neutral	8466	4.86	4.92
Positive	1710	8.34	5.41
Positive	4220	8.02	7.17
Positive	4607	7.03	6.34
Positive	4608	7.07	6.47
Positive	4676	6.81	6.07
Positive	5260	7.34	5.71
Positive	7230	7.38	5.52
Positive	7270	7.53	5.76
Positive	8030	7.33	7.35
Positive	8490	7.2	6.68

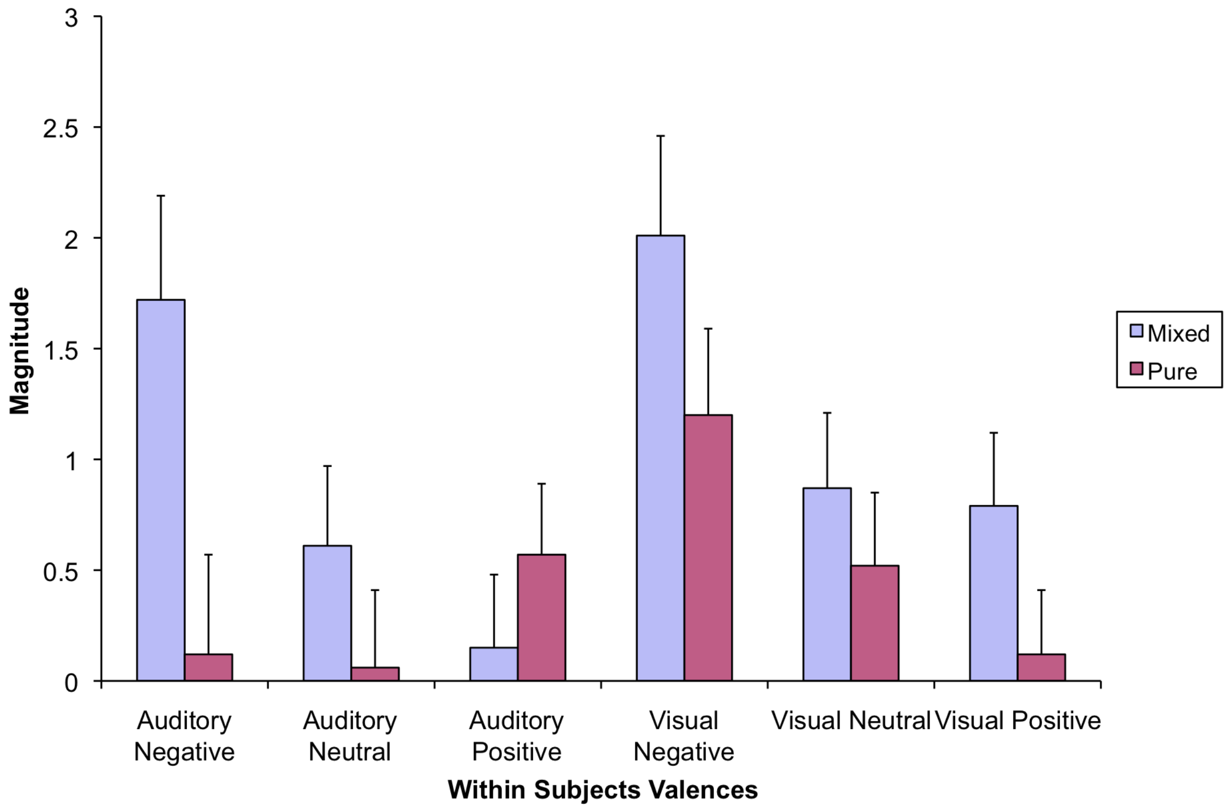
Appendix C

IADS Sounds List with Valence and Arousal

Sound Group	IADS Number	Valence	Arousal
Negative	255	2.08	6.59
Negative	260	2.04	6.87
Negative	275	2.05	8.16
Negative	277	1.63	7.79
Negative	278	1.57	7.27
Negative	279	1.68	7.95
Negative	290	1.65	7.61
Negative	292	1.99	7.28
Negative	424	2.04	7.99
Negative	699	3.59	6.15
Neutral	102	4.63	4.91
Neutral	114	5.01	6.04
Neutral	246	4.83	4.65
Neutral	322	5.01	4.79
Neutral	368	5.15	4.75
Neutral	373	5.09	4.65
Neutral	425	5.09	5.15
Neutral	627	4.83	4.65
Neutral	700	4.68	4.03
Neutral	722	4.83	4.97
Positive	110	7.64	6.03
Positive	215	6.47	7.32
Positive	226	7.78	5.42
Positive	351	7.32	5.55
Positive	353	7.38	6.62
Positive	365	6.97	6.32
Positive	367	7.33	6.72
Positive	810	7.51	4.18
Positive	813	7.2	5.89
Positive	815	7.9	6.85

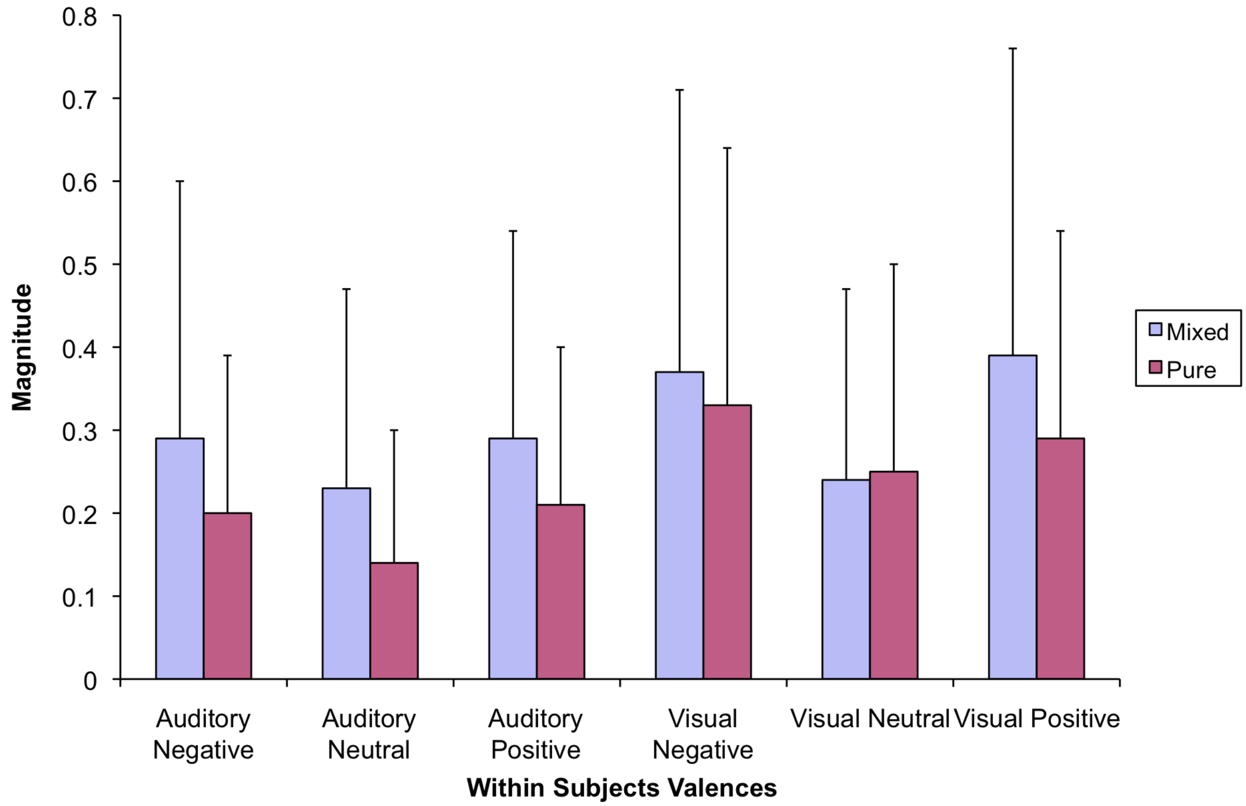
Appendix D

The Magnitude of change of Heart Rate for Auditory and Visual Stimuli by Valence, and Group Membership



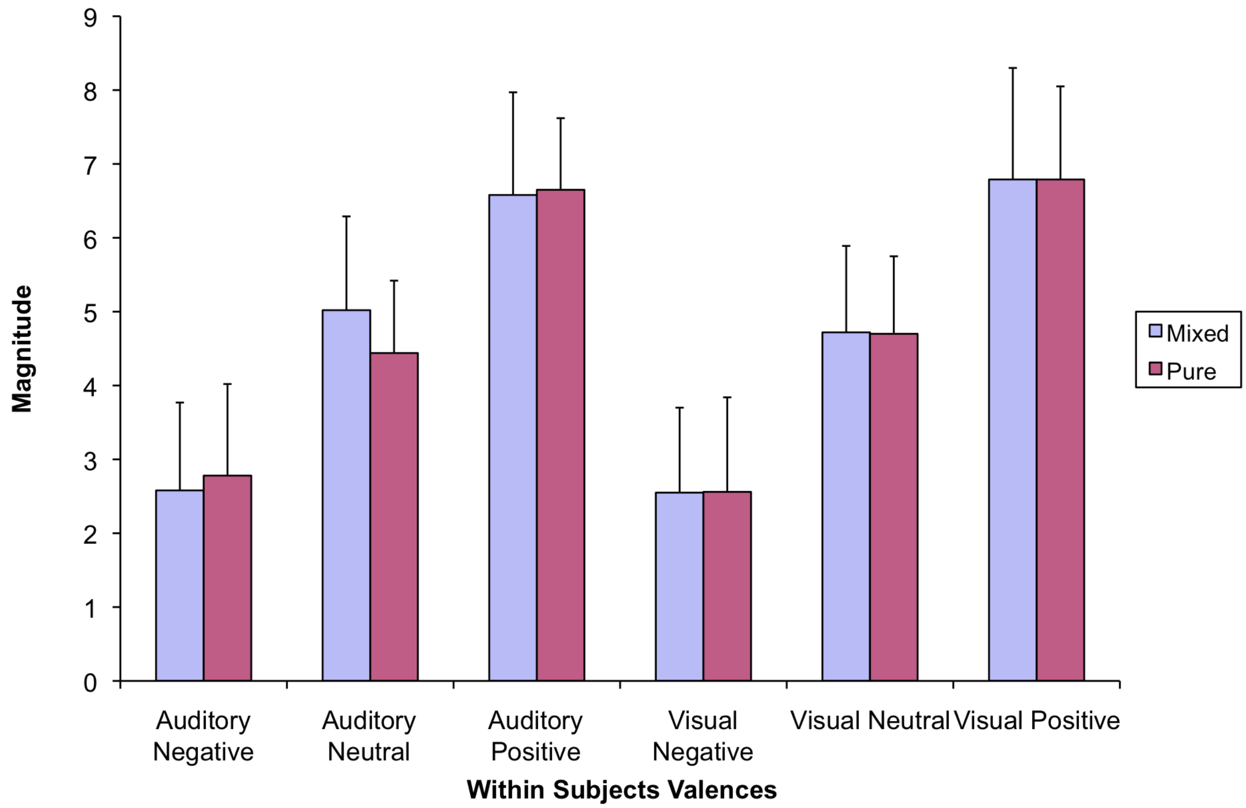
Appendix E

The magnitude of change for Skin Conductance for Auditory and Visual Stimuli by Valence, and Group Membership



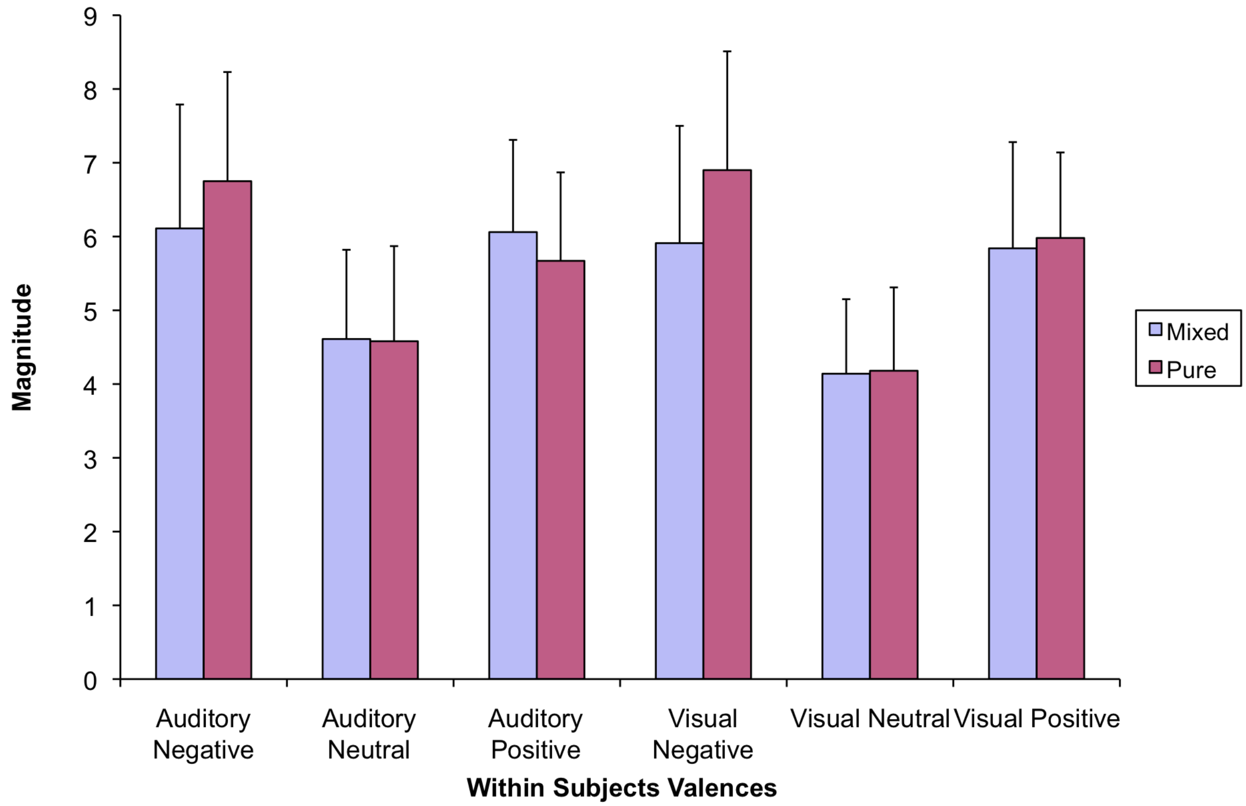
Appendix F

Self-Reported Valence of Auditory and Visual Stimuli by Valence, and Group Membership



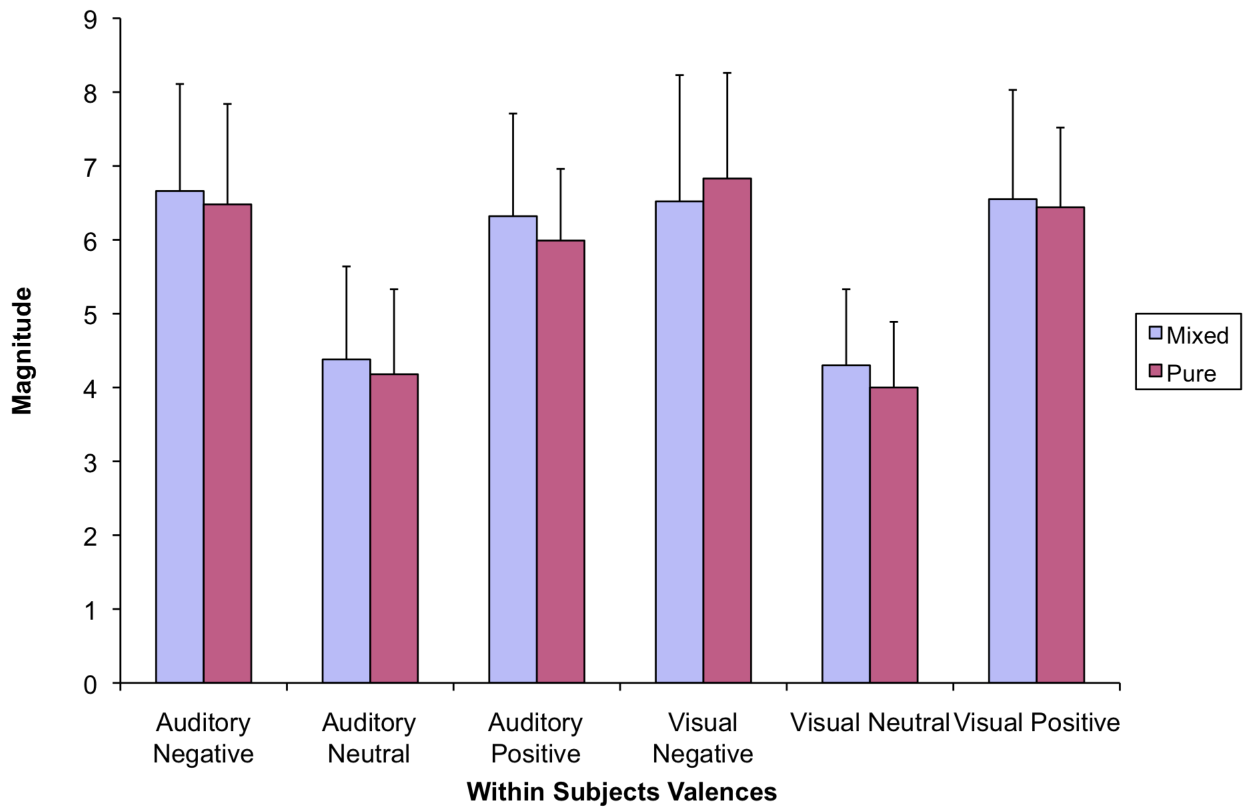
Appendix G

Self-Reported Arousal for Auditory and Visual Stimuli by Valence, and Group Membership



Appendix H

Self-Reported Interestingness for Auditory and Visual Stimuli by Valence, and Group Membership



Appendix I

Self-Reported Dominance for Auditory and Visual Stimuli by Valence, and Group Membership