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The influence of valenced images on perceptual learning

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The Influence of Valenced Images on Perceptual Learning

by

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A thesis prepared in partial fulfillment
of the requirements for the degree of
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ABSTRACT

This study aimed to determine whether the rate of perceptual learning in a vernier discrimination task could be influenced by affective images. Forty-eight (30 Female, 18 Male) subjects were instructed to indicate the direction of an offset over 620 trials. Subjects were primed with either negative, positive or neutral photographs before making the discrimination on all test trials. Feedback regarding offset performance was provided on each trial. Despite initial pilot data indicating that subjects primed with negative, arousing images improved performance over those primed with either neutral or positive images, there was ultimately no reliable advantage for any of the affective prime conditions.

Chapter One

Introduction

Perceptual Learning

A complete account of the role of experience in perception is essential to our understanding of perception more generally. Many research techniques used to evaluate the contributions of perceptual experience employ perceptual learning paradigms. Perceptual learning has been defined as: "[a]ny relatively permanent and consistent change in the perception of a stimulus array following practice or experience with this array…." (Gibson, 1969, p. 49). The essential characteristic of perceptual learning is that it involves durable learning in response to an unchanged stimulus (Epstein,1967). Unstable percepts, adaptations, shifts in ocular dominance, and similar phenomena are excluded because of their ephemeral effects.

Within Epstein's (1967) conceptualization of the field, perceptual learning (PL) includes a variegated set of experimental paradigms. Of those experiments that do not finely control experience, there are those that evaluate the contributions of long-term, pre-experimental experience to perceptual performance. An example of this variety of investigation might involve subjects matching the apparent size of a penny in an apparatus to a hubcap at some distance. Another type of PL experiment entails observations of perceptual performance while subjects are presented with conflicting learned cues, such as instructing subjects to estimate a distance in a stimulus array containing contradictory depth information. Researchers have also tested the influence of

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global changes to the visual system, epitomized in the classic studies of Kohler (1962) in which subjects wore prisms that inverted their view as they navigated real world environments. Developmental studies, the last variety of PL study that involves the use of uncontrolled pre-experimental experience, seek to measure the influence of experience as it accrues over a lifetime. The role of experience can be probed in this case by measuring the vulnerability of young and old to illusions and constancies.

Researchers who seek finer control over the learning environment can employ any of a number of other approaches. Enrichment techniques expose subjects to the to-be-discriminated stimuli during a familiarization period. It is essential within this approach that subjects be equally reinforced for all stimulus levels. Classical learning studies in PL have paired a stimulus and a response (usually a naming or motor response). By pairing a particular response with an aversive stimulus (e.g. shock), researchers can investigate the role of motivation in perception.

Of particular interest in the present context is the final variety of controlled experience experiment, the standard practice approach. Within this paradigm, a subject is instructed to make a sensory discrimination, usually simple, over a series of many trials. Subjects are provided with some form of feedback regarding their performance while still engaged in the task. The level of the stimulus signal will typically remain constant over test trials, so that improvements or decrements in performance can be properly measured.

Since learning is instantiated throughout the brain and has a role in almost all behaviors, many researchers have suggested that PL cannot rightly be called perceptual at all (Pylyshyn, 1999). Theorists who take an expansive view of the role of attention in visual processing, might interpret almost all PL as, at some level, a shift in attention.

Epstein argues that most disputes about whether improvements in discrimination performance constitute PL, or some other, more cognitive, learning, boil down to disputes regarding the definition of perception. Two common criteria for defining a process as perceptual are immediacy and stimulus dependence. The first criterion, immediacy, can be satisfied by implementing controls that minimize the influence of higher order judgments. Discrimination tasks that involve dichotomous decisions regarding equiprobable stimulus classes can minimize the role of strategy. The second criterion, stimulus dependence, indicates that variation in the behavior of the subject must be explainable in terms of stimulus properties. The Thematic Apperception Test, for example, would not be considered perceptual because too little of the subjects verbal behavior is explained by the illustrations.

PL tasks that involve psychophysical judgments, regardless of modality, can be controlled so as to increase the likelihood that learning is in fact perceptual. PL is evident in a number of visual perception tasks, including motion discrimination (Matthews & Welch, 1997), spatial frequency discrimination (Fine & Jacobs, 2000), and hyperacuity tasks (Fahle, 1991). Despite much progress towards understanding the perceptual and neural mechanisms underlying these improvements in performance, many questions regarding PL remain unanswered. The role of attention in PL tasks remains an area of active inquiry. Seemingly conflicting results indicate the centrality of attention in certain perceptual tasks (Fahle, 2004) and its irrelevance in others (Watanabe et al., 2002). Questions remain regarding the locus of the changes that characterize PL (Gilbert et al., 2001). Improvements in certain tasks demonstrate orientation specificity (Poggio, et al., 1992), while improvements in other tasks retain eye and location specificity (Fahle,

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Edelman, Poggio, 1995; Karni & Sagi, 1991; Ahissar & Hochstein, 1997). This poor or absent transfer of learning would seem to indicate that learning occurs early in visual signal processing. However, despite the limited generalization of learning in one portion of the visual field to another, there is evidence that context shifts, in the form of configurational changes in patterns falling on other portions of the visual field, can attenuate PL in the trained region. Some have hypothesized that horizontal connections from the portions of the visual cortex that represent other areas of the visual field play a modulatory role in PL (Crist et al., 1997).

Perceptual Learning Mechanisms

Any of a number of neural mechanisms may underlie perceptual learning (Gilbert et al., 2001). The first possibility involves an increase in the area of cortex used to represent a specific stimulus dimension or portion of the visual field. In some circumstances, recruitment of additional neuronal populations may permit enhanced processing by increasing the signal-to-noise ratio (Hoshino, 2004). Within this essentially correlative hebbian model, PL results from either potentiation or depression of cell assemblies in response to the temporal relationship between the click-trains for each assembly. This integration of larger populations of neurons permits greater representational fidelity along the relevant stimulus dimension.

An alternative account involves sharpened tuning curves (Sheinberg & Logothetis, 2002). The rate of a firing neuron changes in response to certain stimulus properties (e.g. linearity, orientation). The peak of the spike frequency distribution represents the optimal level of some stimulus dimension relevant to the system in which the neuron is functioning. Perceptual learning may involve a sharpening of that curve, so

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that the neuron responds to an ever-narrower band of the relevant dimension. For example, researchers have found that individual cells in the inferior temporal cortex are differentially responsive to a learned single view of an artificial object (Logothetis et al., 1995). This type of learning almost represents an anti-Hebbian view, in which each cell attempts to orthogonalize its representation relative to all other cells (Gilbert et al., 2001). In this way, the cells "spread" to represent a large portion of the stimulus dimension with each cell specialized to respond to an ever-narrower band of stimulation.

A third possible mechanism involves increases in neural synchrony (Thorpe, 2004). Rather than using additional local neurons to encode and process the stimulus, distant neurons may support processing by firing in some temporal relation to the relevant dimension.

In many theorists' conceptualizations of PL, attention is given a central role in learning. In some models, attention is required to identify the stimulus dimension relevant to required discrimination. In others, attention serves as a time-marking mechanism that labels the moment at which the discrimination was made, so that learning can occur in relation to that specific operation. Regardless of the specific function attributed to attention in these models, almost all accounts of perceptual learning leave a role for attention. Perhaps the effects of attention in perceptual learning can be clarified using affective manipulations. This study will present participants with valenced picture stimuli in an attempt to manipulate attention and determine the influence of emotionally-driven attention to the PL task.

Emotion and Attention

Models of emotion have integrated evolutionary theory to great explanatory effect. Theorists have identified a number of domains in which emotion may have influenced fitness, but of particular interest are the areas of attention, perception, and learning. Research into evolution psychology was initially expansive and feckless, with a wide variety of untestable theories presented for varied behaviors. However, explicit criteria have been formulated to define the boundaries within which an emotion can be accurately labeled as an adaptation (Tooby & Cosmides, 1990). For an emotion to be considered an adaptation, ancestral populations found themselves presented with a situation with great enough frequency as to constitute an "adaptive problem." This situation must be identifiable by situation-specific cues. Additionally, these cues must be monitored by algorithms that detect situations and then react in a manner that increases fitness. Clearly an account like this encounters difficulty when explaining emotions such as sentimentality or the distinction between envy and jealousy (Averill, 1997). However, some emotions lend themselves to this type of analysis quite well. Fear, it would seem, fulfills a clear adaptive function. Threats in the environment were present in abundance and constituted an adaptive problem. Moreover, these situations can be quickly detected utilizing visual cues.

Emotions have an underlying physiological reality that has implications for the way the brain processes visual stimuli (Kandel et al., 2000). Evolution has equipped humans with the ability to rapidly categorize visual stimuli into appetitive or aversive categories (Bar & Neta, 2006). This categorization is incredibly fast and robust, capable of discriminating the emotional valence of images in the span of a single frame of video

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(Maljkovic, Martini, & Farid, 2004). Presenting subjects with threatening images (e.g. a snarling dog) activates brain systems associated with defense. The role of the amygdala in regulating behavioral responses to the environment, while implicated for some time (Kluver & Bucy, 1937), has only recently begun to be truly understood. The hypothalamus controls expressions of fear in the peripheral nervous system. In contrast, the amygdala is responsible for changes in the central nervous system in response to threatening stimuli. The amygdala mediates both inborn as well as learned emotional responses in all sensory modalities (Kandel et al., 2000).

In a more concrete example, the sequence of responses initiated by the brain in response to a threatening face is becoming better understood. In one account, the face is first encoded in the inferior temporal cortex, which processes facial expression and gaze direction in a preattentive manner (Soares & Ohman, 1993). Typically, the inferior temporal cortex next signals the amygdala with the emotional content of the faces. The amygdala then activates appropriate behavioral, autonomic, and endocrinal responses.

Additionally, there are also phylogenetically older connections from the thalamus to the amygdala. These connections may provide a rapid track for processing threats without the elaboration that usually occurs in the temporal lobe. These subcortical connections seem to provide coarse, but useful information regarding objects in the visual field. (Fendrick et al., 2001).

Behavioral responses may include orienting behavior, flinching, or the tensing of muscles in preparation for a blow. Autonomic responses include the activation of the sympathetic nervous system. Activation of the sympathetic nervous system results in increased heart rate, decreased salivation, decreased digestion, and a host of other effects

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on biological systems. Endocrinal responses include stimulation of the HPA, or Hypothalamic-Pituitary-Adrenal, axis. The HPA axis floods the blood supply with hormones that prepare the body for dealing with a threat. Cortisol, adrenaline, and other hormones are involved in this threat signaling, preparation, and recovery (Kandel et al., 2000).

In a study using anterograde tracers in the amygdaloid complex of *Macaca fascicularis,* researchers discovered projections from the amygdala back to areas responsible for early visual processing, namely, TE and V1 (Frese & Amaral, 2005, Amaral et al., 2003). Researchers hypothesize that these connections may modulate visual processing in response to threat-related stimuli. These feedback-like projections could support a perceptual system designed to selectively amplify representations that provide vital information about the environment and, as a result, may guide behavior in threatening situations. These connections, however, are only presumably excitatory. The specific function of these reciprocal connections is yet to be elaborated.

Recent evidence suggests that the brain is biologically prepared to address certain threats common to our environment of adaptation, such as snakes, spiders, and other threatening creatures (Soares & Ohman, 1993). In a conditioning experiment, researchers presented participants with either neutral or aversive picture stimuli and demonstrated differences in conditioning effects that could only be explained via innate differences in processing speed. Additionally, participants presented with masked threatening stimuli demonstrated a characteristic electrophysiological reaction greater than what was observed with masked neutral stimuli despite the fact that both presentations were subthreshold (Carretie et al., 2004).

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While some have referred to the processes used to identify and prepare for threatening stimuli as automatic (e.g. Carratie et al., 2004) others, arguably correctly, refer to these processes as preattentive (e.g. Soares & Ohman, 1993; Compton, 2003). Preattentive is the preferred term because automatic processes are not governed by resource limitations, which are notoriously hard to operationalize. Preattentive processing has a number of characteristics that distinguish it from automatic processing (Logan, 1992). As one might assume, this processing occurs in the absence of attention. Preattentive processing is an obligatory processing of all information in the sensory field simultaneously. Grouping by similarity and proximity are examples of this sort of process according to Logan. Many early cognitive scientists did not maintain a distinction between preattentive and automatic processing, but recent evidence suggests that such a distinction might be useful. If automatic processing is simply defined as processing in the absence of attention, then, of course, preattentive processing is automatic. Logan identifies two problems with this definition (which he referred to as the "modal view"). First, it defines automaticity negatively, without identifying the mechanisms and processes responsible for automatic processing. Additionally, with respect to learned automaticity, it does not explain how attention can be withdrawn from cognitive acts that are repeated often enough to diminish their capacity demands. For these reasons, and several others grounded in the traditional early- vs. late-selection literature, it is best to consider the processes responsible for attention to valenced stimuli as preattentive, rather than automatic.

Recent cognitive and information-processing approaches to human psychology have highlighted the informative aspect of affective information (Compton, 2003).

Researchers argue that since selective attention is used to pare down the wash of data across the senses and emotional significance often marks biologically important data, it is likely the mind uses emotional significance to identify objects that ought to be attended (almost always at the expense of others). Emotional reactions to stimuli almost always involve the furthering or impeding of some biological goal (Arnold, 1960).

In order for emotional tagging of stimuli to have any utility in rapid deployment of selective attention, emotional processing of affective stimuli would need to occur quite quickly (Compton, 2003). Evidence from electrophysiological studies indicated brain activity in the ventromedial prefrontal cortex 150ms after stimulus (spider image) onset (Carriete et al., 2004). The ventromedial prefrontal cortex is believed to be involved in threat processing. In this study the threatening stimuli were masked and the participants had no awareness of the threatening stimuli. This would seem to provide additional evidence that threats are processed preattentively. Psychophysiological studies which monitored biological indicators of threat detection (e.g. blood pressure, skin conductance, heart rate, corrugator activity) found a similar rapid response, with reliable changes within 500 ms of stimulus onset (Codispoti et al., 2001). Codispoti and colleagues presented stimuli to participants for 500 ms and found similar patterns of emotionally-linked physiological response as previous studies in which stimuli were presented for 6 s. It would seem as though biological preparedness for threats reaches asymptote quickly, remaining stable after the first 500 ms. Researchers argue that this indicates that stimuli continue to be processed even after presentation. It seems that not only the central nervous system, but the peripheral nervous system as well, can respond to emotional stimuli in well under one second. This window of time that would permit selective

attention to utilize emotional significance as a source of information in situations that would require rapid responses.

Lesion studies involving bilateral simultaneous stimulation provide converging evidence that threat-related stimuli are preferentially processed (Vuilleumier & Schwartz, 2001). Two subjects with right parietal focal lesions demonstrated extinction of briefly presented stimuli in their left visual field. However, when images of spiders were presented in the left visual field, subjects were able to correctly identify images as accurately as controls. It should be noted that the spiders were matched with flowers in terms of low-level visual properties by rearranging the lines in the illustration.

Emotional salience engages attention. Codispoti et al. (2001) presented participants with an abrupt auditory probe while they were presented with affective stimuli. The typical response to a 50 ms presentation of a 103 dB tone is a startle response, which almost always entails a blink. By measuring blink suppression, researchers hoped to evaluate attentional involvement with the affective stimuli. Blinks were inhibited longer for emotionally valenced, either pleasant or unpleasant, stimuli. However, when subject did blink, the magnitude of the startle reflex was greater when participants were presented with negative, as opposed to positive or neutral, stimuli. Similar results obtained in a study by Cuthbert et al. (1998). Researchers concluded that affective information is used to modulate the startle reflex, leading to heightened startle reactions in the presence of negative, or threatening, stimuli. Other evidence for a strong relationship between emotion and attention can be found in a study by Anderson & Phelps (2001). Using a rapid serial visual presentation paradigm, researchers determined that the attentional blink is attenuated when the second target is emotionally salient.

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Futhermore, this attenuation was not evident in a participant with damage to the amygdala.

A recent study by Phelps et al. (2006) may further illuminate this relationship between attention and emotion. In an investigation of transient, covert attention, researchers presented participants with an orientation discrimination task using gabor patches of varying contrast. The patches could be primed by a fearful or a neutral face in the center of the screen. Participants had lower contrast thresholds when presented with the frightened, as opposed to the neutral face. In a second experiment participants were presented with a neutral or fearful face cue in either a peripheral location or distributed about the screen. The location of the peripheral cue changed across trials. Participants had lower contrast thresholds with the frightened faces in both the peripheral and distributed conditions. Interestingly, these results show independent contributions of emotion and spatial attention, such that the peripheral cue, in the quadrant of the screen where the target was to appear, resulted in the lower contrast threshold than the distributed cue, likely because the distributed cue spread attention evenly about the screen. However, the distributed fearful cue still resulted in lower thresholds when compared to the distributed neutral cue. Researchers conclude that reciprocal projections from the amygdala, which processes threats preattentively, loop back to the early visual areas of the extrastriate cortex, increasing the speed and accuracy of visual processing. Additionally, while the effects of emotion on perception may come about in this experiment via the moderating influence of transient, covert attention, there is evidence that emotion may have a potentiating effect on visual processing even in the absence of attention. When the cue was distributed evenly across the screen, so there was no cue for

covert attention to use to localize the target, there still were lower contrast thresholds. This study utilized fearful faces because fearful faces provide ambiguous information about the environment. The information about the environment is ambiguous in so far as it signals a threat, but does not identify it.

Zeelenberg et al. (2006) recently found that emotionally significant words are recognized more accurately than neutral words in a two alternative forced choice experiment. In this case, researchers wished to disentangle the relative contributions of sensitivity and bias in perceptual identification tasks involving emotional stimuli. They conclude that bias is likely not a factor in preferential processing of emotionally changed stimuli.

A surprising role for human scents associated with fear was uncovered in a recent study by Chen (2006). Researchers exposed female subjects in this memory experiment with human scent samples. The samples were collected in the under arms of volunteers who viewed either horror movies or documentaries. Subjects were presented with one of the two sample types while they completed an associative decision task. The decision involved indicating whether the words in 320 word pairs were associatively related. When the words about which the decision was made were associative related, subjects exposed to the sample collected from subjects who viewed the horror movie performed more accurately than those exposed to the other sample. There was an interaction between word pair condition and sweat exposure condition such that subjects exposed to the "threat sweat" were slower to respond when one of the words presented was not threat-related.

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Even something as seemingly idiosyncratic as the preference of common objects seems influenced by biological programs to detect threats (Bar & Neta, 2006). Researchers presented subjects with everyday objects that could either be characterized by long, gentle curves, sharp discontinuities, or control objects with both attributes. Objects were paired across conditions, such that tokens for a given object (e.g. a watch) would be contained in both the sharp and curved conditions. An additional control condition showed abstract, meaningless shapes with either gentle curves or sharp angles. Of the real objects, objects with no sharp discontinuities were preferred first, followed by objects with both sharp and curved surfaces. Objects with only sharp features were preferred least. Curved abstract objects were preferred to sharp objects in the abstract condition, as well. Bar & Neta conclude that this bias towards curved objects results from threatening impression carried by contour alone.

While bottom-up factors can account for part of the observed interactions between emotion and attention, it is likely that top-down influences are also present. The pre-frontal cortex, particularly in the ventromedial and dorsolateral areas, has shown rapid electrophysiological and hemodynamic responses to threatening stimuli (Carriete et al., 2004). Interestingly, there are reciprocal projections between the ventromedial pre-frontal cortex and the amygdala, suggesting that each may be capable of modulating the effects of the other.

Much evidence has been gathered in a clinical context regarding the sensitivity of subjects to valenced information as a function of certain individual differences variables. Fox (1993a) found that subjects high in state anxiety, as measured Spielberger's STAI anxiety index (Spielberger et al., 1970) showed greater latencies in an emotional Stroop

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task when presented with threatening or neutral words. However, these same high-anxiety subjects showed similar delays when presented with other non-threatening distractor conditions. Fox concludes that, while threatening words do create more interference in anxiety-prone subjects, these subjects may suffer from a more general susceptibility to distraction or inability to maintain attentional focus. In a separate study, Fox (1993b) also determined that those high in anxiety allocate attention towards threatening words, but only socially threatening words. Words associated with a physical threat did not capture attention in anxious individuals.

Research by Cohen et al. (1998) found subjects high in state anger, as measured by Spielberger's State Trait Anger Expression Inventory, were more likely to experience interference in an emotional Stroop task when presented with anger-related words. Matthews et al. (2003) found that subjects who scored high on the STAI were more likely to be effectively cued to a target location by the fearful gaze of a face than the neutral gaze of the same face. Similar benefits of a fearful over a neutral face did not obtain for subjects with low STAI scores.

Recently, brain-imaging studies have provided additional evidence that personality variables might influence sensitivity to threatening information. Bishop et al. (2004a, 2004b) presented subjects with a pair of houses and fearful faces simultaneously. Subjects were cued on each trial to indicate whether either the houses or faces were the same or different. When the faces were unattended by subjects with low anxiety (as measured w/ STAI), amygdala response, assessed via fMRI, diminished. However, when the faces were unattended by high anxiety subjects, there was no reduction in amygdala response.

Not all research has supported the contention that threatening stimuli are processed preferentially. In a visual search experiment by Tipples et. al (2002) researchers found no advantage for threatening stimuli. Rather, the same benefits that obtained for detection of threatening animals amidst plants were also present for non-threatening animals among plants. In fact, the search slope for the non-threatening animals was lower than the search slope for the threatening animals. The researchers go on to suggest that previous findings of enhanced processing of threat-related stimuli might be due to individual differences in sensitivity to threat-related information in the environment.

There are a number of possible mechanisms by which emotion could inform attention. Lang et al. (1998) conclude that projections from the amygdala to the sensory cortex, or visual processing centers specifically, might allow emotion to assign attentional priorities. Attention might amplify signals, leading to more elaborate representations, in the appropriate brain areas (Compton, 2003).

Another important distinction has emerged with respect to attentional capture, as opposed to sustained attention, and emotion. Koster et al. (2004) wished to evaluate whether imminent threat captured or held attention. Attention might be engaged by threats in the environment but not held. Alternatively, attention might not be attracted to threats, but when it encounters them it may be difficult for subjects to move attention away. The researchers presented subjects with a visual cue that signaled an aversive burst of white noise. Previous studies have shown enhanced visual processing of stimuli that have acquired aversive associations (Armony & Dolan, 2002). Subjects were instructed to indicate in which of two positions a target appeared as quickly as possible.

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At the same time, the learned cue was presented in one of two positions. Evidence obtained by manipulating both cue validity and onset demonstrated not only attentional capture by the cue, but also sustained attention. While it was found that the conditioned stimulus both attracted and held attention in this study, the distinction remains an important one if the relationship between attention and emotion is to be fully elaborated.

Lastly, while many studies have found that threatening stimuli result in greater attention than other emotional stimuli, some find more a complex and nuanced relationship. Schimmack (2005) wished to evaluate three models of how negative affective stimuli might influence attention. The first possibility he identifies is categorical negativity, in which negative stimuli attract attention simply because it is negative. No distinctions are made between degrees of negativity or specific threat content. A second possibility is that threats are detected more readily because of some evolutionary predisposition. The third possibility he outlines suggests that arousal, and not valence, is the dimension underlying the capacity of emotional images to capture attention. In a series of experiments involving subjects either solving math problems or detecting bars above or below affective images, Schimmack found that arousal ratings of the images provided the best explanation of performance. Comparisons of attentional capture for evolutionary threats (e.g. snakes) with other stimuli of matched arousal and valence revealed no reliable difference. Additionally, comparisons within negative stimuli did reveal reliable differences between performance levels as a function of valence, or degree of negativity.

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The relationship between emotion and attention is a complex one. Investigations must consider whether attention is captured and/or held, possible individual differences in subjects, and whether image valence is confounded with other relevant image properties.

Attention and Perceptual Learning

Certain types of perceptual learning require attention (Weiss, Edelman, Fahle, 1993). However, the specific role of attention remains ambiguous. Three rather successful models will illustrate some of the competing explanations of PL. One property of perceptual learning that needs to be fully addressed by any successful model its great specificity. Training in what are usually very difficult tasks fails to generalize to novel tasks that differ along certain dimensions. Each of the following models attempts to address the specificity with a slightly different approach. Ahissar & Hochstein's (2004) reverse hierarchy model focuses on top-down attentional effects, with a theoretical framework grounded in hierarchical receptive field structure. In contrast, Dosher & Lu's perceptual template model focuses on bottom up processes, with a focus on spatial vision considerations such as channel weighting (Petrov, Dosher, & Lu, 2005). Watanabe & Seitz's model diminishes the role of attention in perceptual learning, focusing instead on the neurochemical processes which underlie attention and reinforcement learning (Seitz & Watanabe, 2005).

Reverse Hierarchy Theory

The reverse hierarchy theory (RHT) of perceptual learning suggests that top-down attention is the critical element in improvements in certain perceptual tasks (Ahissar & Hochstein, 2004; Ahissar, 1999). Advocates of the RHT model argue that all the information necessary to perform the perceptual task in question is present in the

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perceptual system at training. Rather than providing additional information, training assists the participant in identifying task relevant information and ignoring irrelevant information. A second key aspect of the model suggests that as a participant is trained, this search for differentiating features (in a discrimination task, for example) "cascades" from higher to lower forms of representation. This view of perception as a fundamentally hierarchical system which starts with primitive elements like discontinuities in the visual field, which then become contours, which then become features, which are grouped into objects, which then form scenes, is central to the RHT model. Ahissar and Hochstein's hierarchical view of visual perception finds a convincing anatomical basis in receptive field organization. Evidence regarding the network of receptive fields indicates that as visual signals are processed, starting with a more or less retinotopic map in V1, they are converted to more and more abstract forms. More of the visual field is represented in any given receptive field as these signals are processed. However, more complex stimulus properties are required to activate a given receptive field (e.g. linearity or motion). Having established that these receptive fields, and the perceptual processes that they support, are arranged hierarchically and assuming that learning starts at the highest level of representation before working its way down, Ahissar and Hochstein assert that perceptual learning is conservative, with no learning occurring at a level lower than it needs to. In tasks that provide high signal-to-noise ratios (e.g. object recognition), participants' discriminations rely on high-level representations. In situations with low signal-to-noise ratios, participants' discriminations must rely on less refined representations. The RHT suggests that location specificity is the result of the brain seeking the level of representation with the best signal noise to ratio, cascading down to a

level with a retinotopic isomorphism, and the training remaining trapped at that level. Easy perceptual tasks are learned at a high level, leading to almost no orientation or location specificity. The last assumption of their model is that PL is attention driven, with attention selecting the appropriate level of representation and increasing its weight in determining responses.

Perceptual Template Model

Dosher & Lu (1999) present an alternative explanation. The perceptual template model (PTM) provides three possible mechanisms of PL. This quantitative model suggests improvements in performance in perceptual tasks are accomplished via stimulus enhancement, external noise reduction, and internal noise reduction. Stimulus enhancement is characterized by increased signal strength from the relevant perceptual template. External noise exclusion occurs when the template is tuned to exclude irrelevant information. Internal, or multiplicative, noise is variation in the perceptual decision system whose level depends on the magnitude of the stimulus signal. This is in contrast with the additive noise level, which is independent of the signal magnitude and is controlled via external noise exclusion. Using an external noise paradigm, in which the subject must discriminate the orientation of a gabor patch presented between "sandwich" noise masks, researchers were able to investigate each of these possible mechanisms because each has a characteristic effect on the signal contrast-external noise contrast threshold function in a two threshold, two-criterion paradigm. Dosher & Lu conclude that the improvements in their discrimination experiment are due to external noise exclusion and stimulus enhancement. Those who advocate the PTM argue that because gains in one perceptual task do not interfere with performance in other, similar, tasks it is

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unlikely that improvements result from changes in the early visual centers, rather, changes are likely to occur at an intermediate processing stage with relevant channels amplified (stimulus enhancement) and irrelevant channels dampened (external noise exclusion). The PTM explains the mystery of location specificity by suggesting that the reweighting of channels may include the selection of a retinal location. The same can be argued for orientation specificity.

Watanabe et al. (2001) found low level perceptual learning without higher level perceptual learning or conscious attention.   The researchers presented participants with a stimulus array that contained a rapid serial visual presentation (RSVP) task in the foreground and moving dots in the background. At the moment the target was presented in the center of the RSVP portion of the screen, the motion of the dots was manipulated so they moved with 10% motion coherence. Despite the fact that attention was focused centrally, towards the challenging RSVP task, participants showed increased motion discrimination sensitivity in the direction that was primed by the motion stimuli in a subsequent motion discrimination task. Ahissar and Hochstein argue that these effects are more akin to adaptation than PL, however this increase in sensitivity was much more long lasting than most adaptation effects.

Conditioning Model

A model which attempts to explain these specificities is presented by Seitz & Watanabe (2005). The authors suggest that the critical factor in determining what is and is not learned in perceptual learning tasks is temporal proximity. When a reinforcement signal is provided to the subject, what is task-relevant or task-irrelevant can be learned with equal accuracy. Studies which found a lack of task-irrelevant learning, failed to

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provide any consistent relationship between the task-irrelevant features and the target. In the previous study, the target always appeared simultaneously with a given motion direction. Grounding their analysis in the conditioning literature, the researchers suggest that traditional reinforcement approaches can go a long way towards resolving the "stability-plasticity dilemma" in visual perception. Perceptual learning, and similar issues regarding changes in perceptual performance as a function of learning or context, have been given short shrift because of the belief that perceptual skills are hard-wired after a critical period. This seems reasonable because in a threat-filled world, stable percepts allow for rapid and unequivocal processing. However, the balance between stability and plasticity can be effectively accounted for via reinforcement models. Within this framework, the alerting portion of the attention system is responsible for this learning. It is accomplished via the diffuse transmission of neuromodulatory chemicals, such as acetylcholine or norepinephrine.

Additional evidence regarding the role of neuromodulators in perceptual learning can be found in a study by Dinse et al. (2003). Researchers attempted to manipulate somatosensory representation of a tactile stimulus via administration of mementine and amphetamine. Mementine blocks *N*-methyl-D-aspartate (NMDA) receptors, which are implicated in synaptic plasticity. Much synaptic plasticity is accounted for in terms of long-term potentiation and depression (Agranoff et al., 1999). Potentiation, or a reduction in the firing threshold of a neuron, is mediated in large part by NMDA receptors. Amphetamine was chosen to accelerate learning because it activates the sympathetic nervous system and, with it, the HPA axis. After administration, for three hours participants were exposed to a tactile stimulus on the tip of one of their fingers.

Both of these manipulations (administration and exposure) were placebo-controlled. Subject could not view their hand. At the end of three hours, a two-point threshold discrimination was administered to both the exposed finger and another finger. Those who were exposed to the amphetamine showed lower thresholds than an initial measure on the selected finger and no learning on another finger. Moreover, somatosensory evoked potentials showed a greater distance between the represented points in the somatosensory cortex in the amphetamine condition. There was no learning in the mementine condition. Here we see an example of sensitization in perceptual task in the absence of feedback, with learning occurring in one neurochemical milieu and no learning in another.

While the first two models (RHT and PTM) may focus differently, some have suggested that both the top-down and bottom-up approaches are two sides of the same coin (Fahle, 2005). Fahle argues that the specificities (location, orientation, spatial frequency, etc.) are likely to due to modifications in early or intermediate visual processing centers. However, he continues, these modifications are controlled by top-down attentional effects. In a study by Li et al. (2004), researchers found that the neuronal responses of V1 to a stimuli set depended on the perceptual task undertaken by the primate subjects. Primates were given a single type of stimulus that could be employed for either a bisection or a vernier acuity perceptual learning task. Depending on which task was assigned in a particular block the response properties of the receptive field corresponding to the location of the stimulus changed. Li and collegues argue that V1 maybe conceived of as an "adaptive processing unit". Information processing analyses revealed that neurons carried more information about a given stimulus property

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when that attribute was critical for the discrimination task. Similar psychophysical results can be found in Weiss et al. (1993). Participants were trained to perform a discrimination task with two orthogonal offset stimuli. In one condition, participants were told to discriminate the vertical offset stimuli. In the other, participants were told to discriminate the horizontal offset stimuli. After being trained to criterion, it was found that the PL did not generalize to the orthogonally oriented offset stimulus. Apparently, attention is involved in which aspects of the stimulus array are represented in a more elaborate fashion.

Additional evidence regarding the interplay between bottom-up and top-down factors can be found in studies that manipulated feedback for participants in PL tasks. Herzog & Fahle (1997) presented participants with a challenging hyperacuity task, those who received feedback improved more rapidly than those who did not. Even those who did not receive feedback showed some improvement over the course of the experiment. In a second experiment, Fahle cut the error signals in half. Each participant was only aware of half of his or her errors, however, this feedback was enough to put their performance on level with those who received feedback for all their errors. Feedback is evidently important for perceptual learning, but not essential. This represents a challenge to reinforcement accounts of perceptual learning, in which feedback figures quite centrally.

Reviewing what we have covered so far, emotional stimuli can induce rapid physiological changes in the brain, as well as the rest of the body. It is possible that projections from the amygdala to the sensory cortex underlie the robust effects of emotion on visual attention. Threatening stimuli are likely processed in a preattentive

manner. Perceptual learning is characterized as long-lasting changes in the manner in which stimuli are processed. The rate and nature of these changes are governed both by attention and task specificities.

Valenced Stimuli and PL

In a sense, PL and processing of affecting stimuli represent polar ends of a continuum. Improvements in psychophysical discriminations involve extensive practice with highly artificial stimuli. In contrast, processing of emotionally meaningful stimuli is rapid, preattentive, and likely has some fixed evolutionary basis. The role of the limbic system in regulating automatic responses to valenced stimuli is highly conserved, indicating a relatively stable role (Kalat, 1998). The biological and perceptual functions governed by these structures are fairly regular across mammals. Studying the interplay between the rapid, unlearned, obligatory responses elicited when subject view emotional stimuli and the slow, learned, artificial changes of PL may help researchers chart the space between these poles.

Affective manipulations permit a novel means of investigating the nature of attention and task specificity in PL, in so far as the processing of emotionally charged stimuli will permit strong manipulations of the conditions under which PL occurs. The boundaries of PL are inchoate. If varieties of PL performance were found to interact with processing of biologically relevant stimuli, as nearly all emotional stimuli are, this could inform the debate regarding the locus and best characterization of PL.

It stands to reason that if a PL task could be infused with affective content, researchers could modulate the rate of learning in the discrimination. Enhanced processing

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of affecting images and words is a pattern that emerges from the literature on emotional stimuli and perception (Compton, 2003). Within the realm of emotional stimuli, negative or threat-related images are granted perceptual priority. If processing is predisposed or biased towards emotional stimuli, the emotional properties of a PL stimulus or context could be manipulated to control rate of learning.

Emotionally salient stimuli could be integrated into standard PL paradigms in at least two ways. The emotional content could be associated the PL task in time. In this case, a discrimination could be either preceded or succeeded by valenced stimuli. Alternatively, the emotional content could be associated with the PL task in space. Within this approach, affecting images are integral to the learned discrimination. The following three experiments explored the first of these possibilities.

Chapter Two

Pilot Experiment 1

The influence of valenced images on perceptual learning of vernier stimuli.

Priming subjects with affective images will likely impact the rate of learning in a psychophysical judgment. Given the scheduling constraints of undergraduate participants, a PL paradigm that resulted in rapid gains was preferable. Vernier acuity discriminations can be quickly learned (Fahle et al., 1995), and was selected to provide a sensitive discrimination against which to chart subjects' progress. Acuity tasks involve subjects making a fine spatial discrimination and have been shown to be highly learnable. Learning is retinotopic (Fahle, 2005), so a subject must maintain fixation on each trial.

It was hypothesized that the rapidly presented threat-related prime activates an adaptive emotional response within subjects. These rapid orienting responses will facilitate learning in the discrimination immediately following the negatively valenced prime. In order to put the hypothesis to a strong test, images selected for the two conditions from the IAPS (Lang, Bradley & Cuthbert, 2005) were approximately matched for arousal. Images for the negatively valenced condition were all selected for their threat content (e.g. snarling dog, man w/ gun, snake), whereas images selected for the control condition were positive in valance and selected to be stimulating but not threatening (e.g. mountain climbing, windsurfing, etc.).

Method:

Subjects. 56 subjects (40 Female, 16 Male) were recruited from University of South Florida undergraduate classes.

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Materials: The experiment was conducted using an Apple G4 computer running an experimental program created with RealBasic. As can be seen in figure 1, the acuity stimulus consisted of two lines, the bottom of which was offset to either the right or the left. The magnitude of the offset ranged between .032 -.49° arc (1 to 15 pixels). 60 threatening and 60 positively valenced, arousing primes were selected from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2005). The mean valence rating for images in the negative condition was 3.83 (*SD* = .90). The mean valence rating for images in the positive condition was 7.24 (*SD* = .63). The average arousal score for negative images was 5.74 (*SD* = .71). The average arousal score for positive images was 4.92 (*SD* = 1.03).

Procedure: After an initial calibration period lasting 30 trials during which the magnitude of the offset was varied, participants completed 12 blocks of 10 trials. Each participant was presented with a vernier acuity task in one of four corner locations on a computer monitor. For any subject, the offset was presented in the same corner on all trials. As can be seen in figure 1, in addition to the vernier stimulus presented peripherally, there was a "5" or "S" presented simultaneously in the center of the screen. Participants were prompted to indicate the direction of the offset, and then prompted to indicate the identity of the character presented centrally. The magnitude of the offset was adjusted to a level where subjects were approximately 75% accurate.

The sequence of stimuli during the calibration stage is illustrated in figure 2. Each trial began with a fixation stimulus, presented in the center of the screen. Immediately following the fixation, the target stimulus was presented. Next, participants were prompted to indicate whether the offset was to the right or the left. On all trials, any

offset errors were indicated with a buzzer. Feedback was only provided regarding the offset task. Each trial concludes with the subject indicating whether the centrally presented character was a "5" or an "S". The central fixation task increased the likelihood that the offset stimulus will remain at a constant location in the participants' visual field. Additionally, performance is at ceiling when the acuity stimulus is foveated, so peripheral presentation leaves room for improvements.

Participants were presented with trials in either of two conditions. In the threat condition, participants were presented with a threatening image 500ms prior to the target. In the non-threat condition, participants were presented with a positively valenced image for 500ms prior to each target. Because of the limited number of threat-related images in the IAPS, the 60 sampled images in each valence category were presented twice each. However, the order of the images was completely randomized so that one image could appear two times before another image was presented even once. It was hoped that this presentation order would minimize any adaptation effects.

The sequence of stimuli in the threat-primed PL task is illustrated in figure 3. The sequence was identical to the adjustment stage sequence, but contained a threatening or non-threatening prime following the fixation. It was hypothesized that participants in the threat condition would learn the discrimination task faster than those in the neutral condition.

Results:

Due to high variability in performance levels and rates of improvement, observations from the first and second halves of the PL experiment were combined into two large blocks in order to stabilize means. All subsequent analyses will treat learning

as the average performance in the second block minus the average performance in the first block.

The percentage of trials in which subjects failed to report the identity of the central character for all trials, can be seen in figure 4. Any trials in which the subjects did not correctly indicate the central character were excluded from subsequent analyses. In order to check that errors did not vary as a function of prime, an ANOVA was conducted with prime (positive, negative) as the between subjects factor and block (1, 2) as the within subjects factor. There were no reliable effects on errors (block, $F(1,54) = 1.562$, $MS_e = .007$, $p = .23$; prime, $F(1,54) = .532$, $MS_e = .02$, $p = .51$; block x prime, $F(1,54) = .133$, $p = .76$).

Rate of learning was measured in this experiment by subtracting each subject's accuracy level in the first half of the experiment from subject's performance in the second half of the experiment. Figure 5 shows the different amounts of learning. Subjects in the threat primed condition (M = .07, SD = .081) learned more than subjects in the positively primed condition (M = .029, SD = .071), $t(54) = 2.03$, $p = .048$.

Discussion

As anticipated, subjects' performance in the negatively primed condition was superior to subjects' performance in the positively primed condition. This is evidence that PL performance maybe influenced by affective images.

However, several qualifications are in order. This measure of learning, comparing performance in the first and second halves of the experiment, is very coarse. In this case, it was only utilized because subjects' performances were quite noisy.

Additionally, while the arousal level of the images was approximately matched between conditions, it was not exactly so. Lastly, it was the condition with superior accuracy, the threat condition, that had the higher mean arousal rating. This confound will need to be addressed in future research.

It is unfortunate that the subjects' performance levels in this discrimination task were so variable. This could be due to a number of factors. First, the number of trials may be too low. Subjects only completed the primed discrimination task on 120 trials. In contrast, subjects in the study by Phelps et al. (2006) completed 10 blocks of 120 trials. More observations may be needed. While perceptual learning has been shown to develop over short periods of time, typically experiments take several hours for any individual subject. Second, instructions may not have been sufficiently explicit. Subjects seem to have had difficulty maintaining fixation in the experiment. While the number of missed fixations did not vary as a function of block or prime, the number of errors was high. Lastly, the positive images were quite arousing. In an effort to put the threat priming hypothesis to its strongest test, images were selected for the positive condition that had high arousal ratings (e.g. windsurfing, teens on beach, skydiving). Utilizing neutral images as controls would likely have yielded larger effects.

Pilot Experiment 2

This study attempted to resolve certain deficiencies in the previous design by adding a neutrally valenced control condition, increasing the sample, and increasing the number of trials over which learning is assessed.

Method

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Subjects: 69 (39 Female, 30 Male) subjects were recruited from University of South Florida undergraduate classes.

Materials: The PL stimuli employed and program used to gather data were identical to those used in the previous study. 100 negatively valenced, 100 positively valenced, and 100 neutrally valenced primes were selected from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2005). The mean valence rating for images in the negative condition was 3.22 (SD = 1.0). The mean valence rating for images in the positive condition was 7.19 (SD = .75). The mean valence rating for images in the neutral condition was 4.99 (SD = .25). The average arousal score for negative images was 5.88 (SD = .70). The average arousal score for positive images was 5.76 (SD = .78). The average arousal score for the neutral condition was 3.44 (SD = .91). [I could summarize last 6 sentences in 1 table]

Procedure: Procedures were the same in this experiment as in the prior, with the exception of the number of trials. Whereas in the previous experiment subjects completed 150 total trials (120 test trials), in this experiment, subjects completed 350 total trials (300 test trials). The distance between the endpoints of the vernier stimuli were adjusted over the initial 50 trials. As with the previous experiment, subjects were instructed to report both the direction of the offset and the centrally presented character. The magnitude of the offset was adjusted to a level where subjects were approximately 75% accurate.

Results

Despite adjustments, there were differences in baseline accuracy between the negative (M = .76), positive (M = .80), and neutral (M = .80) conditions. Because of this

amount of learning was assessed for each subject by subtracting accuracy in a given primed block from performance in the initial unprimed block. Figure 6 shows the percentage of missed fixations for each condition across the 6 primed blocks. There were no reliable effects on errors (block, $F(5,330) = 1.19$, $MS_e = .006$, $p = .17$; prime, $F(2,66) = 2.58$, $MS_e = .126$, $p = .42$; block x prime, $F(2,66) = 1.68$, $p = .63$). Figure 7 shows normalized learning across blocks. There was no reliable effect of prime on learning, $F(2,66) = .564$, $MS_e = .128$, $p = .564$. There was an effect of block, $F(5, 330) = 8.854$, $MS_e = .004$, $p < .001$. As anticipated, there was a reliable block x prime interaction, such that subjects in the negative condition ended with a performance level that was reliably higher than either the positive or neutral conditions, $F(10, 330) = 1.912$, $p = .043$.

Discussion

As would be expected given the results of pilot experiment 1, subjects in the negative prime condition showed higher rates of learning than subjects in either the neutral or positive conditions. However, it should be acknowledged that subtracting initial performance from performance in a given block might result in between group differences from sources other than the primes. It may be easier for subjects to improve from a low level of performance than it is when they perform at a higher level. If this were the case, the gains shown by subjects in the negative condition could have resulted from their overall lower baseline, pre-prime performance level. The next experiment attempted to bring subject performance to comparable levels between conditions by increasing the number of trials so that the correctives applied in this analysis will be unnecessary.

Chapter Three

Experiment

This experiment was similar to the second pilot experiment, but included 620 trials instead of 350. Additionally, this experiment provided feedback to subjects at the end of the calibration period regarding the number of fixations which they reported incorrectly.

Method:

Subjects. 48 subjects were recruited from University of South Florida undergraduate classes. All subject had normal or corrected-to-normal vision.

Materials: The prime stimuli, PL stimuli, and data gathering program were the same in this experiment as the second pilot experiment.

Procedure: After an initial calibration period lasting 60 trials during which the magnitude of the offset was varied, participants completed 10 blocks of 50 primed trials followed by one unprimed block of 60 trials. Additionally, when the subjects completed half of the primed trials, they were given a 5 minute break which they were required to utilize.

The distance between the endpoints of the two offset lines was adjusted during the initial 60 trial calibration stage, as with the previous experiments. When the calibration period ended, subjects were informed as to percentage of trials in which the fixation was missed and encouraged to maintain fixation.

Participants were presented with trials in one of three conditions. Participants viewed either negative, positive, or neutral images for 500 ms prior to the target.

Because of the limited number of threat-related images in the IAPS, the 100 sampled images in each valence category were presented 5 times each. However, the order of the images was completely randomized so that one image could appear multiple times before another image was presented once. It was hoped that this presentation order would minimize any adaptation or familiarity effects.

Results:

Data for four subjects was thrown out because they missed more than 40% of the centrally presented characters. Analyses were conducted both including and excluding these subjects and, while it did not change the reliability of any of the specific statistical tests, the following analysis excludes those subjects because they were clearing making a trade off between reporting the central character and direction of the offset.

A graph of the percentage of trials in which subjects failed to report the identity of the central character for all trials, can be seen in figure 8. Any trials in which the subjects did not correctly indicate the central character were excluded from subsequent analyses. In order to check that errors did not vary as a function of prime, an ANOVA was conducted with prime (positive, negative, neutral) as the between subjects factor and block (12 levels) as the within subjects factor. While there were no reliable effects on errors (block, $F(11,495) = .781$, $MS_e = .008$, $p = .66$; prime, $F(2,45) = 2.40$, $MS_e = .177$, $p = .10$; block x prime, $F(22,495) = 1.26$, $p = .193$), the effect of prime approached reliability. Subjects seem to miss more of the fixations when presented with the valenced primes. Any tradeoff between accuracy in the offset task and the fixation represents a serious problem when learning measured as conditional accuracy in the offset task. If a subject were to fixate the offset and guess with respect to the central character, they

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would appear accurate in that trials in which the identity of the character is reported inaccurately were excluded.

Figure 9 depicts accuracy for trials in which subject's accurately identified the centrally presented character. An ANOVA with prime (positive, negative, neutral) as the between subjects factor and block (12 levels) as the within subjects factor revealed a reliable effect of block, $F(11, 495) = 4.12$, $MS_e = .007$, $p = .002$. An effect of prime, $F(2,45) < 1$, or a block x prime interaction, $F(22, 495) < 1$, failed to obtain.

In order to more fully explore the possibility of a tradeoff in performance between central character task and offset task, subjects were excluded from the analysis in order to control for the number of missed fixations between conditions. This involved the removal of observations for three subjects in the negative condition and two subjects in the positive condition. Without those subjects, the overall number of missed fixations was comparable between the positive (M = .104), negative (M = .104), and neutral (M = .100) conditions. A graph of missed fixations, once the groups were trimmed to equalize performance can be seen in figure 10. A graph of offset learning for the remaining subjects can be in seen in figure 11. While any conclusions would be suspect because of the violation of the independence assumption of, a second ANOVA was run with same factors as the previous for the sake of thoroughness. This ANOVA used the fixation equalized data set. There was still an effect of block, $F(11, 440) = 3.07$, $p = .001$. There was no effect of prime, $F(2, 40) < 1$, or a block x prime interaction, $F(22, 440) < 1$.

Chapter Four

Discussion

While subject's mean performance across blocks was higher in the negatively valenced condition than the positively valenced condition, considerable variability in individual performance levels prevent any conclusions regarding the contribution of the affective content to accuracy. This stands in contrast to a study completed recently in which subjects' learning of the same discrimination was influenced by valenced primes.

It is unfortunate that the subjects' performance levels in this discrimination task were so variable. The number of trials may still be too low. This study was designed to have twice as many trials as the longest previous experiment using this paradigm, but that does not guarantee enough observations. The number of threatening images used in the study was limited to those sampled from the IAPS. Subjects only completed the primed discrimination task on 500 trials. In contrast, subjects in the study by Phelps et al. (2006) completed 10 blocks of 120 trials. More observations may be needed. While perceptual learning has been shown to develop over short periods of time, typically experiments take several hours for any individual subject. Second, instructions may not have been sufficiently explicit. Subjects seem to have had difficulty maintaining fixation in the experiment. This remains a major problem for this type of task, despite repeated reminders for subjects. While the number of missed fixations did not vary as a function of block or prime, the number of errors was still higher than ideal. Presenting stimuli peripherally is just one technique of pulling performance away from ceiling. Future research may need to employ sandwich masks, divide attention in a way that doesn't involve attending to multiple spatial locations, or some similar manipulation.

Once performance was equalized between prime conditions by deleting data from subjects who missed too many fixations, one can see generally less noisy learning functions in figure 11. While statistical tests cannot be employed because the differential removal of subjects from conditions renders analyses dependent, it is clear that, if one removes subjects who missed to many fixations, the learning task does not move toward superior learning in the negative condition.

Pilot experiment 1 only used positive and negative images. In contrast, in the second pilot and the present experiment three valence conditions were employed. It was anticipated that more valence levels in the priming stimuli would allow more detailed conclusions regarding the cause of differences observed in the valence conditions. Unfortunately, the data is equivocal. No reliable differences were observed between the priming conditions in this final experiment. Differences between the negative and positive conditions in the two pilot experiments would seem to indicate that the differences between conditions is due to benefits associated with viewing negative images, as opposed to costs associated with viewing positive or neutral images. However, such an explanation cannot be excluded. Certain models of affect suggest that positive affect can be considered a sign that attention should be directed elsewhere (Carver, 2003). If that were the case, performance differences would not be solely the result of the negative images. Additional research has indicated that positive affect is associated with a broadening of visual attention, as measured by diminished performance in a flanker task (Rowe et al., 2006). It has been suggested for some time that arousal or fear might result in a narrowing of attentional focus (Baddeley, 1972). This could

conceivably explain the clear tradeoff between central character and offset accuracy in the negative prime conditions.

Many of the problems associated with the affective manipulation in this experimental design can be remedied by using techniques similar to those employed in PL research. In much the same way that researchers who wish to learn about the role of experience in perception gain greater experimental control by creating wholly novel situations in which experience can be manipulated experimentally, affective manipulations can be more finely controlled by creating wholly new valenced associations in an artificial setting. Subject can be trained to associate a given cue with either positive or negative consequences. This minimizes the influence of personality variables, pre-experimental experience, or other individual differences variables which might influence reactions to affective cues. Rather than presenting subjects with images that vary along numerous dimensions, stimuli can be selected which minimize variation. When looking for what may be small differences between valence conditions, sensitivity can be increased by directly manipulating the expectations of participants regarding the affective cue.

Overall, this experiment exemplifies many of the challenges researchers face when attempting to integrate paradigms associated with different areas of inquiry. While affective manipulations may remain a viable tool for researchers to better understand the relationship between attention and PL, greater thought, care, experimental control will be requisite if reliable inferences are to be drawn.

References

Ahissar, M., & Hochstein, S. (2004). The reverse hierarchy theory of visual perceptual learning. *Trends in Cognitive Sciences, 8*(10), 457-464.

Ahissar, M., & Hochstein, S. (2002). The role of attention in learning simple visual tasks. In M. Fahle, & T. Poggio (Eds.), *Perceptual learning.* (pp. 253-272)MIT Press.

Agranoff, B. W., Cotman, C. W., Uhler, M. D. (1999). Learning and Memory. In G. J. Siegel, B. W. Agranoff, R. W. Albers, S. K. Fisher, M. D. Uhler (Eds.), *Basic Neurochemistry* (pp 1027-1052) Lippincott Williams & Wilkins.

Amaral, D.G., Behniea, H., & Kelly, J. L. (2003). Topographic organization of projections from the amygdala to the visual cortex in the macaque monkey. *Neuroscience, 118*, 1099-1120.

Anderson, A., & Phelps, E. (2001). Lesions of the amygdala impair enhanced perception of emotionally salient event. *Nature, 441*, 305-309.

Arnold, M. B. (1960). *Emotion and personality. vol. II. neurological and physiological aspects.* Columbia Univer. Press.

Averill, J. (1997). *The emotions: An integrative approach*, 513-541, Academic Press.

Baddeley, AD. (1972). Selective attention and performance in dangerous environments. British Journal of Psychology, 63(4), 537-546.

Bar, M., & Neta, M. (2006). Humans prefer curved visual objects. *Psychological Science, 17*(8), 645-648

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of General Psychiatry, 4*, 561-571.

Beck, A. T., & Steer, R. A. (1990). *Beck Anxiety Inventory manual*. San Antonio, TX: The Psychological Corporation.

Bishop, S. J., Duncan, J., & Lawrence, A. D. (2004). State anxiety modulation of the amygdala response to unattended threat-related stimuli. *Journal of Neuroscience, 24*(46), 10364-10368.

Bishop, S., Duncan, J., Brett, M., & Lawrence, A. D. (2004). Prefrontal cortical function and anxiety: Controlling attention to threat-related stimuli. *Nature Neuroscience, 7*(2), 184-188.

Carretié, L., Mercado, F., Tapia, M., & Hinojosa, J. A. (2001). Emotion, attention and the 'negativity bias', studied through event-related potentials. *International Journal of Psychophysiology, 41*(1), 75-85.

Carver, C. S. (2003). Pleasure as a sign you can attend to something else: Placing positive feelings within a general model of affect. *Cognition & Emotion, 17*, 241-261.

Chen, D., Katdare, A., & Lucas, N. (2006). Chemosignals of fear enhance cognitive processing in humans. *Chemical Sense, 31(5).*

Codispoti, M., Bradley, M. M., & Lang, P. J. (2001). Affective reactions to briefly presented pictures. *Psychophysiology, 38*(3), 474-478.

Cohen, D. J., Eckhardt, C. I., & Schagat, K. D. (1998). Attention allocation and habituation to anger-related stimuli during a visual search task. *Aggressive Behavior, 24*(6), 399-409.

Compton, R. J. (2003). The interface between emotion and attention: A review of evidence from psychology and neuroscience. *Behavioral and Cognitive Neuroscience Reviews, 2*(2), 115-129.

Crist, R., Kapadia, M., Westheimer, G., & Gilbert, C. (1997). Perceptual learning of spatial localization: Specificity for orientation, position, and context. *Journal of Neurophysiology, 78*(6), 2889-2894

Cuthbert, B. N., Schupp, H. T., Bradley, M., McManis, M., & Lang, P. J. (1998). Probing affective pictures: Attended startle and tone probes. *Psychophysiology, 35*(3), 344-347.

Dinse, H. R., Ragert, P., Pleger, B., Schwenkreis, P., & Tegenthoff, M. (2003). Pharmacological modulation of perceptual learning and associated cortical reorganization. *Science, 301*(5629), 91-94.

Dosher, B. A., & Lu, Z. (1999). Mechanisms of perceptual learning. *Vision Research, 39*(19), 3197-3221.

Duncan, J. (1984). Selective attention and the organization of visual information. *Journal of Experimental Psychology, 113(4),* 501-517.

Ekman, P. & Friesen, W. V. (1976). *Pictures of Facial Affect.* Palo Alto, CA: Consulting Psychologists Press.

Epstein, W. (1967). *Varieties of Perceptual Learning.* McGraw-Hill.

Fahle, M., Edelman, S., & Poggio, T. (1995). Fast perceptual learning in hyperacuity. *Vision Research, 35*(21), 3003-3013.

41

Fahle, M. (2005). Perceptual learning: Specificity versus generalization. *Current Opinion in Neurobiology, 15*(2), 154-160.

Fahle, M. (2004). Perceptual learning: A case for early selection. *Journal of Vision, 4*(10), 879-890.

Fahle, M. (2002). Learning to perceive features below the foveal photoreceptor spacing. In M. Fahle, & T. Poggio (Eds.), *Perceptual learning.* (pp. 197-218)MIT Press.

Fahle, M. (1991). Parallel perception of vernier offsets, curvature, and chevrons in humans. *Vision Research, 31*(12), 2149-2184.

Fendrich, R., Wessinger, M., & Gazzaniga, M. S. (2001). Speculations on the neural basis of blindsight. *Progress in Brain Research, 134*, 353-366.

Fox, E. (1993). Allocation of visual attention and anxiety. *Cognition & Emotion, 7*(2), 207-215.

Fox, E. (1993). Attentional bias in anxiety: Selective or not? *Behaviour Research and Therapy, 31*(5), 487-493.

Gibson, E. J. (1969). Principles of perceptual learning and development. Appleton-Century-Crofts.

Gilbert, C. D., Sigman, M., Crist, R. E. (2001). The neural basis of perceptual learning. *Neuron*, *31,* 681-686

Herzog, M. H., & Fahle, M. (1997). The role of feedback in learning a vernier discrimination task. *Vision Research, 37*(15), 2133-2141.

Hoshino, O. (2004). Neuronal Bases of Perceptual Learning Revealed by a Synaptic Balance Scheme. *Neural Computation*, *16*(3), 563-594.

Kalat, J. (2001). *Biological psychology (7th ed.)*. Wadsworth/Thomson Learning.

Klüver, H., & Bucy, P. C. (1938). An analysis of certain effects of bilateral temporal lobectomy in the rhesus monkey, with special reference to 'psychic blindness.'. *Journal of Psychology: Interdisciplinary and Applied, 5*, 33-54.

Kohler, I. (1962). Experiments with goggles. *Scientific American*, *206*(5), 62-86.

Koster, E. H. W., Crombez, G., Van Damme, S., Verschuere, B., & De Houwer, J. (2004). Does imminent threat capture and hold attention? *Emotion, 4*(3), 312-317

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1998). Emotion and attention: Stop, look, and listen. *Cahiers De Psychologie Cognitive/Current Psychology of Cognition, 17*(4), 997-1020.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2005). *International affective picture system: Instruction manual and affective ratings.* Technical Report A-6. University of Florida, Gainesville, FL

Li, W., Piëch, V., & Gilbert, C. D. (2004). Perceptual learning and top-down influences in primary visual cortex. *Nature Neuroscience, 7*(6), 651-657.

Logan, G. D. (1992). Attention and preattention in theories of automaticity. *American Journal of Psychology, 105*(2), 317-339.

Logothetis, N., & Pauls, J. (1995). Psychophysical and physiological evidence for viewer-centered object representations in the primate. *Cerebral Cortex*, *5*(3), 270-288.

Mathews, A., Fox, E., Yiend, J., & Calder, A. (2003). The face of fear: Effects of eye gaze and emotion on visual attention. *Visual Cognition, 10*(7), 823-835.

Matthews, N., & Welch, L. (1997). Velocity-dependent improvements in single-dot direction discrimination. *Perception & Psychophysics, 59*(1), 60-72.

Öhman, A., Esteves, F., & Soares, J. J. F. (1995). Preparedness and preattentive associative learning: Electrodermal conditioning to masked stimuli. *Journal of Psychophysiology, 9*(2), 99-108.

Öhman, A., & Soares, J. J. F. (1998). Emotional conditioning to masked stimuli: Expectancies for aversive outcomes following nonrecognized fear-relevant stimuli. *Journal of Experimental Psychology: General, 127*(1), 69-82.

Petrov, A. A., Dosher, B. A., & Lu, Z. (2005). The dynamics of perceptual learning: An incremental reweighting model. *Psychological Review, 112*(4), 715-743.

Phelps, E. A., Ling, S., & Carrasco, M. (2006). Emotion facilitates perception and potentiates the perceptual benefits of attention. *Psychological Science, 17,* 292-299.

Poggio, T., Fahle, M., & Edelman, S. (1992). Fast perceptual learning in visual

hyperacuity. *Science, 256*(5059), 1018-1021.

Pourtois, G., Dan, E., Grandjean, D., Sander, D., & Vuilleumier, P. (2005). Enhanced Extrastriate Visual Response to Bandpass Spatial Frequency Filtered Fearful

Faces: Time Course and Topographic Evoked-Potentials Mapping. *Human Brain Mapping*, *26*(1), 65-79

Pylyshyn, Z. (1999). Is vision continuous with cognition? The case of impenetrability of visual perception. *Behavioral and Brain Sciences*, *22*(3), 341-423.

Schimmack, U., & Derryberry, D. (2005). Attentional interference effects of emotional pictures: Threat, negativity, or arousal? *Emotion, 5*(1), 55-66.

Seitz, A. & Watanabe, T. (2005). A unified model for perceptual learning. *Trends in Cognitive Sciences.*

Sheinberg, D., & Logothetis, N. (2002). Perceptual learning and the development of complex visual representations in temporal cortical neurons. *Perceptual learning* (pp. 95-124).

Soares, J. J., & Öhman, A. (1993). Preattentive processing, preparedness and phobias: Effects of instruction on conditioned electrodermal responses to masked and non-masked fear-relevant stimuli. *Behaviour Research and Therapy, 31*(1), 87-95.

Speilberger, C. D. (In press). Preliminary manual for the state-trait personality inventory.

Takeo, W., Náñez, J. E., & Sasaki, Y. (2001). Perceptual learning without perception. *Nature, 413*(6858), 844-848.

Tipples, J., Young, A. W., Quinlan, P., Broks, P., & Ellis, A. W. (2002). Searching for threat. *Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 55*(3), 1007-1026

Tooby, J., Cosmides, L. (1990). The past explains the present: Emotional adaptations and the structure of ancestral environments. *Ethology & Sociobiology, 11*(4), 375-424.

Vuilleumier, P., & Schwartz, S. (2001). Beware and be aware: Capture of spatial attention by fear-related stimuli iin neglect. *Neuroreport: For Rapid Communication of Neuroscience Research*, *12*(6), 1119-1122.

Watanabe, T., Náñez, J. E. S., Koyama, S., Mukai, I., Liederman, J., & Sasaki, Y. (2002). Greater plasticity in lower-level than higher-level visual motion processing in a passive perceptual learning task. *Nature Neuroscience, 5*(10), 1003-1009.

Weiss, Y., Edelman, S., & Fahle, M. (1993). Models of perceptual learning in vernier hyperacuity. *Neural Computation, 5*(5), 695-718.

Zeelenberg, R., Wagenmakers, E. J., & Rotteveel, M. (2006). The impact of emotion on perception. Bias or enhanced processing. *Psychological Science*, *17,* 287-291.

Figure 1. Vernier stimulus used in pilot experiment 1.
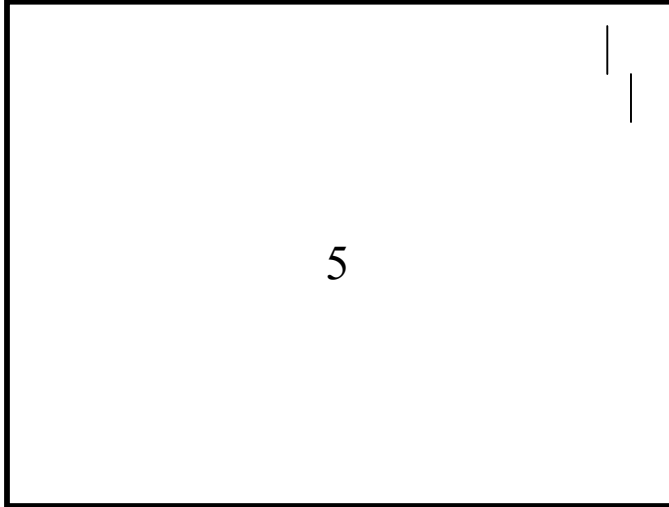
Figure 2. Experiment 1 Sequence—Calibration Stage

Fixation- 150ms	
Target- 100ms	5
Initial Prompt- until response	Press "1" for Left or "2" for Right
Second Prompt- until response	Press "5" or "S"

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Figure 3. Experiment 1 Sequence—Valenced-prime Stage

Fixation- 150ms	
Prime- 500ms	
Target- 100ms	5
Initial Prompt- until response	Press "1" for Left or "2" for Right
Second Prompt- until response	Press "5" or "S"

Figure 4. Graph showing missed fixations in Pilot Experiment 1

Missed Central Characters
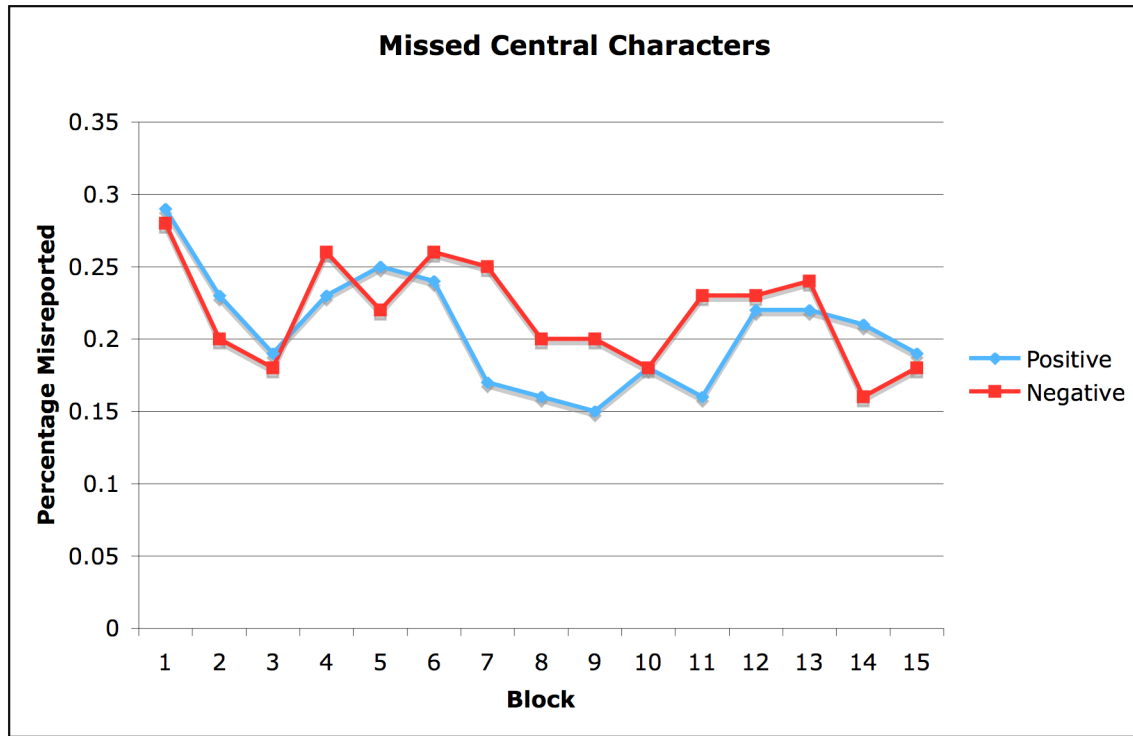
Figure 5. Rate of Learning for subjects in Pilot Experiment 1

Effect of Threat on Perceptual Learning
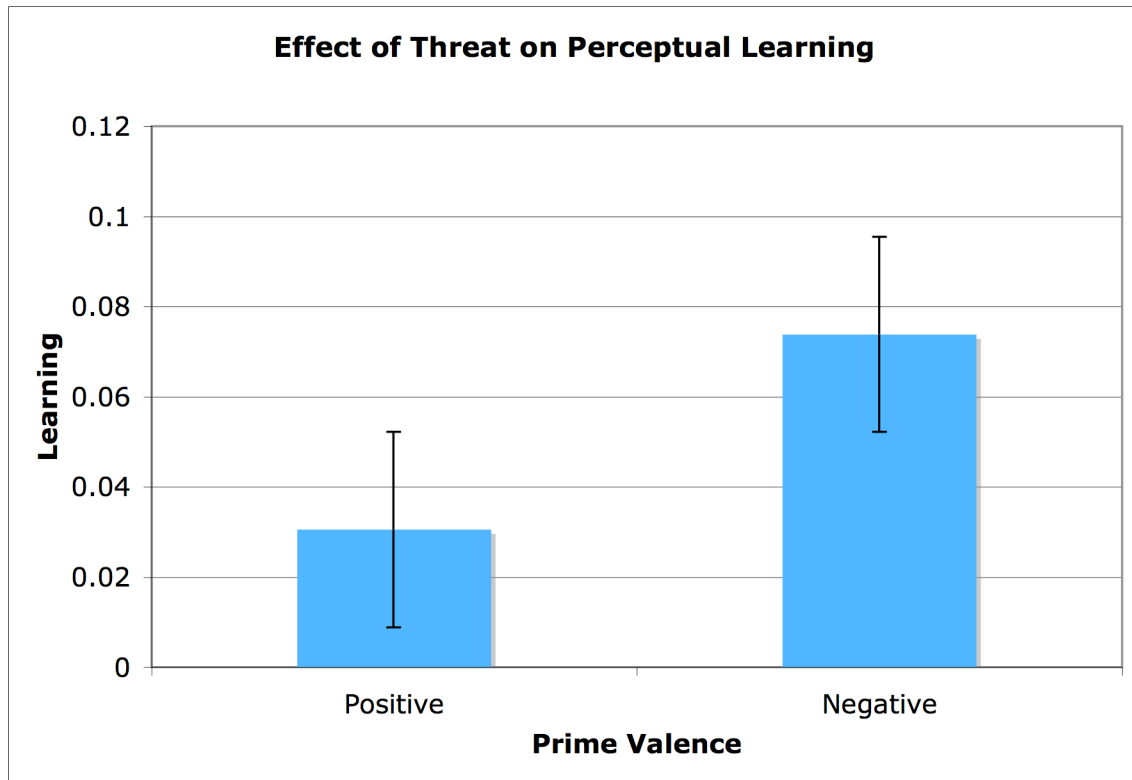
Figure 6. Missed Fixations in Pilot Experiment 2.
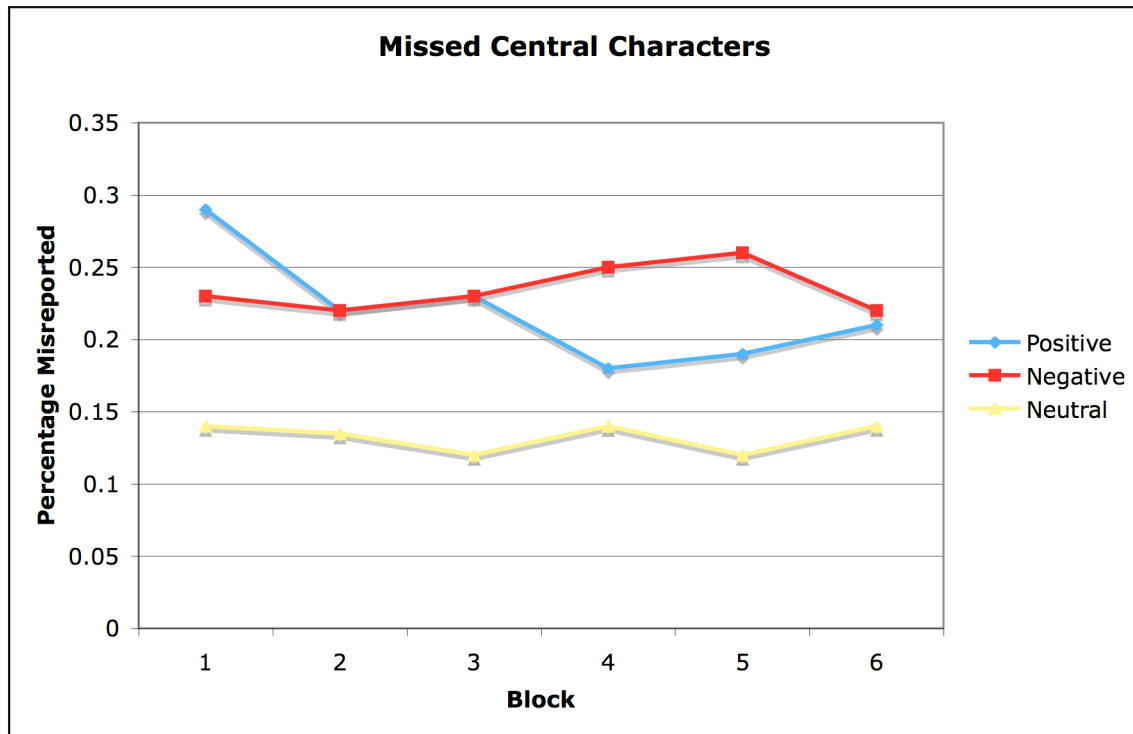
Figure 7. Normalized learning in Pilot Experiment 2

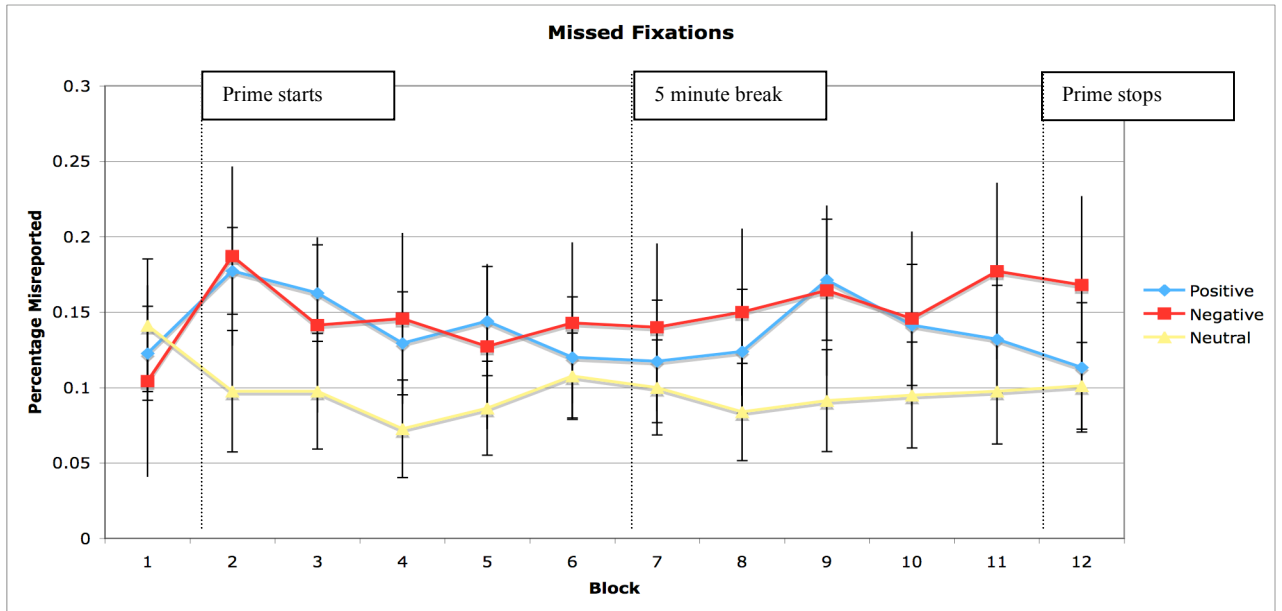51
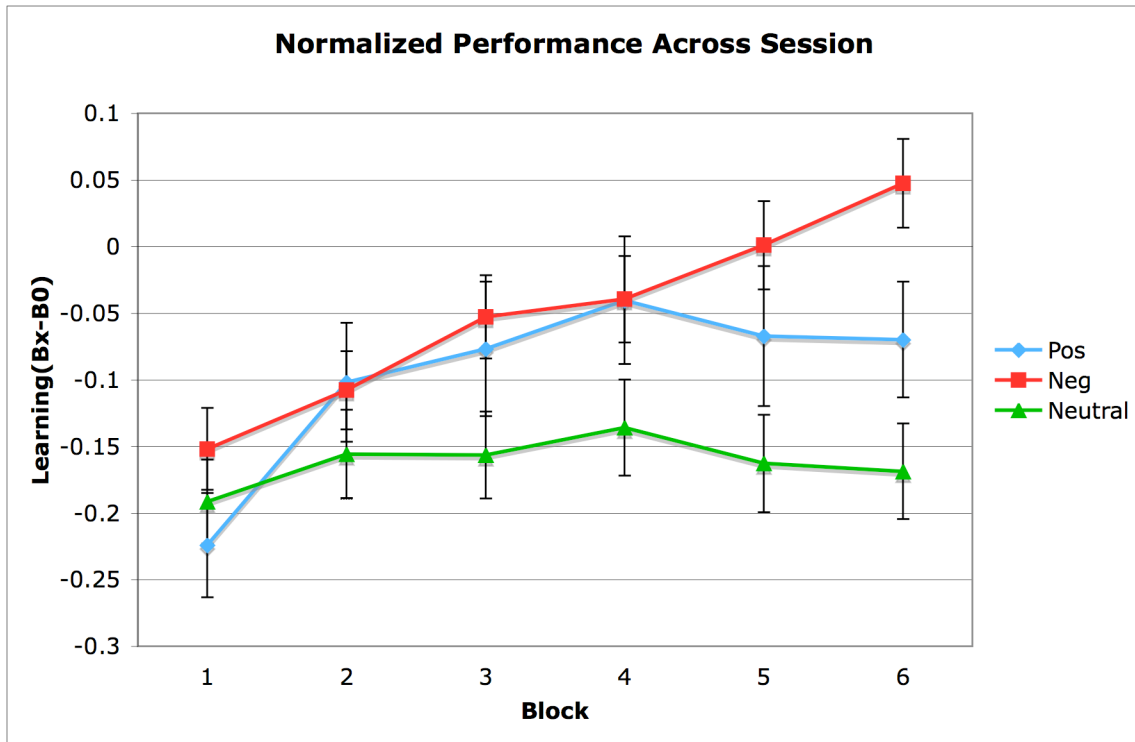
Figure 8. Graph showing missed fixations in Experiment 3

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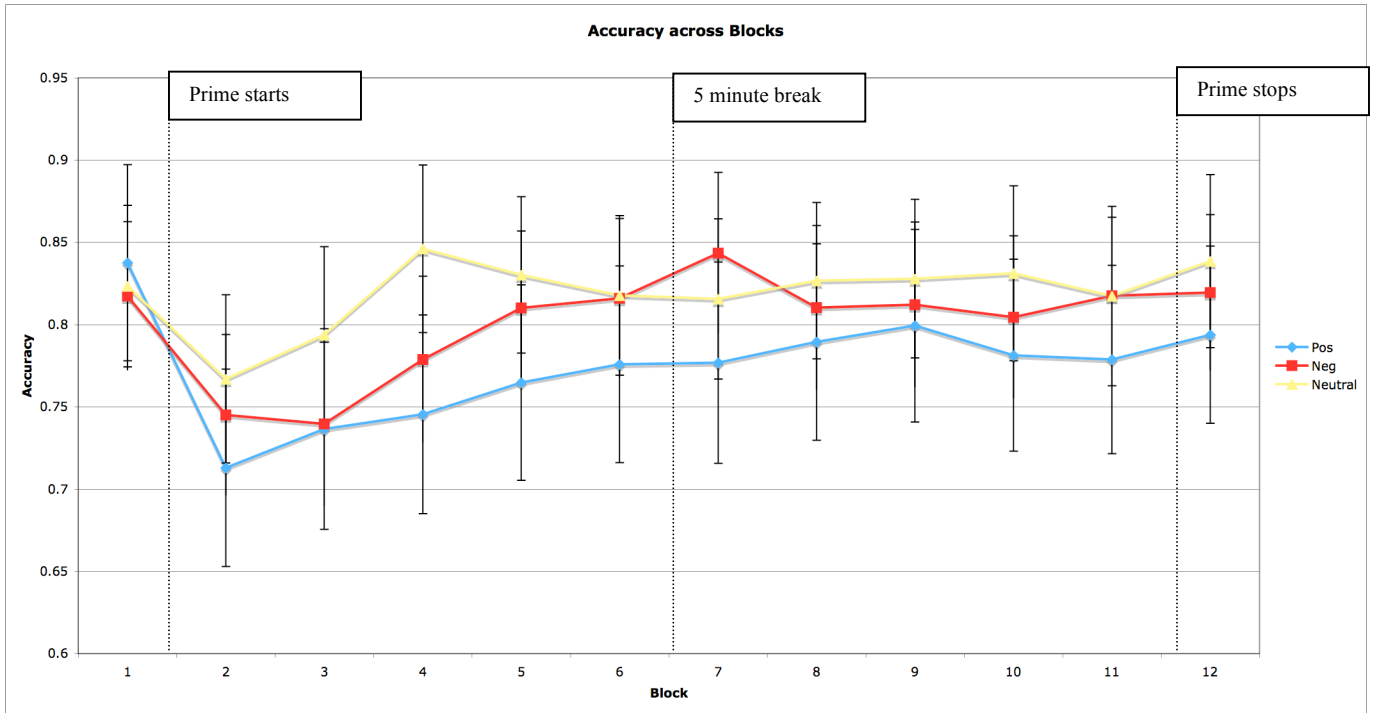Figure 9. Performance for participants in the Experiment

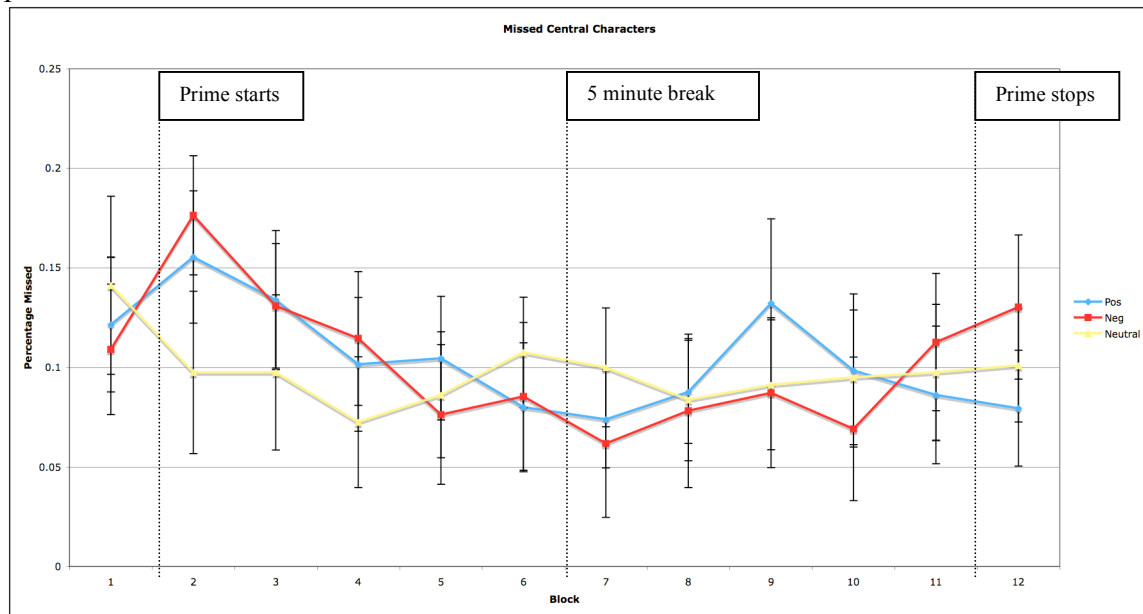Figure 10. Missed Fixations in Experiment once subjects excluded to equalize performance

Figure 11. Performance in the offset task for the Experiment once the groups were trimmed to equalize performance.