A Test of Prinz's Air Theory: Is Attention Sufficient for Conscious Emotion?

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A TEST OF PRINZ'S AIR THEORY: IS ATTENTION SUFFICIENT FOR CONSCIOUS EMOTION?

by

ANAÏS FERN STENSON

Under the direction of Dr. Andrea Scarantino

ABSTRACT

Jesse Prinz proposes that attended intermediate-level representations (AIRs) are sufficient for conscious awareness. He extends this claim to emotion, arguing that attention is the mechanism that separates conscious from unconscious emotions. Prior studies call this entailment into question. However, they do not directly address the intermediate-level requirement, and thus cannot decisively refute the AIR theory of consciousness. This thesis tests that theory by manipulating participants’ attention to different features of subliminally processed words while recording both behavioral and electroencephalogram (EEG) data. Both measures suggest that subliminally processed stimuli are attended according to participants’ conscious intention to complete a task. In addition, the EEG data demonstrate that intermediate-level neural activity was modulated by the subliminal stimuli. Thus, these results suggest that AIRs are not sufficient for conscious emotion. This finding undermines Prinz’s AIR theory, and its account of the distinction between conscious and unconscious emotion.

INDEX WORDS: Attention, Consciousness, Emotion
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ANAÎS FERN STENSON

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1 INTRODUCTION

The relationship between attention, awareness, and emotion is a complex topic that interests both philosophers and psychologists (Clore et al., 2005; Feldman Barrett, 2005; Berridge & Winkielman, 2003; Lacewing, 2007; Prinz, 2005; Winkielman, 2004; Winkielman et al., 2005). In this context, the existence of unconscious emotions has been particularly controversial (Prinz, 2011). Those who view conscious, subjective awareness as intrinsic to emotion regard "unconscious emotion" as an oxymoron, whereas those who adopt a more inclusive view note that affectively charged stimuli can evoke emotional responses, even in the absence of awareness of either the stimulus, the emotion, or both.

Historically, felt experience was considered a necessary component of emotion. William James (1884) articulated an influential statement of this view, writing that, “…our feeling of the same [bodily] changes as they occur IS the emotion” (p. 190). Simply put, the phenomenology of certain physiological changes constitutes an emotion. On this account, emotion entails conscious experience. It follows that there are no unconscious emotions. Many contemporary accounts of emotion descend from this Jamesian view.

Proponents of unconscious emotion reply that consciousness is not necessary for emotion. For instance, Winkielman and Berridge (2004) propose that, “people can have subliminally triggered emotional reactions that drive judgment and behavior, even in the absence of any conscious feeling accompanying these reactions” (p. 121). The behavioral shift is taken as evidence of the emotion, regardless of whether it was consciously experienced. This account operationalizes emotion by equating it with behavioral outcomes that follow from the perception of emotionally charged stimuli.

1 In the present context, "consciousness" and "awareness" are used interchangeably.
Each side has established conditions that are purportedly sufficient for emotion, and both argue that so long as those are fulfilled, a particular state can properly be called an emotion. As a result, the two parties count emotions differently. One way to advance this debate is to examine instances of purportedly conscious and unconscious emotion in order to determine how they differ.

In this thesis, I will accept for the sake of argument that “unconscious emotion” is not an oxymoron, and examine the specific neurophysiological and mental processes that may distinguish between conscious and unconscious emotions. In particular, my focus will be on Jesse Prinz’s (2011) recent proposal that an emotion will become conscious if and only if a valenced stimulus is attended. Valence is the hedonic quality of a stimulus, which falls along a spectrum from negative to positive (Prinz, 2011, p. 161). Prinz’s thesis is then that attention to a stimulus with hedonic quality is both necessary and sufficient to produce a conscious emotion, where by attention he means the availability of a stimulus to working memory (n.d, p. 87).

The goal of this thesis is to test part of this claim: the idea that attention to a valenced stimulus always produces a conscious emotion. I will evaluate how attention to different dimensions of affectively valenced words (such as murder, peace, or cancer) can impact responses to that stimulus, even when the representation of that stimulus does not enter into conscious awareness. For the present experiment, attention is operationalized as a conscious intention to complete a particular task. I hypothesize that such a task will impact subliminal word processing. If this outcome obtains, then Prinz’s entailment between attention and consciousness is incorrect.
To test the relationship between attention, consciousness, and emotion, I examine the behavioral and brain responses to valenced words during two different experimental conditions. In the first, participants were instructed to attend to *valence*. Their task was to classify words as being strongly negative or neutral. In the second, they attended to the *case* of the words. Their task was to classify words as being upper or lower case. In both conditions, two words were presented in rapid succession. The first word was presented for a duration that precludes conscious perception (35 milliseconds (ms)). It was quickly replaced by the second word (3,000 ms), which is consciously perceived. Participants classified this word according to the task (either *attend valence* or *attend case*).

The results of this experiment demonstrate that when attention is consciously directed to a particular feature (valence or case) of words, that intention impacts how subliminal stimulus processing unfolds. Both behavioral and electrophysiological (EEG) responses varied according to the task-congruence of the first and second words. The task-specific effect of the subliminally processed first word on processing of the subsequent target word suggests that participants’ conscious intention to complete a particular task impacted processing at the subliminal level. That is, when both words were congruent according to a given task, the first word facilitated processing of the second word.

These results suggest that, if valenced words are sufficient to elicit emotions, then those emotions can be attended without producing any subsequent conscious experience. Since Prinz contends that conscious and unconscious emotions are distinguished by attention, the current results suggest falsification of his account. That is, this study provides evidence that unconscious emotions can be attended without becoming conscious. In other words, if the present results withstand objections, they demonstrate that conscious and
unconscious emotions are not separated by attention alone. Before accepting this conclusion, though, the theory, experiments, and interpretation of the results should be examined in greater detail.

The thesis is structured as follows. First, I outline Prinz’s theories of emotion and consciousness. I then introduce empirical findings that offer a preliminary challenge to Prinz’s understanding of the role of attention in conscious phenomena. Next, I present my own study, designed expressly to test Prinz’s predictions concerning the role of attention in emotion perception. After reviewing the results of this study, I argue that they spell trouble for Prinz’s theory of unconscious emotions. I then consider Prinz’s likely objections and argue that none succeed in accounting for the present results. In the conclusion, I present evidence that conscious and unconscious emotion processing unfold differently. I then argue that these findings necessitate that Prinz refine the AIR theory both by bolstering his definition of attention and reevaluating his reliance on a hierarchical model of perceptual processing.

1.1 PRINZ’S THEORY OF EMOTIONS AS EMBODIED APPRAISALS

Prinz (2004b) characterizes emotions as “perceptions of patterned changes in the body” that arise within the somatosensory system (p. 371). Emotion has two “raw ingredients:” valence and appraisal (Prinz, 2004b, p. 97). An individual’s appraisal of the valence, or hedonic quality, of a stimulus produces the bodily changes (Prinz, 2004b, p. 100). For instance, the realization that a snake is dangerous produces a particular physiological response—typically, that which will produce the emotion of fear. The perception of these bodily changes constitutes registration of an emotion.
Prinz (2004b) distinguishes between *registration* of an emotion and its *representation content* (p. 58). He specifies that emotions *register* changes in the body, but that they *represent* "relations between external states and ourselves," which he calls “core relational themes” (2004b, p. 60 & 66). Emotions come about (are caused) when the brain registers patterns of bodily changes, but they do not *represent* those changes (Prinz, 2004b, p. 66 & 244). Rather, emotions, like fear, represent core relational themes. In the case of a snake, that theme is danger (Prinz, 2004b, p. 225). Fear does *not* represent a racing heart and sweaty palms. Perceiving a snake *causes* the emotion of fear by producing a suite of bodily changes, such as the racing heart and sweaty palms. These are the physiological “symptoms” of danger. The feeling of fear *represents* the danger posed to the individual by the snake. Emotions are thus valenced perceptions of bodily changes that convey information about an individual’s position in the external world and motivate actions accordingly (Prinz, 2004b, p. 225).

The set of stimuli that can elicit a given emotion are diverse. Prinz proposes that emotion elicitors are unified by the impact they have on a perceiver. For instance, snakes, empty bank accounts, and earthquakes all elicit fear. While reasons those stimuli evoke fear vary, all fear-inducing stimuli will produce a similar set of patterned bodily changes. The many different causes of fear are united by their impact on the perceiver into what Prinz calls a “calibration file” for fear (2004b, p. 100). The contents of calibration files include all of the representations that cause a particular emotion (Prinz, 2004b, p. 100). Thus, there are files for sadness, anger, fear, and so on. For each of these emotions, there are two types of calibration files: one which is “hard wired” in the individual by natural selection, and another that results from cognitive appraisal (e.g., learned associations or
causal inferences). In short, calibration files contain all of the causes of emotions, which have various etiologies.

To summarize, calibration files for particular emotions specify what will cause the patterned bodily changes that are perceived, or registered, and then represented in terms of core relational themes. Prinz (2004b) summarizes his view as follows: “All emotions are embodied appraisals under the causal control of calibration files” (p. 102). Thus, the perception of a snake triggers a set of physiological responses. This pattern of responses is contained within the calibration file for fear. When particular patterns of physiological response unfold, they are appraised in relation to a core relational theme, which is, in this case, danger. This appraisal of danger is then “felt” as fear. In other words, bodily change serves as a barometer, tuned by both phylogeny and personal experience, that indicates the prospects for an individual’s well being. Together, the bodily changes and the appraisal of them constitute the emotion.

Importantly, according to Prinz, neither registration of an emotion nor its representation of a core relational theme entails conscious awareness. Prinz’s theory entails that an attended, intermediate-level representation of a stimulus is sufficient for it to be consciously perceived. On this account, attention to valenced stimuli that generates an intermediate-level representation will produce a conscious emotion.

Prinz (2005a) derives this entailment between attention, intermediate-level representation, and conscious experience from his general theory of perception as, "stimulus detection through a sense organ" (p. 16-17). Prinz (2005a, n.d.) notes that visual stimuli can be processed subliminally (e.g. in cases of blindsight) and infers that subliminal perception also occurs in other perceptual modalities (2005a, p. 23; n.d. p. 9 & 45). Since
Prinz considers emotions to be a kind of perception (namely, that of bodily changes), he infers that they are processed similarly to other percepts (n.d., 53). In short, he holds that there is a common process through which perception unfolds, and that this is conserved across perceptual modalities (n.d., 65-66). Thus, if subliminal visual perception is possible, so is subliminal perception of emotion. To fully appreciate Prinz’s reasoning, we need to delve into the details of the hierarchical model of perception that inspired Prinz’s theory.

1.2 MARR’S HIERARCHICAL MODEL OF PERCEPTION

Prinz’s theory of conscious versus nonconscious perception is based on a model of hierarchical processing set forth by David Marr (1982) and endorsed by Ray Jackendoff (1987). This model distinguishes three stages, or levels, of perception of visual perception.

The lowest level is derived directly from the retinal image (Jackendoff, 1987, p. 170). This level enables detection of basic features of a percept. These include edges, path of motion, and regions with consistent features that set them apart from the rest of the visual field (Jackendoff, 1987, p. 170). The lowest level includes the raw primal sketch, which parses the visual field into primitive forms such as blobs and bars, and the primal sketch, which recombines these elements recursively to derive more complex forms and details from the raw material available in the raw primal sketch (Jackendoff, 1987, p. 171-173). For instance, clusters of small dots might be re-constituted as a two-dimensional shape. This recursive processing continues at each level of perceptual processing, so that each level builds upon the components generated at the prior stage. According to Prinz
(n.d.), the lowest level corresponds to processing in primary areas of sensory cortex (e.g., V1, striate cortex)\(^2\) (p. 43).

Jackendoff specifies that stimulus processing at the low level is fragmentary: distinct features are processed and represented in parallel. It is only when processing advances to the intermediate, or 2.5-D, level that the brain can unify those distinct features into a coherent representation. Jackendoff (1987) contends that this level of processing is the source of conscious experience (p. 293). At this point, stereopsis, motion, shading, surface contours, and texture gradients are unified (Jackendoff, 1987, p. 173). This conjunction of inputs enables two-dimensional object perception (Jackendoff, 1987, p. 174). This processing unfolds in areas of the brain beyond primary sensory cortex. The precise anatomy of the intermediate level is likely to be complex, but Prinz (n.d.) tentatively specifies that it involves extrastriate areas (including V2-V5, as well as V7 and V8) (p. 43).

The third, and highest, level of perception, called the “3D” level, integrates objects into abstract representations that are situated in three-dimensional space (Jackendoff, 1987, p. 174; Prinz, 2004b, p. 208; Prinz, 2005a, “Feelings,” p. 21). In addition, at this level it is possible to visually decompose objects into their component parts and features (Jackendoff, 1987, p. 174). Prinz (n.d.) proposes that this stage of processing occurs in inferior temporal cortex and the lateral occipital complex (p. 43).

This model of perceptual processing is hierarchical in the sense that it proceeds in a step-wise manner, with representational complexity increasing at each level. Within each level, more complex forms are generated from recursive processing of simpler features. Importantly, Jackendoff (1987) specifies that, “in the course of processing, higher-level

\(^2\) Presumably, Prinz is referring to organization of the human brain, but he does not make this explicit.
information can pass down into the 2.5-D sketch and be integrated there, but it is passed down no further” (p. 188). In other words, representations from the raw primal and primal sketches can only move up the processing hierarchy. Thus, the lowest levels are immune to top-down effects.

1.3 THE ROLE OF ATTENTION IN CONSCIOUS EMOTIONS

Prinz applies this hierarchical framework to his account of emotions as perceptions of bodily changes. According to Prinz (2005a), the lowest level of affective perception registers changes in the peripheral nervous system and hypothalamic-pituitary axis (HPA) circuit (that is, where heart and respiration rates are monitored and controlled). These low-level changes in bodily processes (i.e., processes outside the central nervous system) are not sufficient to bring about emotion. Rather, intermediate-level processing is needed to integrate these low-level changes into coherent patterns of bodily response that are represented and perceived as a particular type of emotion (Prinz, 2005a, p. 22; Prinz, 2004b, p. 209; Prinz, 2005b, p. 370-371). Prinz (2004b; n.d.) then makes the crucial proposal that emotions become conscious when attention is added to an intermediate-level emotional representation (2004b, p. 242; n.d., p. 70)

For Prinz (2004b; 2005a), then, intermediate-level processing is necessary for conscious emotion, but it is not sufficient (2004b, p. 209; 2005a, p. 23). Emotions can be represented at this level, without generating a conscious experience. Rather, on his view, an emotion will become conscious only if this processing is attended (2005b, p. 374).

Indeed, Prinz (2005b) characterizes conscious states as “attended intermediate-level representations (AIRs)” (p. 374). In Prinz’s words (n.d.), "AIR theorists will deny that there

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3 Prinz speculates that the intermediate-level is constituted by secondary somatosensory cortex, insular cortex, and portions of the anterior cingulate cortex (2005 a, 370).
can be attention without consciousness” (p. 86-87). Attention plus an intermediate-level representation are individually necessary and jointly sufficient for consciousness. This is also true for emotions. According to the AIR theory, attention and intermediate-level processing of bodily changes are individually necessary and jointly sufficient for conscious emotion.

In order to test Prinz’s hypothesis about the role of attention in conscious versus unconscious emotion, it is critical to understand how he defines attention. In his forthcoming manuscript, Prinz (n.d.) characterizes attention as any process that makes perceptual representations available to working memory4 (p. 77-78). In particular, he claims that, "consciousness arises when and only when intermediate-level representations undergo changes that allow them to become available to working memory" (Prinz, n.d., p. 78).

Prinz (n.d.) emphasizes that attention implies mere availability to, and not necessarily encoding or entry into, working memory (p. 94). According to Prinz (n.d.), attention is not a specific mechanism or process, but rather an outcome: the availability of percepts to working memory (p. 77). Importantly, availability does not entail that an individual can recall what she attended and perceived. Thus, a percept can be attended and consciously experienced without being preserved in working memory. Since Prinz considers attention to be sufficient for consciousness, he argues that the former renders percepts available to working memory, but does not entail that they will be encoded for future access.

4 Prinz defines working memory as the process which briefly stores sensory information, by maintaining, but not representing, it (Prinz, n.d., 25).
Prinz illustrates this relationship between attention and working memory with the example of change blindness (n.d., p. 79). Change blindness occurs when a perceiver carefully scans a continuously changing image, but does not detect the changes. Prinz proposes that this lapse in perception occurs because the viewer cannot recall precisely what the image looked like before (n.d., p. 79). In addition, Prinz contends that all of the elements within the image were consciously perceived (and, therefore, attended), but that they were not encoded in working memory—hence the viewer's inability to identify differences in the image from one moment to the next. In the case of change blindness, a perceiver attends to and consciously perceives the contents of a scene. However, she fails to recall some of what she has seen, because it was not encoded into working memory. Prinz takes this as evidence that neither attention nor consciousness entails encoding in working memory.

This account of attention is referred to as a late selection theory, because it suggests that perceptual processing unfolds independently of attentional modulation until percepts reach the intermediate level (Mole, 2009). At that point, attention functions as the mechanism that selects percepts for entry into working memory. Importantly, though, late-selection models assume that low-level perceptual processing unfolds in the absence of attention. The Marr-Jackendoff model suggests that percepts are only available to attentional modulation once they generate intermediate-level representations (Jackendoff, 1987, p. 188).

Prinz (n.d.) emphasizes the distinction between attention and a closely related process, called orienting (p. 88). The orienting response involves two physiological changes. The first process is eye movement, called saccades, which shift the position of the
fovea so that a focal point is seen in high-resolution. The second process is the shrinking of receptive fields in cells that transduce input from a particular region in order to “hone in” on a location (Prinz, n.d., p. 66 & 120). Both of these changes enhance perception of a particular region in space.

Orienting and attention have distinct perceptual and, typically, temporal impacts. Orienting determines what is perceived by focusing the gaze to particular regions in space. By contrast, attention determines how perceptual processing unfolds. Orienting, then, typically precedes attention, by preparing the nervous system to process certain stimuli in greater detail. However, Prinz (n.d.) notes that orienting and attention can be dissociated (p. 88). For instance, a cue, such as an arrow, might cause a viewer to orient her gaze to a particular region of space. The color of the arrow could instruct her to focus on a particular feature of the upcoming stimulus, such as valence, to which she would then attend. Upon seeing the arrow, she would first orient her gaze to a location, and then direct her focus to processing the semantic value of any subsequent stimuli.

Prinz (n.d.) also differentiates attention and orienting anatomically (p. 88-90). He contends that attention engages the ventral stream, whereas orienting activates the dorsal stream. Thus, attention will have a neural signature: amplification of ventral stream activity, which distinguishes attended from unattended intermediate-level representations. He concludes that attention requires simultaneous dorsal and ventral stream activation, while orienting produces only dorsal stream activation (Prinz, n.d., p. 90).

Prinz (n.d.) worries that orienting is often mistaken for attention (p. 89-90). This concern makes it critically important that any test of the AIR theory carefully separate attentional effects from those produced by mere orienting. My test of the AIR theory aims
to avoid this problem. I will explain how it does so within the section entitled, “Prinz’s Likely Criticisms of the Test and Its Results.”

In summary, Prinz defines attention as the process that makes percepts available to working memory. He distinguishes attention from orienting, specifying that the latter precedes the former and generates enhanced dorsal stream activity. In contrast, attention is distinguished by activation of the ventral stream. He claims that orienting, which increases dorsal stream activity, precedes attention, and that the latter can be identified from increased ventral stream activity. Importantly, Prinz subscribes to Marr and Jackendoff’s model of perceptual processing, and so he presumably grants that low-level perceptual processing is not modulated by attention.

Recall that Prinz (2004b) specifies that emotions are representations of bodily changes that are triggered by a condition, either real or imagined, that is perceived to be relevant to an individual’s well-being (p. 60-62). When that percept engages a core relational theme and generates an intermediate-level representation, it constitutes an emotion. However, the AIR theory stipulates that only attended intermediate-level representations become conscious. Therefore, unattended emotions are necessarily unconscious, whereas attended emotions become conscious. According to Prinz, an attended intermediate-level representation of a valenced stimulus is thus both necessary and sufficient for conscious emotion.

2 PRELIMINARY THREATS TO THE AIR THEORY

As described in the previous section, the AIR theory of consciousness implies that attention and consciousness are tightly connected. In this section I illustrate a body of research that appears to show that subliminally presented, valenced stimuli can be
modulated by attention without becoming conscious. These findings constitute a challenge to the AIR theory, because Prinz specifies that attention to an intermediate-level representation is sufficient to produce a conscious perception.

2.1 A NOTE ON NOMENCLATURE

To properly introduce this experimental literature, I will first clarify how some key terms will be used in what follows, and on the experimental paradigm commonly used to distinguish between conscious and unconscious information processing. I clarify the nomenclature in this section, and then introduce the experimental paradigm in the next.

(a) Emotion: the term ‘emotion’ will be used according to Prinz’s (2004b) stipulations, which designate intermediate-level representations of patterned bodily changes that result from the perception of a stimulus that is important to the individual’s well being as emotions (p. 60). Registration of an emotion refers to detection of a pattern of bodily changes triggered by a valenced stimulus. The emotion that is registered represents an appraisal of what that stimulus implies for the individual’s well-being. Neither registration nor representation of an emotion entails conscious experience.

To illustrate, recall the earlier account of a snake that causes fear. The perception of a snake generates a set of physiological changes. If these changes are represented at the intermediate level, they elicit the emotion of fear. The fear represents the danger that the snake poses to the perceiver. According to Prinz, this entire process—the perception of the snake, the subsequent bodily changes, and the representation of danger—can unfold without producing a conscious feeling of fear.

(b) A conscious emotion is an emotion that is consciously experienced. The “what its likeness” of conscious emotions are called feelings. For instance, seeing a snake might
produce sensations, such as trembling, shortness of breath, accelerated heart rate, and the urge to run away. If these are felt, the fear is consciously experienced. However, all of those sensations could remain below the threshold of conscious awareness. *Unconscious emotions* do not generate a conscious feeling. Throughout the thesis, the terms *subliminal* and *unconscious* are used interchangeably: both refer to cognitive processes that do not generate a phenomenological component. By contrast, *supraliminal* and *conscious* processes are distinguished by their phenomenological components.

(c) *Valence* is the hedonic quality of a stimulus, which falls on the spectrum of negative to positive, or, put otherwise, displeasure to pleasure (Prinz, 2004b, p. 161; Damasio, 1999; Barrett, 2008). For example, snakes are typically considered to be repulsive, or bad. By contrast, kittens are perceived as being pleasant. Therefore, snakes are described as having a negative valence, whereas kittens are positively valenced. Stimuli also differ in the degree of their valence: kittens might be moderately positive, whereas winning the lottery would likely be extremely positive.

(d) *Arousal* refers to the intensity of response induced by a stimulus (*Gut Reactions*, 161; Damasio, 1999; Barrett, 2008). Stimuli that produce strong reactions are high-arousal, whereas those that generate mild reactions are low-arousal. To illustrate the distinction, consider the difference in the degrees of reaction to a grizzly bear or a spider. Typically, the grizzly will evoke a powerful response, whereas the spider will produce a mild or moderate reaction. Very few people will run, full-speed, away from a spider. To contrast, encountering a grizzly bear will prompt most people to get far away as quickly as possible. This reflects the difference in arousal of the two stimuli.
Importantly, the valence and arousal produced by a stimulus are orthogonal to each other. That is, the valence of a stimulus is independent of its level of arousal. To illustrate this separability, imagine reading a newspaper article about a genocide unfolding in a distant country. While this article would likely induce great displeasure (extreme negative valence) in the reader, it would probably not cause her to jump out of her chair, react violently, scream, or alter her immediate plan of action in any way. The article, although upsetting, is not highly arousing. Compare this to the grizzly bear, which is both strongly negative and highly arousing. The bear and the newspaper article are both negatively valenced, but they produce different levels of arousal. Some stimuli are both strongly valenced and highly arousing, while others are neutral in valence but also highly arousing, or vice-versa.

2.2 THE MASKED STIMULUS-PROCESSING PARADIGM

An experimental method that is often used for the empirical study of conscious and unconscious processing is called the masked stimulus processing paradigm (MSPP). In MSPPs, a method called visual masking is used to present stimuli in a way that leads to subliminal processing (Balconi & Mazza, 2009; Gibbons, 2009; Greenwald et al., 2003; Kiss & Eimer, 2008; Marcel, 1983b). To ensure subliminal processing, the stimulus, called a prime, is presented very rapidly (typically for less than 50 ms). Commonly used primes include pictures and words. Primes are often immediately followed by a masking stimulus, called a backward mask, such as a string of symbols (e.g., $#&!). The mask is thought to “overwrite” the visual representation of the stimulus in working memory (Marcel, 1983b). Typically, the mask is followed by a consciously perceived stimulus, called a target. Targets are often of the same genre, e.g. pictures or words, as the primes, but they need not be.
Typically, participants are instructed to make a decision in response to the target. The purpose of MSPPs is to test how this sequence of stimulus presentation impacts subsequent behavior and cognition.

A critical feature of MSPPs is that the prime is only available for subliminal processing. Therefore, the optimal duration for a prime is one that prevents the stimulus from entering conscious awareness, but allows sufficient time for nonconscious detection and processing of features relevant to the experimental task. In many contexts, stimulus durations of approximately 17-56 ms will meet these criteria (Balconi & Mazza, 2009; Gibbons, 2009; Greenwald et al., 2003; Kiss & Eimer, 2008; Marcel, 1983b). In these cases, participants perform at chance rates when asked to identify the prime, and they often deny having seen the stimulus at all (Balconi & Mazza, 2009; Gibbons, 2009; Greenwald et al., 2003; Kiss & Eimer, 2008; Marcel, 1983a). In other words, when primes are presented briefly and followed by a mask, the perceiver has no experience, either immediate or recalled, of the prime. Hence, it is inferred that processing of the prime is fully subliminal.

Elsewhere, Prinz (2007) has rejected claims that conscious states can be unreportable (p. 522). Therefore, he should concur that the primes presented in properly designed masked stimulus processing paradigms are perceived and processed subconsciously (2004b, p. 204). This manner of stimulus presentation provides a way to test Prinz’s claims about the entailment between attention and consciousness: subliminally processed primes should not show any effects of attention manipulations.

To date, there is a body of experimental results from MSPPs that shows that primes can impact behavior (Balconi & Mazza, 2009; Eckstein & Perrig, 2007; Greenwald et al., 2003; Kiss & Eimer, 2008; Marcel, 1983b). In particular, the presence or absence of a prime
can affect the response to a subsequent, consciously perceived target. When the prime and the target share a particular feature (e.g., color, shape, or meaning), then they are said to be *related* with respect to that feature. For example, the words “found” and “pound” share many of the same letters, so they can be characterized as *orthographically related*. Prime-target pairs that differ along the dimension of interest in the experiment are said to be *unrelated*. For instance, the words “comet” and “dishwasher” are *orthographically unrelated*. A common finding is that related prime-target pairs elicit faster and more accurate responses on experimental tasks, when compared with unrelated pairs. Effects appear in the prime’s impact on a subsequent, intentional task, such as a category judgment. This modulation of task performance is called a *priming effect*, or simply *priming*. In a nutshell, when primes and targets are congruent on a feature of interest, the prime will generally facilitate classification of the target with respect to that feature.

I will now present the results of two MSPPs that challenge Prinz’s account of the relationship between attention and consciousness. Both studies suggest that subliminally processed primes are selectively attended according to participants’ conscious intention to complete a specific task. If this is correct, then the results of these studies constitute a threat to the AIR theory. Since the AIR theory specifies that attention entails conscious perception, it denies that subliminally perception can be modulated by attention. Thus, the results of these MSPP studies require careful examination in order to determine whether they suggest falsification of the AIR theory.

The first study, conducted by Greenwald et al. (2003), demonstrated that subliminal primes are evaluated according to both short-term associations learned during the experiment and participants’ conscious intention to complete particular experimental
tasks. These results suggest that subliminal processing is adaptive. It can respond to both recently learned associations and conscious intentions. In this study, the intention was to classify numbers in a particular way. In addition, participants learned associations between single digits and numeric value. Both these learned associations and the participants’ focus on a task modulated how different primes influenced processing of the targets. If this is correct, it suggests that attention can be deployed to subliminal primes without generating a conscious experience.

The experiment followed the basic sequence of a masked stimulus processing paradigm: a subliminal prime appeared first, followed by a backward mask, and then a target, to which participants issued a response. The participants’ task was to classify numbers as greater or less than 55. All numbers were two digits. Participants completed practice trials before the experimental trials. In all trials, the primes were only available for subliminal processing, and the targets were consciously perceived.

During practice trials, the number seven always appeared in the second position of a two-digit prime that was less than 55 (e.g., 17, 27, 37, or 47). Then, during the experimental trials, ‘7’ only appeared in the first position of a prime. Therefore, any prime that contained ‘7’ was greater than 55 (e.g., 74, 77, or 79).

If the primes were not being selectively attended, then the appearance of ‘7’ in the prime should not have impacted response to the subsequent target. However, the primes facilitated or inhibited the reaction time and accuracy for target classification according to the learned association—not the actual relationship of the prime to 55. When primes contained ‘7’ in the first position (e.g. 70 or 78), they inhibited responses to targets greater than 55, but facilitated responses to targets less than 55. This result suggests that single
digits from the two-digit primes and targets were selectively attended in accordance with a newly learned association.

These results demonstrate that subliminal processing is responsive to both recent learning and fine-grained tasks, such as identifying one digit contained within a two-digit number. The experimental design pitted participants’ explicit knowledge about a number (e.g., that 77 is greater than 55) against the recently learned association between ‘7’ and a value less than 55. The results suggest that those associations did impact subliminal processing, even though they contradicted participants’ existing knowledge about number values. In other words, the findings demonstrate that subliminal processing is plastic: even learning that occurs within a single experiment can alter how it unfolds.

The experiment also tested how the intention to complete a particular task impacts subliminal processing. Newly formulated associations between single digits (like ‘7’) and the absolute value of the two-digit number that contained those digits affected the classification of targets. This suggests that the primes were selectively attended. That is, they were evaluated for the presence of a digit with which participants had learned an association to determine whether the number was greater or less than 55. This suggests that attention can impact subliminal processing without engendering any conscious awareness. If this interpretation is correct, it contradicts the AIR theory’s entailment that attention is sufficient for consciousness.

The finding that subliminally processed percepts can be selectively attended challenges the AIR theory generally. In addition, there is a body of research that investigates the relationship between valence, attention, and consciousness via MSPPs. The
results of these studies are a source of evidence regarding the accuracy of Prinz’s account of emotion perception.

Valenced stimuli, particularly negative, is known to capture attention, such that a strongly valenced stimulus will be attended under conditions in which a more neutral stimulus would not (Yiend, 2010). Therefore, if strongly valenced stimuli are embedded within an MSPP, it may be found that the types of subliminal attention effects documented by Greenwald et al. do not appear. Thus, embedding valenced stimuli within an MSPP makes for an especially challenging test of the extent of attention effects on subliminal processing. If conscious intentions can modulate subliminal processing in spite of strong competition from attention-grabbing valenced stimuli, that will constitute robust evidence for attentional modulation of subliminal processing. The results of these studies bear directly on Prinz’s claim that attention distinguishes conscious and unconscious emotion.

Eckstein and Perrig (2007) tested the relationship between a conscious task, stimulus valence, and subliminal processing of words using an MSSP. They measured the impact of prime-target congruity along two dimensions, valence and animacy, on both reaction time and accuracy. Animacy refers to whether the word represents something living (“animate”) or non-living (“inanimate”). Participants were tasked with identifying either the valence or the animacy of the target word. All primes and targets were either negative or positive, and either animate or inanimate. For instance, “baby” is both positive and animate, whereas “hell” is both negative and inanimate.

In the first experiment, participants completed trials in which they alternately classified target words according to valence or animacy. Prime-target congruency on the dimension of interest had a significant effect on reaction time. When participants were
instructed to classify words based on animacy, their responses were faster and more accurate when the prime and target were animacy-congruent (e.g., when the prime was “baby” and the target was “bug”). Similarly, valence-congruent prime-target pairings improved performance during the valence task: the prime “heaven” increased the probability of a fast, accurate response to the target “baby.”

A second experiment extended the first task by compounding the four possible responses (positive, negative, animate, or inanimate) into two. Participants evaluated targets to determine if they were both positive and animate or negative and inanimate. Once again, there were significant effects of prime-target congruity. That is, when a prime and a target were both positive-animate, or both negative-inanimate, responses to the target were faster and more accurate. Thus, the prime “baby” speeded response to the target “kitten,” because both words represent positive, animate entities.

Finally, a third experiment further complicated participants’ task by returning to the valence-or-animacy judgment task, but switching tasks every 16 trials. In spite of this task-switching, priming effects were still significant. In other words, even though participants only focused on the animacy, or the valence, of the target word for 16 trials at a time, the congruity of the prime and target on the dimension of interest still impacted response time and accuracy. This result demonstrates that subliminal processing responds rapidly to shifts in conscious intentions.

These results suggest that subliminal primes are attended according to the conscious intention to complete particular tasks. Primes facilitate processing of targets when the two are congruent on the attended dimension. The findings also demonstrate the flexibility of subliminal attention: priming effects were documented even when tasks were
combined, and when they were frequently changed. In addition, these results show that the intention to complete a task modulates attention at the level of subliminal processing, in spite of the attention-grabbing effects of strongly valenced words.

Together, the results of the Greenwald et al. and the Eckstein and Perrig studies suggest that subliminal processing can be modulated by conscious intentions, such as to classify targets along a particular dimension. A likely cause of these effects is selective attention. If this explanation of the results is correct, then there is reason to think that attention alone is not sufficient for consciousness. That is, since these studies show that subliminally processed primes are selectively attended, but do not generate conscious experience, they challenge the AIR theory. Recall that Prinz claims that attention is jointly necessary and sufficient for consciousness. If primes are attended without generating conscious awareness, this outcome makes the AIR theory untenable. Before concluding that findings from MSPPs invalidate the AIR theory, though, they should be extended to address all of Prinz’s specifications regarding the sufficiency of attention for consciousness.

3 A TEST OF PRINZ’S AIR THEORY

Prinz’s AIR theory implies that attention and consciousness are tightly connected, in the sense that the former is the mechanism that renders intermediate-level representations conscious. By contrast, prior work demonstrates that subliminally processed stimuli can be selectively attended without generating any conscious experience (Eckstein & Perrig, 2007; Greenwald et al., 2003). These results threaten Prinz’s claim that attention to an intermediate-level representation is sufficient to render it conscious, since the primes presented in those experiments appear to have been attended. However, neither the Greenwald et al. nor the Eckstein and Perrig studies demonstrated that the
subliminal primes generated an intermediate-level neural representation. In order to evaluate the impact of these studies on the AIR theory, it is necessary to demonstrate that an intermediate-level representation was generated by the subliminally processed primes.\(^5\)

To determine whether the AIR theory accurately characterizes the distinction between conscious and unconscious emotion, it should be tested with emotionally salient stimuli.

The goal of the proposed work is to replicate and extend prior MSPP results by testing the claim that attention to an affectively charged stimulus will produce conscious emotion.

One way to test the AIR theory is to examine the impact of a conscious intention, operationalized as a task, on subliminally processed stimuli. The theory predicts that attention to a particular feature will not impact subliminal processing of stimuli, unless the stimuli generate conscious awareness (Prinz, n.d.). Recall that Prinz stipulates that attended intermediate-level representations are jointly necessary and sufficient for consciousness. This entailment between attention and consciousness is vulnerable to evidence that attention to subliminally processed stimuli that generate intermediate-level representations does not necessarily produce a conscious experience. Results from MSPPs, such as those employed by Greenwald et al. and Eckstein and Perrig, suggest that conscious intention can modulate subliminal processing. However, these results cannot provide evidence that the primes generated intermediate-level representations. Thus, it can be argued that the results do not directly challenge the AIR theory. Adding neuroimaging measures to a MSPP can resolve the question of whether primes generate intermediate-level representations.

\(^5\) Recall Prinz’s stipulation that an attended, intermediate-level representation of a percept is jointly necessary and sufficient to produce a conscious representation.
Electroencephalography (EEG) is an ideal tool for addressing the question of intermediate-level representation. Electroencephalogram recordings afford fine-grained temporal resolution and sensitivity to the spatial distribution of electrophysiological activity in the brain. Analysis of EEG data from priming paradigms may determine whether prime perception satisfies Prinz’s intermediate-level representation requirement. Such data can help to determine whether subliminal primes modulate activation in regions of the brain that Prinz specifies are responsible for intermediate-level perceptual processing. In addition, EEG data can be evaluated to address Prinz’s claim that attention amplifies ventral-stream activity. Finally, EEG can detect subtle differences in both the time course (when the brain is most active) and spatial distribution (where the brain is most active) of perceptual processing between different conditions. This may reveal differences in cognitive processes that are not apparent from behavioral measures. It can also determine whether intermediate-level regions of the brain were active.

Words are ideal stimuli for this test of the AIR theory. The same word will evoke distinct patterns of neural activity according to what features of the stimulus are attended (Bentin et al., 1999). For instance, a word that processed at the orthographic (visual) level will generate a different pattern of neural activity than had it been processed at the semantic level. These patterns are called “evoked response potentials” (ERPs) and can be considered neural “signatures” of particular levels of processing. Thus, neural responses to word stimuli differ according to the level at which the word is processed.

Bentin et al. (1999) used EEG to demonstrate that attention to particular linguistic features of words modulates neural activity. That is, the brain showed distinct response

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6 Recall that Prinz believes that orienting is often mistaken for attention, and that the latter can be distinguished from the former by ventral-stream activation.
patterns during different tasks, even when the same sets of words were presented across tasks. These patterns were measured as shifts in the amplitude and location of electrophysiological activity. For instance, when participants attended to visual (orthographic) features of words, a large occipito-temporal response occurred approximately 170 ms after stimulus presentation, and was either amplified or diminished according to whether the word was orthographically anomalous or not. This ERP is called the “N170” (Bentin et al., 1999). The N170 was amplified for anomalous versus expected stimuli.

In contrast, when participants’ attention was directed to semantic aspects of the stimuli, the orthographic propriety of a stimulus did not affect the N170. Instead, a word’s value according to an “abstract versus concrete” semantic judgment modulated an electrophysiological response in medial-temporal, temporal-parietal, and fronto-central regions approximately 400 ms after stimulus presentation. This ERP is called the “P400” (Bentin et al., 1999). When attention was directed to a semantic judgment, the P400 component was amplified or diminished according to whether the stimulus possesses the feature of interest. The critical point is that modulation of specific ERP components constitutes evidence of attention to a particular level of linguistic processing.

These results show that task, operationalized as categorization of stimulus according to particular features, modulates the ERPs generated when processing word stimuli. Again, recall that the P400 component was only modulated during the semantic task, and the N170 was only modulated during the orthographic task—even though the same set of stimuli was presented in both tasks. Thus, the P400 provides a neural “signature” of semantic processing, while the N170 is a “signature” of orthographic
processing. Based on these results, Bentin et al. concluded that task-specific modulation of ERP components shows that participant attention was directed to a particular level of processing.

A critical assumption of the Bentin et al. paradigm is that when participants are instructed to attend to a feature, they do so. However, it is possible that being asked to attend to feature $X$ at future times ($t$) does not mean that an individual is attending to $X$ at $t$, even if her brain and behavior are different at $t$ than they would have been had she not been asked to do so. The behavioral outcomes could result from some other mental process. This possibility cannot be eliminated, given that there is no way to directly measure intentions. A parsimonious interpretation of the evidence (the relationship between task and behavioral outcomes) suggests that when an attention manipulation (e.g., the instruction to classify words according to particular features) does alter behavioral outcomes, then those outcomes are likely the result of her attention to that feature. It is not clear how else to account for the difference in behavior, given that this effect obtains across many participants.

Bentin et al.’s finding that attending to specific features of words produces distinct ERP signatures provides a means for determining whether conscious intentions modulate subliminal processing. If participants’ attention is directed to a level of linguistic processing known to generate particular ERP patterns, then the response to primes embedded within an MSPP can be evaluated to determine if that ERP was modulated. If so, that outcome constitutes evidence that the primes were attended according to the conscious intention to complete a specific task. In addition, the EEG data can help determine if the requirement for intermediate-level activation was satisfied, by determining what regions of the brain
were active during the task. This approach thereby provides a means of testing the AIR theory.

3.1 THE PRESENT STUDY

3.1.1 Goals and Hypotheses

In this study, I examine how attention, operationalized as a focus on a linguistic categorization task, modulates emotion-word priming effects. Recall that Prinz (n.d.) allows that attention manifests in multiple ways (e.g., vigilance, selection, and pop-out effects), and that he specifies that all instances of attention make percepts available to working memory (p. 74-76). This criterion is difficult to operationalize: it is not clear how to test for availability without encoding. I contend that Prinz should grant that instructing participants to complete particular tasks will shift the features to which they attend.

The present experiment presented a total of 240 word stimuli that were either words with negatively valenced (“negative-valence”) and highly arousing (“high-arousal”) connotations (such as bullet, cancer, murder, and coffin), or words with neutral valence (“neutral-valence”) and low arousal (“low-arousal”) connotations (e.g., gentle, peace, calm, and plain) in a MSPP. Table 1 details the word properties. Primes were presented very rapidly (35 ms) and masked to ensure that they would not be processed at a conscious level. Both ERP and behavioral measures were used to determine whether attention to the words’ valence would elicit neural activity that was distinct from that produced when participants focused on the orthographic features (case) of the same words. The goal was to test whether modulation of attention can affect responses to the subliminal primes.

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7 This work was carried out under the direction of Dr. Gwen Frishkoff (BELLS Lab, Department of Psychology & Neuroscience Institute, GSU).
I had three specific hypotheses. The first was that task-congruency (e.g. same valence or same case) of a given prime-target word pair would modulate reaction times. Second, I hypothesized that the task-congruency (e.g., same valence or same case) of a given prime-target word pair would modulate ERP components associated with orthographic (case) and semantic (valence) levels of processing. Third, I predicted that the task-congruency (e.g., same valence or same case) of a given prime-target word pair would modulate ventral stream activity.

3.1.2 The Participants

Forty-two participants were recruited from the Georgia State University participant pool to take part in the study (20 men; 22 women). All participants were right-handed, native-English speakers, with normal or corrected-to-normal vision, with no known neurological abnormalities, and no history of reading or language disorders. All gave informed consent prior to participation and received academic course credit, payment, or both.

All participants completed the Edinburgh Handedness Inventory (EHI) and the state Positive and Negative Affect Scale (PANAS) prior to the experiment. In addition, participants completed additional state PANAS inventories after completing the first task, and again at the end of the experiment. Finally, participants completed a questionnaire on which they were asked to respond to three prompts: did they employ any strategies to

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8 Five participants were excluded from behavioral analyses because their data was not processed in time for inclusion in this document. Ten participants were excluded from ERP analyses: five for the foregoing reason, and five due to poor quality EEG recordings.
9 The EHI determines participants handedness (that is, the degree to which they are right-handed), while the PANAS measures emotional temperament.
complete the experiment, if any stimuli had preceded the target words, and whether they had additional thoughts or comments about the experiment.

3.1.3 The Paradigm

Participants viewed a sequence of two words presented on a computer monitor. The first word was the prime for a subsequent target word. Participants initiated trials by pressing the left and right keys together. All trials were self-paced, so that participants could rest as needed. Once a trial was initiated, a central fixation-point (a ‘+’ sign) appeared for 500 ms. This point was replaced by a backward masker (“backward mask”) (50 ms), a prime word (35 ms), a forward mask (20 ms), an inter-word interval (15 ms), and the target word (3000 ms). Participants then had 3000 ms (the duration of the target word presentation) to respond. The total time elapsed between presentation of the prime and onset of the target was 70 ms (stimulus-onset asynchrony). Figure 1 illustrates the timing and order of stimulus presentation.
3.1.4 The Task

All stimuli were presented on a computer screen, in light grey font against a black background. Participants sat approximately 50 cm from the computer monitor. A four-button response box was placed on the table in front of them. Stimulus presentation was controlled by Eprime software, which is a standard tool for recording response time and accuracy.

The experiment consisted of a valence classification task and a case classification task. Half the participants completed the valence task first, and half completed the case task first. Participants’s attention was modulated by overt instructions to focus on a particular dimension of the target word (orthographic or semantic). In one condition, their task was to determine, as quickly as possible, whether the target was presented in upper (e.g., SILK) or lower case (silk) (orthographic task). In the other condition, their task was to classify

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10 “IWI” refers to “inter-word interval,” which indicates the duration of a blank screen between the offset of the backwards mask and the target word.
each word as being either positive (peace) or negative (cancer) (valence task). Altogether, participants completed 960 trials.

Before completing the case task, participants were told to classify words according to whether the word was presented in upper or lower case. Participants were instructed to press a specific button (either left- or right-most) on a response box if the word was upper case, and the other button (left- or right-most) if the word was lower case.11 Next, participants were then guided through two sample trials. They then completed a block of eight practice trials with feedback (correct or incorrect) before starting the experimental trials. In all, each participant completed 480 experimental trials.

Before completing the valence task, participants were instructed that they were to classify words according to whether the word was negative (e.g., bullet, cancer, murder, or coffin), or neutral-to-positive (e.g., gentle, peace, calm, or plain). Participants were told to press a specific button (either left- or right-most) on a response box if the word was negative (e.g., murder), and the other button (left- or right-most) if the word was neutral (e.g., gentle). Participants were guided through two sample trials, completed a block of eight practice trials with feedback (correct or incorrect), and then completed 480 experimental trials.

3.1.5 The Stimuli

In each condition, the prime and the target words were orthographically (case) congruent or incongruent, and emotionally (valence) incongruent or congruent. Thus, there

11 Button assignments were counterbalanced across participants, such that half pressed the left button for upper-case words and the right button for lower-case words. The other half pressed the right button for upper-case words and the left button for lower-case words. This counter-balancing of response buttons was done to prevent reaction times from being influenced by a simple button-preference (e.g. for pressing the right button.)
were four kinds of prime-target pairs: valence congruent-case congruent, valence incongruent-case congruent, valence congruent-case incongruent, and valence incongruent-case incongruent. In addition, there were two valence and two case conditions: neutral, negative, upper, and lower. Table 2 displays each of the eight prime-target word pair permutations.

<table>
<thead>
<tr>
<th>Word Type</th>
<th>Val. (M)</th>
<th>Aro. (M)</th>
<th># Let.</th>
<th>P.O.S.</th>
<th>Con. (M)</th>
<th>Fam. (M)</th>
<th>Freq. (M)</th>
<th>Imag. (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neg. (M)</td>
<td>3</td>
<td>6</td>
<td>4.87</td>
<td>36 N., 15 V., 9 A.</td>
<td>483</td>
<td>519</td>
<td>48.7</td>
<td>526</td>
</tr>
<tr>
<td>Neg. (S.D.)</td>
<td>1</td>
<td>1</td>
<td>0.96</td>
<td>85</td>
<td>55</td>
<td>79.7</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Neg. (Min.)</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>363</td>
<td>344</td>
<td>4</td>
<td>384</td>
<td></td>
</tr>
<tr>
<td>Neg. (Max.)</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>644</td>
<td>609</td>
<td>464</td>
<td>634</td>
<td></td>
</tr>
<tr>
<td>Pos. (M)</td>
<td>6</td>
<td>4</td>
<td>4.78</td>
<td>35 N., 12 V., 13 A.</td>
<td>465</td>
<td>535</td>
<td>67.4</td>
<td>495</td>
</tr>
<tr>
<td>Pos. (S.D.)</td>
<td>1</td>
<td>0</td>
<td>0.96</td>
<td>112</td>
<td>54</td>
<td>79.1</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Pos. (Min.)</td>
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<td>3</td>
<td>3</td>
<td>231</td>
<td>381</td>
<td>4</td>
<td>304</td>
<td></td>
</tr>
<tr>
<td>Pos. (Max.)</td>
<td>8</td>
<td>4</td>
<td>6</td>
<td>602</td>
<td>627</td>
<td>383</td>
<td>616</td>
<td></td>
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<tr>
<td>P-value</td>
<td>0.636</td>
<td>0.344</td>
<td>0.115</td>
<td>0.200</td>
<td>0.038</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 1: Stimulus properties.**

*Note: M. = mean, S.D. = standard deviation, Min. = minimum, Max. = maximum, Neg. = negative, Pos. = positive, Val. = valence, Aro. = arousal, # Let. = number of letters, P.O.S. = part of speech, Con. = concreteness, Fam. = familiarity, Freq. = frequency, Imag. = imageability, N. = nouns, V. = verbs, A = adjectives.*
The same word pairs were presented in both the valence and case tasks. The order of presentation was randomized within each task block. Thus, participants saw the same word pairs during the two tasks. The pairs were created from a list of 120 neutral and 120 negative words. The two word pools were controlled for valence, arousal, concreteness, frequency (Kucera & Francis, 1967), length, and part of speech. Table 1 displays how the stimuli were distributed on each of these dimensions.

3.2 RESULTS

The effects of prime-target congruency were assessed with behavioral and ERP measures. The goal was to test whether task-congruency significantly impacted participants’ behavioral or ERP responses to the stimuli differently in the case and valence tasks. Thus, both behavioral and ERP differences between task-congruent and task-incongruent word pairs were compared within both the case and valence tasks.
3.2.1 Behavioral Data

Response times and accuracy were compared across both tasks (case and valence) and conditions (task-congruent and task-incongruent). Faster or more accurate responses in the congruent versus incongruent conditions, and across the tasks, would constitute evidence of priming. Thus, the results of interest were whether task-congruent pairs produced faster and more accurate responses than task-incongruent pairs.

3.2.1.1 Case-Task Results

There was a significant main effect of case-congruence. Reaction times were speeded \([F(2, 36) = 4.888, p = 0.033]\) and accuracy was higher \([F(2, 36) = 15.17, p < 0.001]\) when pairs were case-congruent. However, this effect on reaction time was driven by the sizeable interaction between case-congruence and task \([F(2, 36) = 26.75, p < 0.001]\). That is, case-congruence accelerated reactions during the case task, but not during the valence task \([M_{con.} = 516 \text{ ms}, M_{incon.} = 539 \text{ ms}; t(36) = -6.882, p < 0.001]\). Case-congruence did not impact reaction times significantly during the valence task \([M_{con.} = 736 \text{ ms}, M_{incon.} = 732 \text{ ms}; t(36) = 0.008, p = 0.994]\).

Similarly, the main effect of case-congruency on accuracy resulted from the strength of the case-task effects. During the case task, responses to case-congruent pairs were more accurate \([M_{con.} = 0.981, M_{incon.} = 0.975; t(36) = 2.477, p = 0.018]\). Case-congruence did not impact accuracy during the valence task \([M_{con.} = 0.921, M_{incon.} = 0.920; t(36) = 0.401, p = 0.691]\). As with reaction times, case-congruency improved accuracy only during the case task.
3.2.1.2 Valence-Task Results

Reaction times were not significantly different for valence-congruent and incongruent pairs across the case \([M_{con} = 528 \text{ ms}, M_{incon} = 527 \text{ ms}; t(36) = 0.065, p = 0.949]\) and valence tasks \([M_{con} = 732 \text{ ms}, M_{incon} = 737 \text{ ms}; t(36) = -1.083, p = 0.286]\). Similarly, valence-congruence did not significantly improve accuracy during the valence task \([M_{con} = 0.923, M_{incon} = 0.919; t(36)=1.372, p = 0.179]\). Thus, the hypothesized effects of task-congruence on reaction times and accuracy during the valence task did not obtain.

3.2.1.3 Comparing Case and Valence Task Performance

The absence of a task-specific valence congruency effect contrasts sharply with the robust task effects for case congruency. One explanation for this discrepancy is that the case task was easier for participants to complete. Many participants commented on the relative ease of identifying case versus valence when they switched from one task to another. Some participants also remarked that they found the valence task difficult. This difference in difficulty is also reflected in the average reaction times of the two tasks: regardless of prime-target congruity, participants were always faster \((N = 37; M_{CaseTask} = 527 \text{ ms}; M_{ValenceTask} = 734 \text{ ms})\), and more accurate \((N = 37, M_{CaseTask} = 0.978; M_{ValenceTask} = 0.921)\) during the case task.

Recall that the word pairs were identical in the two tasks. Pairs such as “silk-PEACE” or “SILK-cancer” appeared in both the case task and the valence task. Importantly, though, case-incongruent pairs, like “SILK-cancer” and “silk-PEACE,” only slowed reaction time during the case task. In contrast, there were no significant effects of case-congruence during the valence task: reaction times were no different for case-congruent pairs, like “silk-cancer,” than for case-incongruent pairs, like “SILK-cancer.” Thus, the same primes
modulated response to the targets differently according to participants’ conscious intention to complete either the case or the valence task. In short, response times were modulated by the task congruence of prime-target pairs, but there was no valence-based, task-specific modulation. These results suggest that primes were selectively attended according to task-relevant features, but perhaps only when the task was relatively easy, as it was during the case task.

3.2.2 Evoked-Response Potentials

ERP components that are sensitive to specific features of a stimulus (e.g., surface-level versus semantic features) are also modulated by attention to a task. The ERPs generated in different conditions were analyzed for components specific to both the task and the congruency of prime and target. Based on Bentin et al.’s (1999) findings that ERP components are modulated by levels of linguistic processing, ERPs were predicted to differ according to both the task and the task-congruence of prime-target word-pairs.

The results from the case task partially mirrored Bentin et al.’s (1999) documentation of orthography-specific ERPs. Case-congruence modulated the occipitotemporal N170 component only during the case task. As shown in Figure 2a, case-incongruent pairs, such as “SILK-cancer” and “silk-PEACE,” generated an amplified N170 vis-à-vis congruent pairs, such as “silk-cancer” or “SILK-PEACE.” Figure 2c illustrates that this effect disappeared in the valence task: N170 amplitudes did not differ across any of the word pairs, regardless of their case congruence. Thus, pairs like “SILK-cancer,” “silk-PEACE,” “silk-cancer,” and “SILK-PEACE,” all produced similar N170 components, regardless of their case-congruence.
While the valence task did not show any modulation of the ERPs documented by Bentin et al., prime-target valence congruency did affect neural activity differently during the two tasks. The valence congruency of pairs impacted processing in both orbitofrontal and centro-parietal regions differently during the case and valence tasks. Early orbitofrontal differences between valence-congruent and valence-incongruent pairs were maximal approximately 240 ms after presentation of the target \([t(32) = -4.4, p < 0.001]\). A second statistically significant difference in orbitofrontal activity emerged at approximately 584 ms and diminished by 706 ms after the target. The difference between responses to congruent and incongruent pairs peaked at 660 ms \([t(32) = 6.0, p < 0.001]\).

Activity in the centro-parietal region was also modulated by the valence-congruence of pairs presented during the valence task. Valence congruent and incongruent pairs generated statistically different patterns of electrophysiological activity in this region from approximately 170 to 260 ms after the target \([t(32) = 4.5, p < 0.001]\). After diminishing slightly, valence-congruence differences in this region peaked again at approximately 338 ms after the target \([t(32) = 4.7 (p < 0.001]\).

In addition to these differences between electrophysiological responses to pairs between the two tasks, the valence-congruency of prime-target word-pairs modulated a late orbitofrontal component during the valence task only (see Figure 2b). The amplitude of this ERP was enhanced, meaning that it was more negative, after participants saw incongruent pairs. Thus, during the valence task only, valence-incongruent pairs like “SILK-cancer” and “dead-peace” amplified orbitofrontal activity, whereas valence-congruent pairs like “silk-peace” and “DEAD-menace” did not. The orbitofrontal component was not modulated by the valence congruency of prime-target word-pairs during the case
task (see Figure 2d). Note that orbitofrontal regions are part of the ventral stream, and recall that Prinz considers ventral stream activity as evidence of attention. Therefore, these task-specific valence-congruency effects provide evidence that attention was engaged during evaluation of prime-target congruency.

Again, the same prime-target word-pairs appear in both tasks. Thus, all of the example pairs given above (“SILK-cancer,” “silk-PEACE,” “silk-cancer,” “SILK-PEACE,” “dead-peace,” and “DEAD-menace”) appeared in both tasks. However, valence-incongruent pairs alone (e.g., “SILK-cancer,” “silk-cancer,” and “dead-peace”) amplified late orbitofrontal negativity only during the valence task (see Figure 2b). Likewise, case-incongruent pairs alone, like (“silk-PEACE,” “SILK-cancer,” and “DEAD-menace”) modulated the N170 only during the case task (see Figure 2a). The two tasks differed only in whether participants were instructed to attend to case or valence. The fact that the ERPs differed according to prime-target task congruity suggests that primes were processed in accordance with participants’ intention to complete one task or the other. This result is especially interesting in light of the absence of significant behavioral priming effects for the valence task: while prime-target congruity did not measurably alter behavior, it did impact activity in the brain.

Recall that three hypotheses were formulated regarding the anticipated results of this experiment. The first was that task would modulate reaction times according to whether primes and targets were task-congruent or task-incongruent. This task-congruency effect was observed for the case task, but not for the valence task. The second hypothesis predicted that prime-target congruency would modulate ERP components associated with orthographic (case) and semantic (valence) levels of processing. This ERP
effect was documented in both tasks. Finally, the third hypothesis proposed that prime-target congruency would modulate ventral stream activity. The occipito-temporal N170 and orbitofrontal effects constitute evidence of ventral stream modulation that confirm Prinz’s prediction.

As explained in the earlier discussion of Greenwald et al. (2003) and Eckstein and Perrig (2007), there is substantial evidence that subliminally processed primes can be selectively attended, even with competition from valenced stimuli (Gibbons, 2009; Kiss & Eimer, 2008; Marcel, 1983a). The current work extends those results in two ways. First, behavioral and ERP measures both revealed task-specific priming effects. Second, when the task was changed, the stimuli remained the same: precisely the same set of 480 word pairs appears in each of the tasks. Thus, a finding of task-specific effects cannot be considered the result of differences in either the stimuli or the procedure, since these were constant across tasks. And, since participants alternated which task they completed first, but the task-specific effects obtained regardless of task-order, the results are not driven by simple learned associations between primes and targets that facilitated responses during the second block. This point is important, because it demonstrates that the priming effects are tied to the task. In short, this study bolsters prior work by showing that identical primes can be processed differently, according to a consciously mediated task.
Figure 2a

Figure 2b
Figure 2c

Figure 2d
I will now address several questions about the interpretation of this study's results and their relevance for Prinz's theory of emotion, attention, and awareness. One question is whether exposure to a valenced word elicits what Prinz (and others) would recognize as a *bona fide* emotion (see Coan & Allen, 2007). In *Gut Reactions*, Prinz states that perceptual states trigger emotions (p. 75). To illustrate, he examines the evidence that pictures of snakes trigger emotions, and concludes that they do. He further argues that this type of direct emotion elicitation extends to learned emotional responses, such as words. Prinz (2004b) hypothesizes, "[a]ssociative learning can probably forge a link between emotions and any perceptual experience that occurs in conjunction with them" (p. 75). This associative linkage extends to concepts. Prinz (2004b) states that, "concepts then become emotion elicitors of their own" (p. 76). In short, the causes of emotion vary widely. These causes are unified by their impact on a perceiver: each cause brings about a physiological change that is represented as an emotion. By this measure, Prinz should agree that valenced words can elicit emotion.

This conclusion is also supported by Prinz's interpretation of findings from a study by Winkielman and Berridge (2003) as evidence for the occurrence of unconscious emotion. The Winkielman and Berridge paradigm tests whether subliminal exposure to pictures of emotive faces (e.g., angry or happy) impacts participants' rating and consumption of an unfamiliar beverage. Winkielman and Berridge found that subliminal exposure to faces displaying negative emotions decreased both participants' total consumption and rating of the drink. Winkielman and Berridge consider count this as
evidence of unconscious emotion, and Prinz (2005a) concurs (p. 17). Their paradigm parallels that used in the present experiment. Both utilize subliminally processed, valenced stimuli to elicit emotion. Additionally, both count behavioral shifts as evidence of emotion-elicitation. These commonalities suggest that Prinz should consider the present experiment to be a valid test of unconscious emotion processing.

If Prinz accepts that subliminal primes elicit unconscious emotions, the key question becomes whether the primes can be attended. The results of the present study demonstrate that subliminal perception is impacted by conscious intentions to complete a task. That is, they show that a conscious focus on a task impacts even subliminal stimulus processing. This “task focus” effect is most parsimoniously understood as attention. In The Conscious Brain, Prinz grants that attention refers to various phenomena, from pop-out effects to vigilance (p. 74). What unifies these phenomena as instances of attention, Prinz suggests, is that each results from a change in information processing in the brain (n.d., p. 74).

Based on the results of the present experiment, I propose that when participants adopt the intention to complete a task, either to attend case or attend valence, their brains process information differently than it would in the absence of an explicit task. This interpretation is supported by the findings of task-specific differences in participant performance. Attention is the best candidate for a mechanism that explains these results: the only component of the experimental set-up that changes from one task to the other is the instructions to participants about what they should focus on. These task-effects, in turn, suggest that attention is not sufficient for consciousness processing to occur. The AIR theory establishes that subliminal attention is impossible, and so Prinz will be motivated to
provide an alternative explanation of these findings. To do so, he must explain how subliminal primes can be influenced by a conscious intention (task) without being attended.

5 PRINZ’S LIKELY CRITICISMS OF THE TEST AND ITS RESULTS

The results of this study appear to challenge the AIR theory. The subliminal primes impacted neural and behavioral outcomes according to both the participants’ conscious task, and the task-congruence of the prime and the target. However, Prinz will probably reject an interpretation that attributes these effects to attentional processing. Six objections and alternative explanations merit consideration. First, Prinz (n.d.) stipulates that feature selection (e.g., identifying upper or lower case) is a cause, not an effect, of attention, and that the task-switching effects constitute the former, not the latter (p. 74-75). Second, the task effects could be the outcome of orienting, rather than attention. Third, Prinz might provide convincing evidence that the primes were presented too quickly to be attended. Fourth, he might argue that primes did not generate intermediate level representations. Fifth, Prinz could protect the AIR theory by demonstrating that the primes were not available to working memory. Finally, he might concede that simple perceptual processing, like case identification, can be modulated by attention, but that the present results do not threaten his account of emotion representations. I will now consider each of these potential objections to the interpretation of these findings as evidence of subliminal attention.

5.1.1 Objection 1: Selection, Not Attention

One plausible explanation for the present findings, which suggest that attention impacts subliminal processing, is that participants’ conscious intention to attend to case or
valence shifts the level at which primes are processed. If this hypothesis is correct, then specific features are selected for processing, even at the subliminal level. This feature-selection effect presumably results from attention. However, Prinz (n.d.) stipulates that selection is a cause of attention, not an effect (p. 74-75). To support this claim, he argues that the famous “cocktail party effect,” that of hearing one’s own name from across a noisy and crowded room, demonstrates that a percept, such as one’s name, can be selected prior to being attended. This point merits consideration: it seems correct that a region or object must be selected before its features can be attended. However, this account raises the question of what mechanism underlies the initial selection, particularly in light of present findings that conscious intention modulates feature selection.

Presumably, participants’ conscious intention to complete a specific task determines what features are selected, which then enables evaluation of the relevant features. For instance, during the valence task, participants focused on classifying the words as negative or neutral. This conscious intention resulted in the selection of the words’ semantic meaning. Features irrelevant to this task, like case, were neglected. Once a word’s semantic value had been selected, it could then be evaluated as either negative or neutral. This account suggests that there must be two related components of word processing in this task: attention to particular word features, which then prompts selection of those features for further analysis. Thus, attention to a task is necessary to motivate feature selection, which is in turn necessary for evaluation of those features vis-à-vis a the task criteria.

Prinz is correct to observe that feature selection is necessary for evaluation of a stimulus. However, it is not clear how feature selection itself can occur without attention. In the present study, it appears that the participants' attention to particular linguistic
features modulated how the words were processed. Simply put, it was attention to the task that motivated feature selection.

In addition, Prinz characterized attention as the process that renders percepts accessible to working memory. Selection presumably does just that. Both this point and the apparent necessity of attention to guide selection suggest that Prinz’s exclusion of selection from the realm of attention is problematic. Future work should investigate whether these two forms of attention, selection and evaluation, are sufficiently dissimilar to support Prinz’s claims. At present, though, the selection account does not constitute a coherent defense of the AIR theory.

5.1.2 Objection 2: Orienting, Not Attention

Prinz might also turn to orienting as a defense of his theory. In The Conscious Brain, Prinz rejects several arguments for attention in the absence of consciousness and suggests that some or all of these arguments are based on conflation of attention proper with orienting. According to Prinz (n.d.), orienting engages two physiological processes that typically accompany attention: eye saccades and shrinking receptive fields in primary perceptual processing areas (p. 87). Together, these orienting responses could produce a higher-resolution representation of a percept. The subliminal primes might then cause different neural and behavioral responses because of differences in simple visual features (e.g., upper or lower case font). Prinz argues that neither a shift in saccades nor shrinking receptive fields constitute attention. Instead, these processes constitute an orienting response that is mistaken for attention. Prinz could reject the validity of this test by claiming that task-specific priming effects result from orienting, rather than attention.
Indeed, Prinz (n.d.) argues that orienting to primes, rather than attention, accounts for the priming effects reported from masked-priming studies (p. 91). In other words, he explains these effects as the outcome of shifts in eye saccades, shrinking cellular receptive fields in visual processing areas of the brain, or both. However, overt orienting (eye saccades) cannot account for attention effects that are seen for foveal stimuli. Orienting focuses the fovea on the location where a stimulus will appear. If the location of targets varied, then primes could enhance processing by triggering eye saccades to the correct location. However, in this study, primes and targets appeared in the same central location on all trials, across both tasks. Moreover, it is unclear how changes in visual processing can account for effects that are specific to different levels of processing (i.e., surface-level versus semantic processing). All stimuli in the present experiment were words presented in the same location. Their variations in case, valence, and arousal are too subtle to produce processing differences based on spatial focus alone. In short, orienting does not appear to provide an explanation for the processing differences that result from task congruence.

Perhaps the notion of orienting could be stretched to accommodate some of these data. Prinz might argue that the case-task results can be explained by shrinking of cellular receptive fields in the cells that were activated by orienting to the prime. This orienting-effect could enhance detection of slight graphical differences between stimuli, such as size and curved or straight edges, which can be processed at a low level (in V1). This kind of low-level feature detection would not necessarily generate an intermediate level representation. The case results would no longer pose a challenge to the AIR theory.

However, it is not clear how orienting effects alone can account for the valence-congruency ERP differences that obtained during the valence task. The basic graphical
features of the words, which would be perceived more clearly if receptive fields shrink, do not reveal anything about semantic value. Since both the case and valence tasks generated unique ERP correlates, shrinking receptive fields alone cannot account for the valence-task ERP effects.

Prinz (n.d.) does propose a spatial metric for differentiating attention from orienting: he argues that attention and orienting evoke different patterns of neural activation (p. 90). Orienting is associated with the dorsal visual pathway, while attention proper engages both the dorsal and the ventral pathways. Thus, Prinz (n.d.) predicts that if a representation is the object of attention, it will increase processing in ventral visual processing areas (p. 90). Results of the present study show that both orbitofrontal regions and language-related ventral areas (occipitotemporal areas) were activated during these tasks. According to Prinz’s own account, activation of these regions suggests that primes were modulated by attention, rather than by orienting alone.

5.1.3 Objection 3: Attention Takes Time

Another question Prinz may have about interpretation of the present results regards the time course of attention. He asserts that, "attention takes time" (n.d., p. 71). More specifically, Prinz claims that "[t]he representation that is caused by a stimulus can be modulated by attention only if it endures for a temporal interval that is long enough for attention to do its work" (n.d., p. 72). He does grant that a fleeting image can produce an iconic memory that endures for 300-500 ms (n.d., p. 72). However, he argues that backward-masked primes presented for brief durations cannot produce enduring
afterimages, and thus cannot be attended. According to Prinz, extremely brief exposure is not sufficient. Absent the preservation of an iconic image, attention cannot unfold.

Prinz (n.d.) supports the claim that attention takes time by citing two studies (p. 72). Both suggest it takes approximately 110-125 ms for a stimulus to generate an intermediate-level visual representation. Prinz grants that stimuli presented for shorter durations can produce representations, as even an extremely brief presentation can generate an iconic memory that lasts long enough to be modulated by attention. However, he specifies that when a briefly presented stimuli is masked, no iconic image will endure. Thus, these stimuli cannot generate intermediate-level representations and are therefore not available for attentional modulation (Prinz, n.d., p. 72).

In the present study, primes were presented for 35 ms and followed by a masker, which presumably overwrote any iconic memory of the stimulus. According to Prinz’s account, this mode of presentation prevents primes from generating an intermediate-level representation, and thus precludes attentional modulation. However, the present data show that the attention manipulations had measurable effects on priming. To claim that these effects are not the outcome of attention simply because the stimuli were not presented for a sufficient durations is ad hoc. Prinz (n.d.) grants that attention includes multiple cognitive processes, such as vigilance, monitoring, and pop-out, onto the folk psychological notion of attention (p. 74). Given this inclusive characterization of

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12 On page 72, Prinz writes, "The representation that is caused by a stimulus can be modulated by attention only if it endures for a temporal interval that is long enough for attention to do its work."

13 Prinz characterizes vigilance as, “remaining alert and responsive to anything that might come before our senses,” monitoring as, “when we retain perceptual contact with an object or scene[,] or tracking, as when we watch an object move through space,” and pop-out as, “when a stimulus stands out from things around it” (Prinz, n.d., 74).
attention, and Prinz’s own acknowledgement that it is plausible that not all instances of attention result from a common mechanism, there is no compelling reason to believe that duration of exposure alone determines availability to attention. Unless he can supply additional evidence to support his claims about the time course of attention, this objection is insufficiently supported.

5.1.4 Objection 4: Attention Without Intermediate-Level Representation

A stronger defense of the AIR theory might be to argue that primes are attended, but that they do not generate an intermediate-level representation. Instead, attention to primes modulates only low-level perceptual processing. The case-task-specific priming differences could then be explained as the result of attentional effects on low-level feature detection, such as the size and orientation of edges.

This account would insulate the AIR theory from the threats posed by MSPPs, because Prinz specifies that only attended intermediate-level representations will become conscious. Thus, attended low-level processing is not sufficient for consciousness. Selective attention might alter processing at this level sufficiently to differentiate stimuli according to simple features. This low-level feature selection might explain the task-specific priming effects without threatening the AIR theory.

However, it seems that Prinz cannot pursue this defense, because he subscribes to Marr’s account of visual processing, as recapitulated by Jackendoff (1987). According to Marr and Jackendoff, top-down processes can only modulate processing from the 2.5-D (intermediate) level forward. They specify that low-level perception is not available to top-down modulation (Jackendoff, 1987, p. 186). A conscious intention to complete a particular task almost certainly constitutes top-down modulation. Thus, according to the Marr-
Jackendoff model, the primes could not have been modulated by attention to a particular task. Unless Prinz breaks with this description of perceptual processing, he should grant that conscious intention cannot modulate low-level perceptual processing.

However, in *The Conscious Brain*, Prinz suggests that he is willing to modify the Marr-Jackendoff model of perceptual processing. He grants that, “[t]here is strong evidence that brain regions involved in the control of attention directly modulate intermediate-level areas, which then influence low-level areas through feedback” (n.d., p. 77). Thus, he is willing to allow that attention can impact low-level processing. Prinz states, “[i]f this is right, increased brain activity in low-level areas is an aftereffect of attentional modulation in intermediate-level areas” (n.d., p. 77). Therefore, on Prinz’s account, attention can impact low-level processing, but only by first acting on intermediate-level representations.

This account of low-level attention effects provides an opening for Prinz to explain the present findings of task-specific priming in a way that protects the AIR theory. The targets were consciously perceived. Therefore, according to the AIR theory, the targets must have generated intermediate-level representations that were attended. Prinz could argue that the attention to task-specific features at the intermediate-level then trickled down to the low level. There, primes would then have been processed differently in each task, according to the attentional focus that was consciously applied to the intermediate-level representations.

Still, it is unclear how attentional modulation of low-level processing can account for the valence-congruency effects on ERPs that were documented during the valence task. The Marr-Jackendoff model stipulates that low-level processing is limited to basic feature detection, such as of edges or movement. Enhanced low-level processing could improve
performance during a visual task. However, even if this characterization of low-level perceptual processing is correct, it cannot account for the semantic judgments, which were necessary for ascertaining prime-target congruence during the valence task. Barring a novel account of how processing at the low level enables semantic judgments, even Prinz's willingness to grant that attention might act at low-level does not provide a satisfactory account of the valence-task ERP effects.

5.1.5 Objection 5: An Absence of Behavioral Priming Effects Evidences an Absence of Attention

Prinz might emphasize that the absence of behavioral differences (in either accuracy or response latency) in the valence task demonstrates that, at least in regards to emotion, the AIR theory is correct. Prime-target valence congruency did not modulate response latencies or accuracy in the valence task. These results suggest that the primes' valence was not attended during the valence task.

Independently, the absence of behavioral effects in the valence task is congruent with the AIR theory's predictions for subliminal emotion processing. It suggests that subliminal emotion elicitation does not generate intermediate-level representations that are available to attentional modulation. However, when considered alongside the case-task results, this null result during the behavioral task presents an informative contrast. That is, the significant reaction-time effects of case-congruency during the case task did not appear during the valence task. This difference demonstrates that the priming effects did vary according to task: the case task produced case-congruency priming, whereas the valence-task revealed no behavioral priming. This asymmetry indicates that conscious intentions can modulate subliminal processing. However, the extent to which that occurs may depend
on the complexity or salience of the task. It is plausible that the extremely short duration of the prime presentation did not allow extensive semantic processing, whereas it was sufficient for case identification.

Participant reports corroborate this “insufficiency” hypothesis regarding the absence of behavioral valence-congruency priming effects during the valence task. As noted previously, participants frequently commented on the difficulty of the valence task, particularly when they had completed the case task first. Participants struggled most during the first quarter of the valence block, often repeatedly asking the experimenters how they should be evaluating the words. In addition, some participants either struggled with the instruction to "go with their gut" in determining the valence of the target, or commented that they considered the valence to be opposite to how it was used in the experiment. For instance, one of the neutral words was "errand." The Affective Norms for English Words (2010) database lists the mean valence of the word ‘errand’ as 4.58 (on a scale of 1 to 9, with 9 being most positive), and its mean arousal as 3.85 (on a scale of 1 to 9, with 9 being highly arousing). However, some participants noted that they consider ‘errand’ to be a negative word, and thus repeatedly classified it as such. In addition, some participants said they struggled with words that they felt could be considered as either negative or approximately neutral. Examples of these include plain, manure, and pollen.

The behavioral data corroborate participants’ comments about the difficulty of the valence task. The effect of task on reaction time shows that the blocks were asymmetrical in difficulty ($F(2, 36) = 93.67, p < 0.000$): participants were much faster during the case task ($M = 527.5$ ms) than the valence task ($M = 734.4$ ms). Participants were also more accurate during the case task ($M = 0.978$) than the valence task ($M = 0.921$). Overall, there was a
significant main effect of task on accuracy \((F(2, 36) = 192.713, p < 0.000)\). These differences between the tasks may account for the lack of congruency effects on reaction time and accuracy during the valence task. That is, the valence task was clearly more difficult than the case task. This difficulty may have prevented the anticipated behavioral effects of valence-congruency from appearing during the valence task.

In contrast with the behavioral effects, the robust ERP differences between valence-congruent and valence-incongruent prime-target pairs only during the valence task suggest that, although there were no corresponding behavioral differences, participants did detect the valence of the primes. If they had not, the consistent indexing of the orbitofrontal and centro-parietal activity to the valence congruency of the prime and target would not obtain. In tandem, the valence-congruency effects on ERPs, but not on response latency and accuracy, suggests that the primes’ valence did impact processing during the valence, but not the case task. These subtle effects were probably washed out by participants’ uncertainty about how to classify the valence of some targets, which led to slower overall reaction times and decreased accuracy.

5.1.6 Summary of Defenses of the AIR Theory

In summary, Prinz has a few paths for defending the AIR theory from the current results. He can try to bolster the distinction drawn between selection and attention, and then attribute the priming effects to the former. Similarly, orienting might account for the case-congruency effects. However, it cannot account for the valence task results. Furthermore, the N170 and orbitofrontal ERP modulation demonstrates that the task-generated, ventral-stream activation, which Prinz specifies is indicative of attention. In order to successfully attribute the priming effects to orienting, Prinz will need to refine his
account. Alternatively, he might contend that the primes did not produce intermediate-level representations, but that they were available for attentional modulation that trickled down from the intermediate level. To do so, he will have to explain how shifts in low-level processing can account for the valence-congruency ERP effects during the valence task.

6 CONCLUSION

Prinz argues that intermediate-level representations are complete and available for conscious access. What sets those that become conscious apart is attention. Importantly, this account postulates that attention functions as a late-selection mechanism: it acts upon the outputs of perceptual processing to determine which percepts become conscious. In other words, attention functions like a spotlight that selects some intermediate-level representations for consciousness. Prinz considers that emotions are perceived and processed in the same manner as all types of percepts. In short, he applies a hierarchical model of visual processing to emotion. This account requires careful review, especially since the AIR theory cannot satisfactorily explain some of the present results. In particular, these results suggest that an attended intermediate level representation is not sufficient for consciousness.

Two components of Prinz’s account of the relationship between attention and consciousness are vulnerable to attack. The first, introduced above, is his vague definition of attention. The second is his subscription to Marr and Jackendoff’s model of perceptual processing. The “vagueness” problem results from Prinz’s definition of attention. Recall that Prinz (n.d.) makes “availability to working memory” a jointly necessary and sufficient criterion for attention: “attention can be identified with the processes that allow
information to be encoded in working memory” (p. 76). It is unclear how to measure availability to working memory, or operationalize this criterion for testing.

To protect the AIR theory from the results of MSPPs, Prinz needs to provide a more specific account of attention—one that can be operationalized and tested. At present, his loose definition of attention makes it unclear how to test and, potentially, falsify the AIR theory. Falsifiability is a widely accepted criterion for scientific theory, and it is one that the AIR theory should satisfy (Popper, 1963). A more refined account of attention will enable decisive tests of the AIR theory. In turn, it will help to resolve how the present findings impact the theory. If Prinz can narrow his definition of attention to exclude the present findings, then they will not challenge the theory. The results will be understood to be a byproduct of unattended intermediate level representations, not AIRs.

The second issue to address in evaluating the AIR theory is whether it rests upon an accurate model of perceptual processing. The Marr and Jackendoff model, which Prinz invokes, stipulates that top-down processes, like intention to complete a task, do not modulate perceptual processing at the lowest level. In addition, the model assumes that perceptual processing proceeds in a linear, hierarchical manner. By adopting this model, Prinz assumes that perceptions are assembled one feature at a time, from the low- to high-levels. However, there is evidence to suggest that this assumption is incorrect. If it is, then the intermediate-level entailment of the AIR theory may require reevaluation.

In a series of MSPP experiments, Marcel (1983b) demonstrated that feature-detection degrades in a manner opposite to that which is suggested by phenomenological experience. By manipulating stimulus-presentation duration, he found evidence that seemingly complex features, like semantic value, are detected prior to basic visual
elements. To be precise, as length of stimulus presentation decreased, the first perceptual failures were for simple presence or absence judgments. Graphical feature-detection was degraded next, followed by semantic-value detection. Using a MSPP with a word-recognition task, participants firstly lost the ability to detect primes, secondly were unable to identify graphic features first, and lastly failed semantic-relatedness judgments (a, 1983b). The important implication is that the apparent difficulty of a perceptual task does not map onto how quickly it is performed. This finding suggests that perceptual processing might unfold differently than human phenomenology suggests. Relatedly, Marcel’s results suggest that perceptual processing does not start with basic feature detection and proceed in a step-wise fashion, as Marr proposed. Marcel contends that his results undermine two assumptions about perceptual processing. The first is that conscious and unconscious representations are identical. He calls this the identity assumption. The second is that perception proceeds in a linear, hierarchical fashion. He calls this the perceptual microgenesis hypothesis (Marcel, 1983a).

In addition to Marcel’s findings, prior work has used MSPPs to examine whether processing at the sub- and supra-liminal levels differs in degree or in kind. The results suggest that perceptual processing unfolds differently at the two levels. For instance, Balconi and Mazza (2009) used ERPs as indices of the neural processes generated by pictures of neutral and emotional faces, presented for either 30 or 200 ms. Both emotional salience and duration modulated ERPs generated in response to the pictures. The ERP components differed in location, duration, and amplitude between both the emotion versus neutral and the sub- versus supraliminal conditions.
Similarly, Kiss and Eimer (2008) investigated whether sub- and supra-liminally processed faces generate different ERPs according to the type of emotional expression. Participants classified masked images of faces as being either fearful or neutral in both supraliminal (200 ms) and subliminal conditions (8 ms). The ERPs depended on both presentation duration and valence. Fearful faces elicited enhanced early, anterior ERPs in both sub- and supra-liminal conditions. However, only subliminal trials generated robust frontal and central fluctuations at around 200 ms (N200) in response to both neutral and fearful faces. In the supraliminal trials, fearful faces evoked a sustained frontal positivity and an enhanced central-parietal fluctuation at around 300 ms (P300). Importantly, modulation of the N200 component was unique to subliminal processing of the stimuli.

Behavioral studies also reveal substantive differences between sub- and supra-liminal processing conditions—not that subliminal processing is simply attenuated in comparison to supraliminal conditions. For instance, some types of learning are enhanced at the subliminal level. It has been known that complex relationships can be learned implicitly, as demonstrated in Reber's (1993) influential studies of implicit grammar learning. This finding has been replicated and refined. Lambert et al. (1999) suggest that some contingencies can be learned subliminally, but not supraliminally. Specifically, they observed learning of a reverse contingency between the position of a cue and a subsequent target when stimuli were presented subliminally, but not when they were presented supraliminally. These divergent results suggest that sub- and supra-liminal levels processing unfold differently.

The results of studies like these show that level of awareness impacts the way in which stimuli are processed: sub- and supra-liminal processing of the same percept unfolds
differently. Importantly, this difference is not merely one of degree. If the identity assumption is correct, then subliminal processing should simply be either attenuated or truncated relative to supraliminal conditions. The distinct differences in processing suggest that the identity assumption is incorrect. In addition, Marcel’s findings show that perceptual processing does not unfold in the manner predicted by a hierarchical model. Instead, complex feature detection is preserved even after simple feature detection is lost. These results undermine the perceptual microgenensis hypothesis.

The Marr and Jackendoff model predicts that comparisons of sub- and supra-liminal processing of the same percept will generate identical neural effects of processing at the low and intermediate levels.\(^{14}\) Thus, the model invokes the identity hypothesis: it posits that sub- and supra-liminal processing only differ from the point when the latter produces a conscious experience of the percept. Prinz’s articulation of the AIR theory suggests that sub- and supra-liminal perceptual processing is analogous. Then, in the late stages of processing, attention acts at the intermediate level to determine which percepts are consciously perceived. However, this account is undermined by a series of studies that have demonstrated that perceptual processing unfolds differently at the sub- and supra-liminal levels.

By endorsing the Marr and Jackendoff model, Prinz is forced to assume a late-selection model of attention. That is, he contends that attention acts on fully-formed representations, rather than at earlier stages of perceptual processing. While late-selection theories of attention like Prinz’s are common, they are challenged by accounts that propose that attention modulates the earliest stages of perceptual processing (Duncan, 2006; Ruff, 2006). However, note that one prediction might be that processing would be attenuated in the subliminal condition, due to the weak perceptual input.
Without allowing that attention might modulate low-level perceptual processing, it is difficult to explain either the present results, or those from Lambert et al. (1999), Marcel (1983b), Kiss and Eimer (2008), and Balconi and Mazza (2009). In addition, it prevents him from allowing that different features of the same percept might unfold across multiple processing pathways in tandem. Prinz is thus tethered to the perceptual microgenesis assumption. Prinz can readily explain away some of the present results, if he will grant that attention can modulate low-level perceptual processing. He could then ascribe the present case-task findings to the effects of attention to low-level feature detection.

These challenges to the identity assumption are also problematic for Prinz’s account of conscious and unconscious emotions. He has proposed that the two are separated only by attention. However, results of studies like Balconi and Mazza (2009) and Kiss and Eimer (2008) suggest that conscious and unconscious emotion are not processed identically. Recall that the subliminal conditions generated ERPs that were not present at all in the supraliminal condition. Those results suggest that the identity assumption is incorrect. If it is, then it is the distinct neural processes that generate conscious and unconscious emotions differentiate them—not just whether they are attended.

In conclusion, Prinz has three tasks to complete in order to defend the AIR theory. First, he should provide a specific, testable account of attention. Second, he must either defend or revise his endorsement of the Marr model of perceptual processing. Third, he should revise his claim that attention alone separates conscious from unconscious emotion, given the findings that show marked differences in the neural processing of subliminally and supraliminally processed valenced stimuli. These undertakings would be substantial, but if Prinz can successfully address each of them, the AIR theory will remain credible.
WORKS CITED


42. Winkielman, P. (2004). Emotion, behavior, and conscious experience: Once more without feeling. Feeling is Perceiving: Core Affect and Conceptualization in the


APPENDIX: METHODS SECTION

Participants

Forty-two participants (20 men; 22 women) were recruited from the Georgia State University participant pool to take part in the study. All participants were native English speakers, were right-handed ($M_{EHI} = 66.2$), and had normal or corrected-to-normal vision. Participant ages ranged from 18 to 39 ($M = 22.3$, s.d. = 4.88). Participants received academic course credit, payment, or both.

Study Procedures

The experiment took place in the Brain Electrophysiology of Language and Literacy Systems (BELLS) Lab (Georgia State University; Frishkoff, PI). A typical session lasted for two and a half to three-hours. When participants first arrived, they were oriented to the lab, and then completed an informed consent form and intake paperwork, including a basic demographics form, the Edinburgh Handedness Inventory, and the Positive and Negative Affect Scale (Watson et al., 1988). They were provided with a brief explanation of the experimental procedures before proceeding.

For recording of electroencephalographic (EEG) activity, participants were then fitted with a 256-channel array of sensors (Manufacturer: Electrical Geodesics Inc. Eugene, Oregon). The sensor array was connected to a 256-channel DC (direct current) amplifier, and the signals were transmitted to a Mac Pro computer, where they were digitally recorded for offline analysis (bandpass: DC to 500Hz). Before beginning the experimental task, scalp-to-electrode impedances were checked, and the sensors were adjusted where needed to improve contact with the scalp. Most or all of the sensors were kept below 50kΩ (channels with poor signal-to-noise were removed during offline analysis) (Ferree et al.,
Participants received instructions and some brief training on how to minimize physiological sources of noise, or “artifacts,” due to blinks, eye movements, and muscle activity before the task was presented.

Participants then received detailed instructions about the structure of the experiment (8 blocks of 120 trials) and about their task. Step-by-step instructions and sample questions were displayed on a 24-inch CRT display, followed by a short practice block before Block 1 (Task 1) and Block 5 (Task 2; see below for task design). Eprime experimental control software (Psychological Software, Inc.) was used for stimulus presentation and recording of behavioral data.

Experimenters provided water, chocolate, and coffee on request and communicated with participants via an intercom system during breaks between experimental blocks.

Stimuli

Stimuli consisted of 120 neutral or slightly positive words and 120 negatively valenced words (see below for ratings). In addition, each stimulus was presented in either upper or lower case. The words were combined to form 120 prime-target word pairs (60 neutral words only appeared as primes, and 60 appeared as targets; the negative words were also split into two psycholinguistically matched sets of 60 primes and 60 targets).

Each stimulus pair belonged to one of four conditions: (1) Case-congruent, valence-congruent (e.g., bonus-glory); (2) Case-congruent, valence-incongruent (e.g., crash-sunshine), (3) Case-incongruent, valence-congruent; or (4) Case-congruent, valence-incongruent. Each positive and each negative target appeared four times within each task, that is, exactly once per block. There were 16 different prime-target word-pair permutations in all. Table 3 summarizes the 16 types of prime-target pairs.
<table>
<thead>
<tr>
<th></th>
<th>Upper-Upper</th>
<th>Upper-Lower</th>
<th>Lower-Lower</th>
<th>Lower-Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative-Negative</td>
<td>Valence and case congruent, e.g., DEAD-CANCER</td>
<td>Valence congruent, case incongruent, e.g., DEAD-cancer</td>
<td>Valence and case congruent, e.g., dead-cancer</td>
<td>Valence congruent, case incongruent, e.g., dead-CANCER</td>
</tr>
<tr>
<td>Negative-Neutral</td>
<td>Valence incongruent, case congruent, e.g., DEAD-PEACE</td>
<td>Valence and case incongruent, e.g., DEAD-peace</td>
<td>Valence incongruent, case congruent, e.g., dead-peace</td>
<td>Valence and case incongruent, e.g., dead-PEACE</td>
</tr>
<tr>
<td>Neutral-Neutral</td>
<td>Valence and case congruent, e.g., SILK-PEACE</td>
<td>Valence congruent, case incongruent, e.g., SILK-peace</td>
<td>Valence and case congruent, e.g., silk-peace</td>
<td>Valence congruent, case incongruent, e.g., silk-PEACE</td>
</tr>
<tr>
<td>Neutral-Negative</td>
<td>Valence incongruent, case congruent, e.g., SILK-CANCER</td>
<td>Valence and case incongruent, e.g., SILK-cancer</td>
<td>Valence incongruent, case congruent, e.g., silk-cancer</td>
<td>Valence and case incongruent, e.g., silk-CANCER</td>
</tr>
</tbody>
</table>

The 16 conditions were carefully balanced in arousal (ratings from the ANEW database) and in number of letters, parts of speech, concreteness, frequency, familiarity, and imageability. In addition, the prime-target pairs were arranged so they had zero forward and backward associative strength, to ensure that any word semantic effects could be unequivocally attributed to valence, as opposed to than other semantic dimensions.

Table 4 (next page) summarizes the stimulus properties.
Table 4: Stimulus properties.

Note: M = mean, S.D. = standard deviation, Min. = minimum, Max. = maximum Neg. = negative, Pos. = positive Val. = valence, Aro. = arousal, # Let. = number of letters, P.O.S. = part of speech, Con. = concreteness, Fam. = familiarity, Freq. = frequency, Imag. = imageability, N. = nouns, V. = verbs, A = adjectives.

<table>
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<tbody>
<tr>
<td>Neg. (M)</td>
<td>3</td>
<td>6</td>
<td>4.87</td>
<td>36 N., 15 V., 9 A.</td>
<td>483</td>
<td>519</td>
<td>48.73</td>
<td>526</td>
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<tr>
<td>Neg. (S.D.)</td>
<td>1</td>
<td>1</td>
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<td>3</td>
<td>85</td>
<td>55</td>
<td>79.67</td>
<td>65</td>
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<tr>
<td>Neg. (Min.)</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>363</td>
<td>344</td>
<td>4</td>
<td>384</td>
<td></td>
</tr>
<tr>
<td>Neg. (Max.)</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>644</td>
<td>609</td>
<td>464</td>
<td>634</td>
<td></td>
</tr>
<tr>
<td>Pos. (M)</td>
<td>6</td>
<td>4</td>
<td>4.78</td>
<td>35 N., 12 V., 13 A.</td>
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<td>535</td>
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<tr>
<td>Pos. (S.D.)</td>
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<td>54</td>
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<td>3</td>
<td>3</td>
<td>231</td>
<td>381</td>
<td>4</td>
<td>304</td>
<td></td>
</tr>
<tr>
<td>Pos. (Max.)</td>
<td>8</td>
<td>4</td>
<td>6</td>
<td>602</td>
<td>627</td>
<td>383</td>
<td>616</td>
<td></td>
</tr>
<tr>
<td>P-value</td>
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<td>0</td>
<td>0.636</td>
<td>0.344</td>
<td>0.115</td>
<td>0.200</td>
<td>0.038</td>
<td></td>
</tr>
</tbody>
</table>

Again, it is important to note that the same word pairs were presented in the valence and case tasks. The order of presentation was randomized within each task block. Thus, participants saw the same word pairs during the two tasks. See "Experimental Task," below, for details on stimulus presentation and stimulus order.

Experimental Task

The experimental task consisted of 960 trials, which were presented in eight blocks of 120 trials (Task 1: Blocks 1-4; Task 2: Blocks 5-8). Participants were encouraged to rest between blocks and were provided with chocolate or refreshments on request.
Each trial began with the presentation of a rectangular outline, which cued the subject to initiate the experimental sequence when ready by pressing the right or left response key. During the inter-trial interval, participants were permitted to blink, itch, or adjust their position, after which they were asked to count slowly to ten to allow the amplifier to recover before using the response keys to advance to the next trial. Once the subject initiated a trial, a central fixation (‘+’ symbol) appeared for 500ms. The word (the prime) was then presented foveally for 35ms and was forward and backward masked to reduce the likelihood that it would be consciously perceived (see Fig. 1 below). The forward mask consisted followed after a short interval (35 ms) by a second word (the target). Thus the stimulus-onset asynchrony (SOA) was 70 ms. The target lasted for 3,000 ms. The subject task was to decide as quickly and accurately as possible whether the target word was, or both. They were to answer ‘yes’ if the probe was related to the prime, target, or both the prime and target, and to answer ‘no’ if the probe was unrelated to either the prime or target. The stimulus protocol is illustrated in Figure 1.

![Stimulus protocol](image)

*Figure 3: Stimulus protocol.*
As noted above, subjects first completed four blocks in which they were asked to focus on one of the two stimulus features of interest (valence or case). In the Valence Task, they were asked to respond as quickly as possible whether the target stimulus was a strongly negative word, or not. In the Case Task, they were to respond as quickly as possible according to whether the target stimulus was an upper or lower case word. “Yes” and “no” (right vs. left) keys were counterbalanced across participants for both tasks. In addition, the order in which the targets appeared and the order of the two tasks were counterbalanced across participants.

Response time and accuracy were recorded using Eprime experimental control software (Psychological Software, Inc.). Incorrect trials, and trials on which RT was less than 100 ms or greater than 3,000 ms, were rejected prior to analyses.

**ERP Data Preprocessing**

The continuous (raw) EEG was segmented into 1,300 ms epochs, starting 400 ms before onset of the prime word. Segmented data were then digitally filtered with a .01Hz high-pass filter and a 30-Hz lowpass filter. Channels that were consistently noisy were removed and interpolated using data from surrounding channels. The cleaned, segmented data were then averaged across trials (within participants and within condition), resulting in a set of event-related potentials, or ERPs. ERP data were re-referenced to the average of the 256 recording sites and were baseline corrected, using the average of the 400 ms pre-prime epoch. The individual subject ERPs were then subjected to statistical analyses. Grand-averaged data were used for inspection of waveforms and topographic plots. T-tests were used for qualitative (uncorrected statistical) comparison of ERPs across tasks and
conditions (prime-target case and valence congruency).

**Behavioral and ERP Pattern Extraction Statistical Analysis**

The effects of prime-target congruency were assessed with behavioral and electrophysiological (ERP) measures. The goal was to test whether task-congruency significantly impacted participants’ behavioral or electrophysiological responses to the stimuli differently in the case and valence tasks. Thus, both behavioral and ERP differences between task-congruent and task-incongruent word pairs were compared within both the case and valence tasks.

For statistical analyses of behavioral data, a two-way analysis of variance (ANOVA) was performed on the participant data. The main effect of task on both reaction time ($F(2, 36) = 93.67, p < 0.001$) and accuracy ($F(2, 36) = 192.71, p < 0.001$) was significant. Follow-up contrasts demonstrated that responses to case-congruent word pairs (240) were significantly faster relative to case-incongruent pairs (240) during the case task [$F(2, 36) = 26.75, p < 0.001$].

**Case task results.** Participants were always faster ($M_{CaseTask} = 527$ ms; $M_{ValenceTask} = 734$ ms), and more accurate ($M_{CaseTask} = 0.978; M_{ValenceTask} = 0.921$) during the case task. There was also a significant main effect of case-congruence. Reaction times were speeded ($F(2, 36)= 4.888, p = 0.033$) and accuracy was higher ($F(2, 36)= 15.17, p < 0.001$) when pairs were case-congruent. However, this effect on reaction time was driven by the sizeable interaction between case-congruence and task ($F(2, 37) = 26.75, p < 0.001$). That is, case-congruence accelerated reactions during the case task, but not during the valence task ($M_{cong.} = 516$ ms , $M_{incon.} = 539$ ms; $t(36) = -6.882, p < 0.001$). Case-congruence did not impact reaction times significantly during the valence task ($M_{cong.} = 736$ ms , $M_{incong.} = 732$ ms).
Prime-target case congruency speeded response time only during the case task, and had no impact on behavior during the valence task.

Similarly, the main effect of case-congruency on accuracy resulted from the strength of the case-task effects. During the case task, responses to case-congruent pairs were more accurate ($M_{cong.} = 0.981$, $M_{incong.} = 0.975$; $t(36) = 2.477$, $p = 0.018$). Case-congruence did not impact accuracy during the valence task ($M_{cong.} = 0.921$, $M_{incong.} = 0.920$, $t(36) = 0.401$, $p = 0.691$). As with reaction times, case-congruency improved accuracy only during the case task.

**Valence task results.** Reaction times were not significantly different for valence-congruent and incongruent pairs across the case ($M_{cong.} = 528$ ms, $M_{incong.} = 527$ ms; $t(36) = 0.065$, $p = 0.949$) and valence tasks ($M_{cong.} = 732$ ms, $M_{incong.} = 737$ ms; $t(36) = -1.083$, $p = 0.286$). Similarly, valence-congruence did not significantly improve accuracy during the valence task ($M_{cong.} = 0.923$, $M_{incong.} = 0.919$; $t(36)=1.372$, $p = 0.179$).

**ERP results.** Case-congruence modulated the occipitotemporal N170 component only during the case task. Case-incongruent pairs, such as “SILK-cancer” and “silk-PEACE,” generated an amplified N170 vis-à-vis congruent pairs, such as “silk-cancer” or “SILK-PEACE” (see Figure 4a). This effect disappeared in the valence task: N170 amplitudes did not differ across any of the word pairs, regardless of their case congruence (see Figure 3c). Thus, pairs like “SILK-cancer,” “silk-PEACE,” “silk-cancer,” and “SILK-PEACE,” all produced similar N170 components, regardless of their case-congruence.

Prime-target valence congruency did affect neural activity differently during the two tasks. Valence congruency impacted processing in both orbitofrontal and centro-parietal regions differently during the case and valence tasks. Early orbitofrontal differences
between valence-congruent and -incongruent pairs were maximal approximately 240 ms after presentation of the target \(t(32) = -4.4, p < 0.001\) (see Figure 5). A second significant difference in orbitofrontal activity emerged at approximately 584 ms and diminished by 706 ms post-target. This late difference between responses to congruent and incongruent pairs peaked at 660 ms post-target \(t(32) = 6.0, p < 0.001\).

Activity in the centro-parietal region was also modulated by pairs’ valence-congruence during the valence task. Congruent and incongruent pairs generated significantly different patterns of electrophysiological activity in this region from approximately 170 to 260 ms post-target \(t(32) = 4.5, p < 0.001\) (see Figure 5). After diminishing slightly, valence-congruence differences in this region peaked again at approximately 338 ms post-target \(t(32) = 4.7, p < 0.001\).

In addition to these differences between electrophysiological responses to pairs between the two tasks, the valence-congruency of prime-target word pairs modulated a late orbitofrontal component during the valence task only (see Figure 4b). The amplitude of this ERP was enhanced, that is, it was more negative, after participants saw incongruent pairs. Thus, during the valence task only, valence-incongruent pairs like “SILK-cancer” and “dead-peace” amplified orbitofrontal activity, whereas valence-congruent pairs like “silk-peace” and “DEAD-menace” did not. The orbitofrontal component was not modulated by the valence congruency of prime-target word pairs during the case task (see Figure 4d).

For further analysis of ERP data, see Stenson & Frishkoff (in prep.).
Figure 4a: Case-task case-congruency N170 ERP

Figure 4b: Valence-task valence-congruency orbitofrontal effects
Figure 4c: Valence-task case-congruency N170 null effect

Figure 4d: Case-task valence-congruency orbitofrontal null effect
Orbitofrontal difference ($t(32) = 4.5 (p < 0.001)$).

Centro-parietal difference ($t(32) = 4.5 (p < 0.001)$).

Figure 5: Task-congruency centro-parietal ERP differences