CATCHING THE MIND’S EYE: THE EFFECT OF INTERNAL DISTRACTION ON EXTERNAL ATTENTION

BY

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DISSEPTION
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ABSTRACT

Most studies of human attention focus on how individuals are able to allocate their attention to various perceptual sources in the environment. Yet, the internal processing of information, such as holding or manipulating information in working memory, speech comprehension, and long-term memory retrieval, are also attentionally demanding. If attention is to be conceptualized as a general pool of resources that gives processing priority to some sources over others, then both stimuli in the external and internal environments must both draw from this pool. Furthermore, if some externally sourced stimuli are able to capture attention due to their potential behavioral relevance, then the processing of significant internal information may be able to capture attention as well. The ability for speech to impact attention, specifically the processing of incongruous or highly meaningful speech, was investigated in a series of six experiments. Experiment 1 examined how one-liner jokes, a stimulus with affective qualities as well as the need to manipulate information, could impact performance on an unrelated visual attention task. Experiments 2 and 3 looked at how being presented with a semantically inconsistent word in a stream of non-sentential, category-consistent words could affect visual attention task performance. Experiments 4, 5, and 6 assessed the impact of hearing taboo words on visual task performance. Experiment 1 opened the door to the possibility of speech processing related visual attention disruption, with individuals showing reduced performance in a visual task when concurrently processing the punch-line of a joke. Experiments 2 and 3 revealed no visual task disruption as a result of hearing non-sentential, semantically incongruent information, and actually trended toward showing a slight performance boost when hearing category-inconsistent words. Auditory presentation of taboo words in Experiments 4, 5, and 6 was consistently able to disrupt performance on an unrelated visual attention task, delaying responses to visual targets when presented immediately following taboo words. As a whole, the current data suggest that when attention is split between the internal processing of auditory information and an external visual task, surprising or meaningful auditory information can impact visual attention and that the effects vary as a function of the nature of the surprising information.
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SECTION 1: BACKGROUND INFORMATION

Chapter 1: Introduction

The overarching goal of this thesis was to explore the interaction between internally and externally directed attention. Previous research has informed our knowledge of how the attentional system is able to coordinate between both internal and external sources of information. This is done mainly by assessing performance in situations of sustained information maintenance or manipulation coupled with an externally directed task. Beyond the manipulation and maintenance of information, the emotionality of a stimulus and our own affective state influence information processing and the distribution of attention. Investigations have revealed much about the various factors influencing internally directed attention, yet do not address the impact of attention capture by internal processing. And while attention capture by stimuli in the external environment has been extensively researched, the effects of attention capture by internal sources remains unexplored. Of primary interest was the identification of candidate mechanisms for internal attention capture or disruption and the examination of those mechanisms in isolation to evaluate their relative impact.

Human beings have available to them at any given time, either perceptually or mentally, countless sources of information and only a limited amount of this information can be processed and dealt with effectively. Attention exists not only to enhance and give preferential treatment to a subset of information, but also to filter out and dampen the signal from other competing sources. The nature of what is able to capture attention, the allocation of attention, and the limits of our attention have been the focus of decades of research. In perhaps the most famous quote concerning attention of all time, William James states, “Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought” (James, 1890). However, humans rarely deal only with “possible objects” or “trains of thought” in isolation at any given time. Put another way, our minds must constantly process and allocate resources to both the external environment and our own internal thoughts and memories.

This thesis is organized in 5 sections, each containing several chapters. In the remainder of the first section I will discuss relevant findings in the study of attention, the broad motivations
for the current set of experiments, the cognitive effects of semantic and contextual inconsistency, the interplay of emotion and attention, and working memory and the central executive. Each part of the introduction section seeks to explore various ways in which the interactivity of internal and external attention has already been addressed. Sections 2, 3 and 4 present work examining the impact of joke comprehension, semantic inconsistency, and taboo words on visual task performance, respectively. Finally, in Section 5, I summarize my findings and attempt to integrate my work into a broader discussion of internal and external attention as a whole.

1.1. Attention

Focus and Guidance of Attention. In moving forward, it is useful to characterize what is meant by external attention and internal attention. In a recent paper Chun and colleagues characterize external attention as the online selection and modulation of modality-specific sensory information with distinct temporal and spatial characteristics. Internal attention, on the other hand, is described as the selection and modulation of internally sourced information, not available to the sensory system, such as information in long term memory, working memory, and decision making processes (Chun, Golomb, & Turk-Browne, 2011). A key distinction made is that external attention is modality specific and yoked to a distinct point in time and space. External attention is necessarily our primary way of handling information coming in from the world and allows us to select and enhance what is relevant and (attempt to) inhibit what is not relevant. Internal attention functions in the same way but for knowledge and memories. We turn our attention inward to select a response according to some rule, modulate our allocation of external attention, or access a memory or piece of knowledge. Internal attention can invoke the memory of experiences in a specific modality, a specific point in time, or a specific location in space, but the focus of internal attention is on previously gained knowledge or experience. And while external and internal attention normally work in concert, they are nonetheless conceptually different.

In the domain of externally directed attention it is tempting to equate the focus of our gaze with the focus of our attention, but it has been known for some time that the focus of attention is distinct from simply where one is looking. This is not to say that fixating an object in the environment or turning the body to better hear a stimulus cannot improve the resolution of one’s sensory experience, but rather that these actions are not sufficient for awareness.
Externally directed attention can roughly be divided into overt and covert attention, corresponding to the physical orienting of the sense organs (e.g. the eyes) toward a stimulus, or mentally shifting attention to a source of information in the absence of any overt physical movement (Posner, 1980). It is the allocation of overt and covert attention to various aspects of the environment that guides what dominates our perceptual and conscious experience.

Try as we might, we are not completely in control of where and how we allocate our limited attentional resources. In most cases, we are fairly good at attending to the internal and external sources of information that serve us in our current goals. However, some stimuli are able to grab our attention against our will regardless of their relevance to our current goals. Certainly, we have all had the experience of hearing a loud noise or seeing sudden movement that compels us to look in the direction of the sound or motion. These occurrences have the potential to be behaviorally relevant and can alert an individual to the need for action so their ability to draw attention makes sense. Yet, in many instances, attention is drawn to stimuli that do not signal the need for action, yet still distract our attention away from our current task. When attention is taken away from a current task by some stimulus that is either unexpected or irrelevant it is said to have been “captured” (Most & Simons, 2001). Attention capture can be as helpful as it can be annoying depending on the circumstances in which it takes place. While driving, noticing movement at the side of the road signaling the presence of an oblivious pedestrian can save a life while a flashy billboard can dangerously take attention away from the task of driving. In the lab, attention capture is often measured by how performance on a task varies when an individual is presented with unexpected or surprising information that is irrelevant to the primary task. If an individual is aware that something has grabbed their attention, this is referred to as “explicit attention capture.” If an individual is unaware that attention has been captured, or only the behavioral impact of a capturing stimulus is examined, “implicit attention capture” is said to have occurred (Most & Simons, 2001). Explicit attention capture is generally easy to assess as you can simply ask a participant if they noticed a stimulus or if anything grabbed their attention. Implicit attention capture, on the other hand, must be inferred from task performance. The logic is that if attention has been captured by an irrelevant stimulus, then attention will be drawn to that stimulus first, delaying the deployment of attention to other task relevant items. In the case of a task such as visual search using response time (RT) as a dependent measure, implicit attention capture can be said to have occurred if longer RTs are
observed in trials when an irrelevant, capturing stimulus is present (Simons, 2000). In all cases, some stimulus draws attention, taking limited processing resources away from our current goal. At the root of attention capture is the notion that stimuli draw our attention for a reason and, even if they turn out to be completely irrelevant, it is their potential relevance that drives capture. Along these lines, attention capture has been observed for moving objects, objects that appear to be looming (appearing to approach the observer on a collision course), and objects that provide a luminance transient, as in cases of a suddenly appearing objects (Franconeri, Hollingworth, & Simons, 2005; Franconeri & Simons, 2003). In almost all studies of attention capture, the capturing stimulus stands out because of some physical characteristic, such as appearance or motion. Generalizing a bit further, we could define those stimuli that are able to capture attention as not just those that are physically different, but meaningful in a more general way. In this way, attention capture could also operate via mechanisms that are independent of physical properties but rely instead on the semantic aspects of a stimulus. Exploring this further could broaden and clarify the definition of attention capture as a phenomenon not limited just to the domain of externally directed attention, but internally directed attention as well.

**Attentional Limitations.** The function of attention is to give processing priority to some subset of the external environment or our own thought processes. In our normally seamless conscious experience, we rarely notice, or even consider, the limits of our attentional system. However, the limits of attention have been exposed in mundane, fascinating, and sometimes frightening ways. Studies of visual attention have revealed noteworthy limitations to how individuals are able to distribute their attention spatially and temporally.

Investigations into visual search (the search for a target item among competing distractor/candidate items) have shown repeatedly that target identification requires focused attention. And while target identification can occur with overt or covert attention, the limits of peripheral vision often require movement of the eyes around a search display. In many instances, successful identification is not possible by distributing attention broadly across the entire display but rather requires inspection of individual items (Wolfe, 1998). Visual search is traditionally discussed in terms of these two modes of search: search that can be done successfully while attention is broadly distributed across the search display and search that requires individual inspection of items. When the object of search can be differentiated from
other distractor items in the display by a single feature, such as color (e.g. searching for a green circle among red circles), search for the object is thought to be done in parallel and the object seems to “pops out”. Search of this form is attentionally undemanding and requires only that individuals attend to the search display overall. Additionally, the time it takes to indicate if a target object is present or absent typically does not increase as you add more distractor items to the display. Conversely, when the target of a search is defined by a conjunction of features, such as shape and color (e.g. searching for a green circle among red circles and green squares), individuals are unable to simply tune their attention to the presence of a single feature, as in the previous case, but must instead inspect items individually in order to determine their status as a target or distractor/candidate item. As might be expected, when search requires the inspection of individual (or at most small groups of items) increasing the number of items in the search display increases the time it takes to indicate if a target item is present or absent (Treisman, 1988).

When target identification is difficult, our focused attention can only process so much, leaving us with no other choice than to often consider only one item at a time.

One of the most compelling examples of the limits of attention is a now famous experiment demonstrating that many individuals will fail to notice the presence of a large unexpected object (in this case, a gorilla) in a visual display if their attention is engaged in a demanding primary task (Simons & Chabris, 1999). This can be seen as both a great success, and a spectacular failure. On one hand, our attentional system is so effective at narrowing our focus that we fail to see something large and unexpected. On the other hand, this serves as a cautionary tale warning us that our attentional system is inherently limited and that when we focus, other possibly important aspects of the environment may not reach awareness.

Yet, the focus of our attentional system is rarely limited to individual items. A paradigm known as multiple object tracking has revealed our impressive ability to use our (mostly covert) attention to keep track of multiple moving objects at once. Success in this task can vary as object tracking becomes more attentionally demanding. The number of items we can successfully track is not a set number but rather depends critically on the difficulty of item tracking (Alvarez & Franconeri, 2007). The more demanding a task is, the more attention it requires, leaving less attention to devote elsewhere. Insufficient attention can result in the
inability to successfully perform an extremely demanding task or process other aspects of the
environment if the current attentional demands exceed our attentional resources.

Attention is not just limited in the spatial domain, but temporally as well. Specifically, if
a stimulus grabs our attention, either due to task relevance or distinctiveness, there are limits to
how quickly the attentional system can process and bring that stimulus to awareness before
becoming available again to process subsequent stimuli. Individuals often fail to report the
second of two targets in a rapidly presented stream of stimuli if the second target appears within
200-500 msec of the first target (Raymond, Shapiro, & Arnell, 1992; Chun & Potter, 1995). This
“attentional blink” is thought to result from an inability to effectively process and “boost” the
second target into awareness due to ongoing processing of the first target (Dux & Marois, 2009).
Thus, the “attentional blink” reveals more than the limits of reengaging attention. It also
demonstrates that attending to and bringing a stimulus into awareness limits the ability to process
and become aware of other events that occur close in time.

Attentional shortcomings are particularly critical in real life. It is important to consider if
skills on one attention task can be predictive of successes and failures in other areas. Covert
attention, specifically skill on a task requiring distributed attention known as “useful field of
view”, has been shown to predict crash risk during driving (Ball & Owsley, 1991; Ball, Owsley,
Sloane, Roenker, & Bruni, 1993). This implies that performance in a laboratory can be
diagnostic of attention in real life. And while the specificity of attention should not be ignored,
individuals do vary in their ability to focus attention, and this skill has some generality. It is
always important to keep in mind how attentional performance in the laboratory can extend to
situations that you encounter in your day to day life. In the lab, individuals are faced with
somewhat artificial, and in most cases, simplified situations. Showing that performance in a
highly controlled task can predict performance outside the laboratory suggests that attention
functions similarly in many situations and that it is not only valid, but useful to apply the
knowledge we have gained about attention in the laboratory to inform our understanding of how
we interact with the world.

**Attention and Multitasking.** So far, I have discussed the limits of attention to external
sources. But, as stated previously, the processing of internal sources of information must not be
discounted. Attention aids us in successful task performance, which takes on a variety of forms.
In this thesis, “task” means any goal-oriented cognitive process. A “task” could be as complex as examining an x-ray, as commonplace as mental addition, or as mundane as watching a bird fly. Each task requires attention that could be allocated elsewhere and we can view attention as a limited resource, one tapped whenever you perform a task. Our management of attention among tasks is just as critical as our ability to focus on either internal or external tasks alone.

Investigations of dual-task performance have revealed that, in most cases, concurrent engagement in two tasks impairs functioning in both. Impaired dual task performance is thought to stem from a variety of sources including our inability to perfectly coordinate our attention between the external environment and internal task rules and goals (Pashler, 1994). Moreover, attention is required not just for tasks themselves, but also managing when and how we switch between tasks. The act of switching temporarily disrupts performance in the switched-to task partly due to our inability to completely inhibit previous task goals and representations which interfere with the current focus (Monsell, 2003). Even something as ordinary as driving a car is negatively impacted, often frighteningly so, by the everyday act of conversation (Strayer, Drews, Johnston, 2003; Horrey & Wickens, 2006). Here, an activity as simple as taking part in a conversation can have very real effects on a task that is often quite dangerous.

It is clear that while attention functions wonderfully in most cases, there exist clear limits that are shared across both external and internal sources of information. The interactivity and engagement of both systems together must be considered in order to truly, and accurately, characterize the limits and functioning of human attention. Investigations into the limits of attention have greatly informed our understanding of how we prioritize and process the limited subset of environmental and cognitive information available to us at any given time. However, the way in which we coordinate focus between internal and external sources is not completely understood. This thesis aims to elucidate how externally and internally directed attention function together. Specifically, I aim to investigate situations in which attention is drawn to, or even captured by, internal sources and how this may influence attention directed to the external environment.

1.2. Broad Motivations
The Psychology of Magic. An intriguing recent approach to the study of attention draws upon the knowledge and practice of magicians to examine magic tricks and the achieved effects through the lens of psychological phenomena. For centuries, magicians have honed their craft in an attempt to maximize success by cleverly exploiting the limits of human attention. The skills and knowledge underlying the practice of magic can not only inform, but also contribute to a greater understanding of perception and cognition (Kuhn, Amlani, & Rensink, 2008). Phenomena such as inattentional blindness (Most, Scholl, Clifford, & Simons 2005; Simons & Chabris, 1999) have been used to explain how magicians are able to accomplish their tricks (called the “effect”) with the “method” (how the trick is done) often in plain sight. Specifically, magicians uniquely consider the interplay between attention to internal and external sources, often manipulating individuals’ attention to turn their attention inward in order to obscure some action in the external environment. The primary way in which this is achieved is through misdirection.

Misdirection refers to actions that aim to focus attention on some source, effectively reducing, or eliminating entirely, attention to other sources. Misdirection can be physical or psychological. Physical misdirection refers to the manipulation of an individual’s gaze by utilizing bottom up cues such as sudden motion. Psychological misdirection utilizes social cues, expectancies, and knowledge to manipulate attention independent of an individual’s gaze. (Kuhn et al, 2008; Macknik, King, Randi, Robbins, Teller, Thompson, & Martinez-Conde, 2008). In both cases, attention is manipulated to focus on one locus (task, spatial location, information, etc.), leaving other aspects of the environment unnoticed. The distinction made between physical and psychological misdirection, and the execution of psychological misdirection, suggests that magicians have a keen understanding of the interplay between internally and externally directed attention. In fact, researchers have used a magic trick to show that psychological misdirection can be used to affect overt and covert deployment of externally directed attention (Kuhn, Tatler, & Cole, 2009).

The primary goal of misdirection is to reduce the salience of the method used to achieve the desired effect. This is often done by manipulating overt and covert attention such that the focus of external attention is to spatial locations disparate from where the method is taking place. However magicians also understand that the salience of a stimulus is reduced by splitting
attention between multiple sources, regardless of whether those sources are internal or external (Macknik et al, 2008). One way magicians masterfully do this is by engaging the audience, either as a group or directly, in conversation. By requiring individuals to process a stream of speech or, even more effectively, by asking questions, the magician expertly splits the audience’s attention without them even realizing it. The effectiveness of speech processing as a method of misdirection is a nice illustration of the interactivity and functional connectedness of internal and external attention.

The use of psychological misdirection to subtly manipulate and engage internally directed attention is most relevant here. One clever way in which magicians focus attention internally, is with the use of a “false solution.” The “false solution” is a technique in which a performer fakes either getting caught or messing up a trick, only to reveal later that the blunder was a ruse. In these situations, the spectator reduces their attention to scrutinizing the magician’s movements and actions, seemingly absorbed in their processing of the “revealed” solution (Kuhn et al, 2008). By getting the audience to attend to their thoughts about the mistake and not to analyzing the trick, internally directed attention effectively masks the method.

Magicians and magic theorists also speak of misdirection in terms of “degrees”. Each degree of misdirection functions differently than the previous degree, increasing in effectiveness (de Ascanio, 1964/2005). Misdirection in the first degree refers to providing an audience with multiple sources on which to focus. Never executing a trick in isolation, magicians always perform other actions to draw attention such as distracting movements, comments, or facial expressions. These seemingly innocent actions exploit attentional limits by splitting audiences’ attention. Misdirection in the second degree builds on the first by including one action that is more intrinsically interesting than another. By increasing the attentional allure of a non-method action, magicians increase the probability that attention will not be focused on the method. Second degree misdirection tactics include banter, faster or more intriguing movements, and even physical attractiveness (of say, a scantily clad stage assistant). By not only providing multiple sources of information on which to focus, but making a decoy action interesting, magicians more effectively split attention than by multiple actions alone. Finally, misdirection in the third degree refers to an action that seeks to direct the audience’s eye gaze to a desired stimulus. Magicians hope to make it impossible to see a given method by causing individuals to
shift their gaze away, ensuring successful execution of a trick. Though considered to be the most powerful, misdirection in the third degree is used most rarely. A sudden noise or visual stimulus is certainly effective at drawing attention, but is also obvious and suspicious. Furthermore, misdirection in this degree is frequently infeasible when engaged in up-close magic in which there is often only a table, or nothing at all, separating the performer from the audience (de Ascanio, 1964/2005). In tapping into the knowledge of magicians, it becomes clear that psychologists are not the only population with an informed understanding of human attention. Magicians are keenly aware of not only the limits of attention, but specifically the way in which attention can be split between the external environment and internal thought processes. Clever exploitation and manipulation of these limits allows for truly astonishing effects which can be thought of as compelling, and entertaining, failures of attention.

**Humor and Attention.** The primary impetus to the current line of research exploring the interaction between internal and external attention came from a specific insight of magicians. As mentioned above, magicians employ many methods of misdirection to manipulate the audience’s attention. One particular method that stands out as unique is the use of humor. Magicians claim that jokes are much more than a way to boost the entertainment value of their tricks, citing the use of laughter as not only integral to their performance, but a way to effectively freeze the attentional spotlight such that the audience is blind to their methods (Macknik et al, 2008). Going further, is the notion that it is not laughter itself, but a kind of attentional disengagement following a joke that leaves the spectator unfocused on the particulars of a trick’s performance allowing for more successful trick execution (Kuhn et al, 2008). The supposed external attention disengagement following the delivery of a joke seems a special case of internally directed attention distinct from most instances of internal processing. The assumption is that the processing of the joke, and the subsequent realization of the punch-line, results in a moment, however brief, when attention is completely and uncontrollably drawn to internal processing of the humor. Processing of a joke’s punch-line represents a possible case of what could be considered internally generated attention capture. A quote by Arturo de Ascanio, a Spanish magician, captures this idea of attention capture within the stream of consciousness quite well writing:
Patter, in fact, can generate thoughts in the spectator’s mind. As it turns out, when a significant thought goes off in his brain, its light is so blinding—even if only for an instant—that although he might be looking, he won’t see a thing. This is because humans do not see with their eyes but rather with their minds, and at that moment the brain is busy absorbing the information, gauging it, and weighing its meaning and relevance. (de Ascanio, 1964/2005).

Jokes as a whole represent a class of stimuli that are deceivingly complex. Any or all aspects of joke comprehension could potentially impact the distribution of attention between internal and external attention. As such, it is necessary to consider each aspect of humor comprehension in isolation. I will start by briefly discussing a broad theory of humor comprehension. Next, I will discuss jokes as a specific example of a more general class of “insight” situations. Later in the introduction, I will go into detail about how the emotional aspects of joke processing might influence attention. I introduce and discuss jokes not to further an understanding of jokes as a phenomenon per se, but rather to use them as convenient inspiration for identifying and isolating special cases of internal processing in the service of better understanding the interaction between external and internal attention.

Humor comprehension is proposed to consist of two parts, a “surprise” stage and what is called a “coherence” stage where frame-shifting must take place (Coulson, 2000). When the punch-line to a joke is delivered, the word or phrase that makes it funny is often surprising. This surprising word or phrase requires an individual to reanalyze what they have just heard by retrieving a different “frame” from long term memory to reinterpret the information currently being held in working memory (Coulson, 2000). Therefore the comprehension of humorous stimuli goes beyond the normal processing of speech by requiring not only the retrieval of semantic information from long term memory, but an active reinterpretation and re-retrieval of a new “frame” of thinking. This cognitively intensive and central executive driven process (discussed below) casts humor comprehension as a unique example of a process requiring, and in a sense demanding, internally directed attention. It is possible that simply the processing of unexpected information is able to capture attention. Furthermore, even if unexpected information fails to impact attention on its own, the act of reinterpretation and retrieval of a new frame of thinking could take up valuable attentional resources that could otherwise be directed externally.
Insight and Attention. Interestingly, many instances of humor are seen as special examples of a larger class of situations involving the experience of what has been deemed “insight” (Kounios & Beeman, 2009). Insight refers to any situation where the subjective experience is a sudden realization or, more informally, an “Aha!” moment. The experience of insight is not limited to humor comprehension and random realizations, but can occur in problem solving, object identification, and creativity. The prevailing notion is that the experience of insight reflects ongoing processing that suddenly emerges into awareness such that we experience the “Aha!” moment due to a sudden reinterpretation of the current context (Kounios & Beeman, 2009). This occurs following the delivery of a punch-line in the case of jokes, but can also occur when the solution to a problem or puzzle suddenly springs to mind. The experience of insight seems to be more than just a subjective feeling, with unique patterns of brain activation and activity accompanying the solution of problems solved by insight versus analytical means (Jung-Beeman, Bowden, Haberman, Frymiare, Arambel-Liu, Greenblatt, Reber, & Kounios, 2004). Within the internal/external attention framework, insight problems, and other situations that commonly feature the experience of an “Aha!” moment, could present a unique opportunity for the study of internally directed attention. By their nature, insight problems require the manipulation of information in working memory as the individual attempts to arrive at an initially non-obvious solution. This generally requires that the most prepotent thoughts and ideas be either inhibited or willfully cast aside in favor of less obvious thoughts and solutions. Insight problems provide for an attentionally demanding task that provides a unique kind of manipulation of information in working memory in a more natural, less artificial context.

Critically, situations of insight provide a kind of internal stimulus “onset” in the form of a sudden thought or realization. In most cases, attention capture, either explicit or implicit, is only thought of as occurring by way of external stimuli. The experience of insight may have a clear influence on externally directed attention as in typical situations of attention capture. The impact of the experience of insight on externally directed attention, be it the processing of a joke’s punch-line or the sudden solution of a puzzle, could provide a unique way to look at what happens to externally directed attention when attention is almost uncontrollably drawn inward. To this author’s knowledge, there are no existing investigations looking into situations of thought-driven attention capture above and beyond just being lost in thought or rumination. It
seems quite plausible that similar effects could be observed for internally generated attention capture under the right situations.

1.3. Semantic and Contextual Inconsistency

The possibility exists that simply the act of recognizing an inconsistency in the current context may, in some sense, capture attention. In the above section, the first stage of humor comprehension was described as a “surprise” stage (Coulson, 2000). For humor, this surprise is related to a punch-line that is unexpected or in some way out of place given the current context. The surprise is then followed by a reinterpretation and “coherence” stage and while this second stage of joke processing may indeed demand internally directed attention, the semantic inconsistency alone may be sufficient to impact attention. The “recognition” of inconsistency could come in many forms. Event related potential (ERP) studies investigating the brain’s electrophysiological response to meaningful stimuli have shown increased amplitude of the N400 component of the ERP in response to semantically incongruous or unexpected information (see Kutas & Federmeier, 2011 for a review). On some level, the brain is sensitive to the semantic analysis of information very early after it is encountered, and is sensitive to how this information fits with the information preceding it. These effects can also be observed in the absence of a sentential context. N400 effects have been shown to an item in a list that does not match the semantic category of the items previously presented in the list (Harbin, Marsh, & Harvey, 1984). Even when not surprising in the sense of a punch-line, it is possible that the recognition of semantically inconsistent information extends beyond the brain’s electrophysiological response in a way that temporarily grants the new information an internal salience that captures attention internally, drawing attention away from the external environment.

Related to this idea is the classic finding demonstrating the “release from proactive inhibition” (Wickens, 1970). In these studies on short term memory, memory for items of a similar kind (strings of letters or numbers) progressively declines over a few trials seemingly due to items from previous trials interfering with memory for current-trial items. Importantly, this proactive interference is reduced if new information to be remembered differs on some dimension compared to the items remembered in previous trials. This “release from proactive inhibition” can be achieved by changing items in a variety of ways but is most effective when the new items differ on some semantic dimension. In essence, individuals are able to recognize that
the new items to be remembered are semantically distinct in some way compared to the items in previous lists. One explanation for this effect (though not in this terminology) is that the new items, as a result of their semantic distinctiveness, capture or receive more attention (Wickens, 1970). I won’t attempt to argue for or against, this explanation for the effect, but rather emphasize that on some level, the recognition that the current items differ from items in previous trials provides for some kind of differential internal process that could be partially driven by attention.

Finally, the idea of unexpectedness and distinctiveness can be extended beyond situations of semantic incongruity to any situation in which something happens that is distinct compared to what came before it. It turns out that even the recognition of the violation of a very simple, non-semantic context has been shown to impact attention. In a study investigating the impact of auditory “oddballs” on attention, participants were given the task of categorizing digits as odd or even. Critically, each digit was preceded by simple tone. When the tone preceding the digit differed from a standard tone (an “oddball”), response times to digit categorization were slowed (Parmentier, Elford, Escera, Andrés, & Miguel, 2008). This slowed response was thought to stem from shifting attention to the novel, distinct tone effectively delaying the engagement of attention to processing the digit. This provides preliminary evidence that the violation of even a very simple “context” can result in impairments to task performance. It should be noted that in this auditory oddball study, the oddball tone differed from the other tones in terms of its physical characteristics and thus drew attention in a bottom-up manner, whereas I am more concerned with stimuli that capture attention because of the internal processing of their meaning. However, it is still important to note that even the violation of a very simple and artificial context can shift the balance of attention resulting in behavioral decrements.

1.4. Emotion and Attention

Turning the discussion briefly back to humor, the experience of mirth that accompanies listening to humorous speech brings with it forces independent of the flash of cognitive light associated with sudden punch-line comprehension. Humor, by definition, tends to involve sudden, and often uncontrollable, positive emotions. Indeed, processing of humor recruits not only brain areas associated with linguistic processing and semantic integration, but reward as well (Goel & Dolan, 2001). So when considering humor as potentially impactful vis-à-vis
attention, it is necessary to look not only at the transient effects of humor processing, but the potentially enduring effects as well. Humor’s effectiveness as a way to manipulate attention may indeed come from processing of the punch-line itself. It is likewise possible that sustained affective states or the differential processing of valenced information influences the coordination of internally and externally directed attention.

**Affective Stimuli and Attention.** Emotionality, by virtue of its assumed behavioral relevance or importance, has been thought to afford a stimulus almost automatic access to processing and awareness (Pratto & John, 1991). If this were the case, then it would suggest that emotional stimuli might usurp top-down attentional control, demanding internally directed attention and diminishing processing resources. However, it has been shown that emotional stimuli, like anything else, require attention (but not necessarily awareness) to be processed (Pessoa & Ungerleider, 2004). That being said, when attention *is* available to process emotional stimuli, emotionality does afford a stimulus certain benefits and can impact concurrent stimulus processing. In a set of experiments placing emotional images within an image rapid serial visual presentation (RSVP) task, negatively emotional images (Most, Chun, Widders, & Zald, 2005) and positively emotional images (Most, Smith, Cooter, Levy, & Zald, 2007) were shown to produce an attentional blink (Raymond et al, 1992; Chun & Potter, 1995). Impressively, this effect was also shown for stimuli that were not inherently emotional, but instead had been conditioned with an aversive tone (Smith, Most, Newsome, & Zald, 2006). This finding is particularly compelling as it demonstrates that emotional stimuli do not strictly exert their influence for evolutionary reasons, but rather that learning can change the way we internally attend to otherwise neutral stimuli.

The attentional benefit to emotional stimuli has been further shown for stimuli on both ends of the valence spectrum. Equally arousing emotional stimuli, of both positive and negative valence, seem to influence attention equally. Positive and negative words, matched on arousal, were shown to provide the same level of T2 sparing (increased detection of the second target) in an RSVP task (Anderson, 2005) suggesting enhancement of processing usually limited by attentional constraints (Dux & Marois, 2009). Thus, emotional stimuli seem to affect attention and processing by virtue of their arousing nature and a resultant boost in signal. Interestingly, this boost in signal has been shown to improve measures of early visual processing. When
presented with an emotionally negative face prior to making a tilted Gabor judgment, participants displayed greater contrast sensitivity than when stimuli were preceded by a neutral face. Additionally, this benefit was shown to interact with attention as the effect was even greater when the emotional face appeared at the location of the subsequent target (Phelps, Ling, & Carrasco, 2006). And while a boost in signal provided by emotional stimuli may have improved performance in the previous case, this boost in signal could be detrimental if provided for task irrelevant information.

Informing the concept of internal and external attention are cases where emotional stimuli have been shown to directly interfere with the internal manipulation of information. In one instance, task-irrelevant emotional images presented along with math problems were shown to increasingly interfere with performance as a function of how arousing the images were rated (Schimmack, 2005). This finding reinforces the notion that interference stems from arousal, not valence, and that emotional task-irrelevant information can negatively impact the effective allocation of attention. Importantly, the images in the previous study were task-irrelevant, demonstrating that emotional information is increasingly difficult to inhibit as it becomes more arousing. Individuals also show increased reaction times in an N-back task (thought to utilize the central executive) using fearful faces in place of neutral stimuli (Kensinger & Corkin, 2003). This evidence should be taken with caution, though, as increased N-back reaction times were not observed when using emotional words or on a separate working memory maintenance task using emotional stimuli.

The influence of emotionality extends beyond the arousing nature of stimuli themselves. Emotion-related personality traits, and the impact these traits have on emotional state, can also influence attention. Following an insult, high trait anger individuals have shown increased interference by word emotionality in Stroop color naming performance. This effect was not present for individuals of low trait anger, or for non-insulted individuals, suggesting that the effect was driven by current emotional state (Eckhardt & Cohen, 1997). In a particularly clever demonstration of the transient impact of emotional state on attention, Most and colleagues had romantically involved couples perform two different tasks. The female partner would participate in the previously mentioned image RSVP task featuring emotional distractor images, while the male partner rated images of either landscapes or other females on attractiveness. The self-
reported level of uneasiness the female partner experienced due to her partner rating other females correlated significantly with the amount of disruption caused by negatively emotional images in the RSVP task. Additionally, the correlation between unease and disruption only manifested when the female was aware that their partner was, at that moment, rating other females (Most, Laurenceau, Graber, Belcher, & Smith, 2010). Together these findings suggest that in the right conditions, general emotional states can increase sensitivity or susceptibility to emotional stimuli, and that this effect need not persist.

**Affective State and Attention.** Beyond the effect that emotional states can have on stimulus processing, there are also indications that affective state can influence the allocation of attention. It has been hypothesized that positive and negative emotional states change the distribution of attention. Negative emotional states are thought to narrow the focus of attention, effectively reducing the processing of non-target information, while positive emotional states are thought to broaden the attentional focus, both externally and internally (Finucane, 2011; Rowe, Hirsh, & Anderson, 2007). On the unhappy end of the spectrum, after viewing film clips intended to induce negative emotions, fear (and to a lesser extent anger) was shown to reduce response times for incongruent trials in a flanker task compared to a control condition (Finucane, 2011). Conversely, following induction of positive mood by music, individuals have displayed more interference on incongruent trials in a flanker task due to increased distractor processing. Adding to this finding, those in the positive mood condition also showed increased performance on a verbal remote associate tasks thought to index breadth of semantic access (Rowe et al, 2007). This latter finding is particularly intriguing as it suggests that the distribution of attention, both externally to visual information and internally to information in long term memory, can be broadened and narrowed by affective state independent of volitional control.

Overall, the effects of emotionality on attention can be divided into two main classes of effects, those stemming from the emotionality of stimuli themselves, and those that arise as a result of general affective states. For stimulus emotionality, the main impacting factor seems to be the level of arousal that the stimulus elicits, with arousal boosting the signal for emotional stimuli providing them with a neural advantage. This results in advantaged processing in some situations while also making emotional stimuli harder to inhibit or disengage from in other situations. An increase in arousal could also serve to add general noise to the cognitive system,
making the selection of task relevant information and the effective allocation of attention by the central executive more difficult. General positive and negative affective states seem to have differential effects regarding the allocation of attention. Affective states seem to influence not only susceptibility to the influence of emotional stimuli, but also the way attention is distributed to both external and internal sources of information. Previous research has informed how emotional stimuli are processed and how general affective states impact the allocation of attention, however the question of how the internal attention capture by surprising emotional information impacts our externally directed attentional remains open.

1.5. Working Memory and the Central Executive

Working memory is often defined as the cognitive system capable of temporarily storing and manipulating information no longer accessible to the perceptual system (Baddeley, 1992). Working memory deals exclusively with internal processing and thus must be considered in any discussion of internally and externally directed attention. In Baddeley’s multi-component model of working memory, the working memory system is divided into multiple subsystems: the visuospatial sketchpad, the phonological loop, the episodic buffer, and the central executive (Baddeley, 2012). The visuospatial sketchpad, the phonological loop, and the episodic buffer provide for limited capacity stores for visual, auditory, and multidimensional episodic information respectively. The central executive is tasked with the manipulation, coordination, and organization of information within, and between, the subsystems of working memory and long term memory. Given an individual’s current goals, the central executive is tasked with focusing attention, dividing attention, task switching, and interfacing with long term memory such that memories and knowledge can be brought into awareness (Baddeley, 2012). The central executive, as conceptualized in the multicomponent working memory model, serves as not only the gatekeeper of information, but the controller of attention, both to internal and external sources. The functional relationship between working memory and attention has led some to claim that the two cognitive processes are essentially the same (Cowan, 2001; Engle, 2002). However, careful research has revealed them to be both behaviorally and neurally distinct as working memory and attention have been shown to have distinct capacity limits (Fougnie & Marois, 2006) and unique patterns of heightened activity with increased load in each domain (Tomasi, Chang, Caparelli, & Ernst, 2007). Internally directed attention can partially be
conceived as the focusing of processing resources by the central executive on manipulation or maintenance of information such as long term memories, temporary modality specific information, or a combination of both.

**Working Memory Maintenance and Attention.** Of current interest, are investigations into the interaction between working memory processes and externally directed attention. The impact of working memory tasks on visual attention performance seems to largely depend on the type of working memory being utilized. Maintaining information in working memory has actually improved performance in tasks where working memory items and distractor processing overlap (Kim, Kim, & Chun, 2005; Park, Kim, & Chun, 2007). This suggests there is some modularity to working memory, as maintaining one type of information can reduce resources available to process similar, potentially distracting information. One important aspect of the multicomponent working memory model is that the model allows for each subsystem to be even further divided into subsystems. The further modularity and specificity of processing within subsystems is supported by the finding that while visual search efficiency is not negatively impacted by a non-spatial visual working memory task (Woodman, Vogel, & Luck, 2001), spatial working memory load (thought to more closely overlap in processing with visual search), reduces visual search efficiency (Oh & Kim, 2004; Woodman & Luck, 2004). This lends further support to idea that working memory is somewhat specialized, as allocating internal attention to the maintenance of spatial locations reduces our ability to perform spatial tasks such as visual search. The characteristics of both the task and the items in memory seem to be influential when maintaining items in working memory.

Lavie’s load theory of selective attention (Lavie, Hirst, de Fockert, & Viding, 2004) makes specific predictions about how different kinds of load, perceptual or cognitive, will influence attention. Elevated perceptual load results from increasing the complexity or variability of external stimuli, while heightened cognitive load usually stems from simultaneous performance of an internal task. Within the framework of load theory, increasing perceptual load will fully utilize perceptual attention resources and the processing of distracting information in the environment will decrease, improving task performance. Conversely, low perceptual load leaves open perceptual resources to process distracting stimuli, harming task performance. On the other side of the coin, an increase in cognitive load (such as a concurrent working memory
task) interferes with central executive processing and the effective allocation of attention, resulting in impaired task performance. By reducing cognitive load, you reduce the amount of strain placed on the central executive allowing for more effective cognitive control and attentional focus (Lavie et al, 2004). From the point of view of load theory, directing attention internally will increase cognitive load, disrupting task maintenance and effective resource allocation. Interestingly, an increase in perceptual load has been shown to decrease the prevalence of task unrelated thoughts during performance of a visual attention task, indicating that high perceptual load may not just reduce distraction cause by external stimuli, but internal “stimuli” as well (Forster & Lavie, 2009).

**Working Memory Manipulation and Attention.** It is necessary to look not just at the maintenance of information in working memory but also at situations in which attention is focused internally to the manipulation of information. Manipulation of information draws more heavily on the central executive, requiring more sustained internally directed attention and focus. Given its role in the focusing and coordination of attention, the central executive is most impaired by tasks that are attentionally demanding, just as the phonological loop is most disturbed by phonological tasks (Baddeley, 2012). The reverse is also true. Central executive load requiring manipulation of information has negatively impacted visual search efficiency (Han & Kim, 2004) and rates of inattentional blindness have been shown to increase when a critical stimulus appeared during active manipulation of information in working memory (Fougnie & Marois, 2007). Increased rates of inattentional blindness were not displayed during maintenance, or when manipulation was thought to be complete, suggesting a particularly demanding role of active information manipulation. It seems that while maintaining information in working memory has varied effects depending on the nature of the stimuli, tasks that require active manipulation of information have a more general negative impact on concurrent task performance. The aforementioned “coherence” stage of humor processing (Coulson, 2000) could be viewed as a naturalistic example of working memory manipulation. The surprising, humorous information must be integrated into a new “frame” of thinking, a process requiring the individual to use their working memory and knowledge to actively connect the punch-line to the preceding context in a novel, and often unconventional way. If some special situations of information processing are able to uncontrollably draw attention internally, this could impact both the maintenance of information in working memory, and more likely, the ability of the
central executive to manage attention and effectively shift attention from one focus to another in dual task situations. Internally salient information would likely prove difficult to inhibit in favor of more task relevant processing thus leading to performance decrements.

1.6. Summary

The interplay between internally and externally directed attention has been addressed in a variety of ways. Magicians have informed the study of internal and external attention by describing how they exploit the limits of our attention in entertaining ways. The study of misdirection recognizes our inability to completely process external and internal streams of information simultaneously and takes advantage of this to great effect. Investigations of working memory and attention have demonstrated the impact of both maintenance and manipulation of information on concurrent task performance. And while both maintenance of information in memory requires some level of internal attention, disruption of the central executive and manipulation of information has proven to be far more disruptive to external attention. The study of emotional influences on attention reveals that not all stimulus processing is equal and that some stimuli bring with them meaning that changes the way they are processed. Emotional stimuli are frequently given a neural advantage in that their signal is “boosted” resulting in a kind of internal salience. This boost in signal can be beneficial or detrimental depending on the task relevance of the emotional stimuli. General emotional states have also been shown to impact the allocation of attention with good and bad moods being reflected in more broad and narrow attentional processing respectively. Finally, the study of insight looks at those special situations where the solution to a problem is not arrived at analytically, but rather springs to mind in a sudden “Aha!” moment. These moments seem to be more than just subjective feelings, as they are reflected in unique patterns of brain activity.

The objective of this thesis is to investigate the interplay between internally and externally directed attention, specifically situations when the meaning of a stimulus may capture attention in a way that impacts externally directed attention. Jokes provided inspiration for various ways in which semantics might be able to influence attention by focusing attention on processing the meaning of auditory information at the expense of attention to tasks requiring externally directed attention. In Section 2, I directly address the claim that jokes are able to “freeze” or disrupt the attentional spotlight. Jokes are multifaceted in the ways in which they...
could potentially impact attention and thus provide a nice starting point for examining situations in which semantics can disrupt or impact attention to the outside world. Sections 3 and 4 take isolated components of joke processing and look at their potential individual contribution to attentional disruption. In Section 3, I examine the specific impact of semantic inconsistency on attention. I begin by addressing how being presented with semantically incongruent information impacts the ability to simply detect a visual target. I end Section 3 looking at how semantically incongruent information impacts performance on a more attentionally demanding task requiring not only target detection, but identification and response selection. Section 4 explores taboo words as an analogue to the surprising, emotional aspect of joke processing. Section 4 first investigates the impact of taboo words on simple visual target detection and then moves on to examining the impact of auditorily presented taboo words on a visual attention task requiring target identification and correct response selection. Finally, in Section 5, I provide a general summary of the experiments examined within, offering an integrative discussion of how the experiments as a whole inform our understanding of the coordination of internally and externally directed attention and what can be said about semantically driven, internally sourced attention capture.
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SECTION 2: HUMOR AND ATTENTION

Chapter 2: Humor and Attention Introduction

The initial impetus for this project as a whole was to examine the intuition of magicians that, following a joke or humorous statement, there is a brief period of time when an individual seemingly disengages attention from external sources of information. In the parlance of magicians, this kind of “misdirection” manipulates the audience in such a way that shifts attention to focus on the internal processing of the humorous speech, neglecting external sources of information such as the magician’s physical actions. Section 2 discusses and directly examines this claim. A rapid serial visual presentation (RSVP) paradigm was used in conjunction with a secondary task of listening to short, humorous audio clips. A joke is distinct from normal speech in that there is generally an identifiable punch-line that makes the statement humorous. It seems likely that the time in which attention would be most strongly turned inward following a joke would be immediately following the punchline. An attempt was made to place visual targets requiring a response during times in which an individual was processing the punchline of jokes and thus most likely to have attention focused inward. If there truly is a disengagement of attention when an individual is processing a punch-line, then there should be reduced detection of or slower reaction times to RSVP targets appearing during this time.

2.1. General Section 2 Methods

**Equipment and Software.** Experiments were conducted on Mac Minis with a 2.5 Ghz Intel core i5 processor with 4 Gb of memory running OSX version 10.8.3. Graphics were provided by an Intel HD Graphics 4000 graphics card with 512 Mb of memory. Stimuli were presented on BenQ model 2420TX 24” monitors set at a resolution of 1920x1080 (1080p) and a refresh rate of 100 Hz. Participants’ heads were not confined to a chin rest and instead individuals were told to sit comfortably in front of the desk, which placed viewing distance at approximately 60 cm. At this viewing distance the screen subtended approximately 41.7° of visual angle horizontally and 26.9° vertically.

Experiments were run using version 3 of the Psychophysics Toolbox running in Octave version 3.6.4. Octave is an open source alternative to the MATLAB programming software (http://www.octave.org). Auditory stimuli were prepared using the free sound editing software
Audacity (http://audacity.sourceforge.net/). Statistical analyses were performed using SPSS Version 21.0 and SPSS Version 22.0.

**Participants.** Participants were all students between the ages of 18 and 30 from the University of Illinois at Urbana-Champaign. All participants were required to be (self-reported) native English speakers with normal or corrected to normal vision, normal or corrected to normal hearing, no color vision deficiencies, and no condition that might compromise their ability to read words printed on a computer screen. All participants were compensated with credit to partially fulfill course requirements in University of Illinois psychology courses.

**Procedure.** All auditory stimuli were presented through headphones which participants were required to wear throughout each session to allow for multiple individuals to be run at once. Prior to beginning, participants were presented with a test sound to ensure that volume was at an adequate level and were allowed to adjust the headphones to their liking. Up to 3 participants were run at the same time, each at their own computer, separated by partitions. Following each session, participants were debriefed as a group.

### 2.2. Development of Stimuli

A collection of “one-liner” joke stimuli were compiled from books of jokes and from various websites online. Each joke was selected such that the “punch-line” to the joke occurred as close to the last word as possible. One-hundred and forty-two such jokes were initially compiled. Each joke was recorded by the author to provide a standard voice with consistent audio quality. Jokes ranged in length from 3 to 11 seconds and were presented through headphones which participants wore throughout the experiment.

The compiled 142 jokes were presented to a group of 6 undergraduate research assistants to give each joke a 1 to 5 “funniness” rating. These ratings were then averaged and ranked in order. The funniest 51 jokes were then selected for use in the experiments as a result of the inability to use all 142 due to time constraints.

**Joke Stimulus Norming.** One challenge for observing a humor induced attention blink lies in successfully placing the target during the period of time when an individual is “getting” the joke. In an attempt to maximize the likelihood of placing RSVP targets during the time of
“getting” the joke, joke stimuli were normed by collecting “get-it” times for each. These “get-it” times were then averaged across participants such that an average “get-it” time was obtained for each joke. These joke specific “get-it” times were then used for visual target presentation timing in Experiment 2.

**Joke Stimulus Norming Methods.**

*Participants.* Seven University of Illinois undergraduate students (2 female, 5 male; mean age: 19.6) participated in the joke norming.

*Procedure.* Participants were instructed that they would be hearing a series of humorous one-line jokes and to simply listen and press the spacebar as soon as they “got” each joke. Each trial began with a fixation “asterisk” after which the audio clip would start playing. They were also instructed to give each joke a 1 to 5 rating on funniness at the end of each trial. Individuals were told to sit a comfortable distance away from the computer screen. An average “get-it” time was calculated for each joke and used in Experiment 1.

**Chapter 3: Preliminary Humor and Attention Work**

**3.1. Experiment 1**

Experiment 1 provides preliminary evidence that task performance can be impaired by processing of humorous “one-liner” stimuli. Using the unique “get-it” times obtained in the joke norming, participants monitored an RSVP stream of letters during which a uniquely colored target letter would appear. The decision to use an RSVP paradigm was made based on previous evidence that meaningful (i.e. emotionally arousing; see: Most et al, 2005 and Most et al, 2007) images can induce visual target detection impairments in an RSVP task, reminiscent of the attentional blink. Building on this idea, it could be the case that hearing humorous stimuli might have the same effect. This could be due to the positive emotionality of humor, in line with the previous studies by Most and colleagues, or it could be due to some other aspect of joke processing. Single target RSVP was thought to be a good first candidate task on which to test the effects of concurrent joke and punch-line processing. On each trial, the visual target could appear either 3 seconds after the humorous audio clip was finished, or at a time based on each joke’s unique “get-it” time in an attempt to place targets during punch-line processing. The goal
of Experiment 1 was to examine if some form of a humor induced attentional blink or impairment could be observed by comparing reaction times and detection rates of targets when the target appeared at different times relative to the punch-line of the joke.

### 3.1.1. Experiment 1 Methods.

**Participants.** 10 University of Illinois undergraduate students participated in Experiment 1 (5 females, 5 males; mean age: 19.3 years).

**RSVP Task Design.** RSVP stimuli were letters of the alphabet that appeared at the center of the screen. Each letter subtended approximately 1.15° of visual angle horizontally and 1.34° vertically. Stimuli were presented on a gray background with an RGB value of [140, 140, 140] with non-target RSVP stimuli presented in black font (RGB = [0, 0, 0]) and target stimuli appearing in a shade of gray darker than the background (RGB = [100, 100, 100]).

Each trial began with a fixation “asterisk” for 2 seconds. The audio would begin playing 3 seconds following the disappearance of the fixation “asterisk.” The RSVP stream began a random 1-2 seconds before the start of the audio stream and continued for 5 seconds following the end of the audio stream. Letters in the RSVP stream were displayed for 50 msec with an interstimulus interval (ISI) of 100 msec. The sequence of letters was determined randomly with the condition that the same letter would not appear twice in a row. Because of the varying lengths of jokes, there was no standard number of letters in each RSVP stream as the number of letters in each RSVP stream was calculated individually for each trial taking into account the random 1-2 seconds before the audio, the audio stream length, and the 5 seconds of continued stream following the end of the audio.

Target stimulus condition was determined randomly such that there were never more than 4 trials in a row from one condition. Of these 51 trials, roughly 50% featured the target letter appearing during the processing of the punch-line according to each joke’s unique get-it time, and roughly 50% occurred 3 seconds after the audio stream was complete. Target stimulus condition was not split exactly evenly between each condition due to each session having 51 total trials overall. Thus participants received 26 trials of one target stimulus condition and 25 trials of the other. It was equally balanced as to how many participants received one condition.
more than the other. The first 5 trials of each session were considered practice leaving 46 experimental trials. Analyses include only experimental trials.

Depending on trial condition, the RSVP target in each trial appeared either 3 seconds following the end of the audio or at a unique time based on each joke’s “get-it” time. After reading in the “get-it” time for each joke, target times were determined by placing the target 1 second prior to each joke’s “get-it” time. This 1 second adjustment served to place the target during the time of actual punch-line processing as the “get-it” times on their own would include punch-line processing plus time for response execution. With the adjustment, the unique target times ranged from 500 msec before the end of the audio stream to 1500 msec after the end of the audio stream. The order of jokes was randomized for each participant.

Figure 1. Schematic of the procedure for each trial in Experiment 2.

Procedure. Before beginning participants were given verbal instructions explaining the task and how to respond. Participants were told to pay equal attention to both the RSVP task and the audio stream as they would have to not only respond to the RSVP task, but also recall jokes from memory on a random subset of trials. Participants were instructed to monitor the RSVP stream for a gray letter in a stream of black letters and to press the spacebar as quickly as
possible upon detecting the target letter. Participants were also instructed to hold in memory the identity of the letter to report at the end of each trial. Following each trial, participants reported the identity of the target letter via the keyboard and gave a rating (1 to 5) of how funny they found each joke. On 5 random trials throughout the experiment participants were asked to record the previous joke to the best of their memory on a sheet of paper provided by the experimenter (mean # of trials in between recall trials = 10).

3.1.2. Experiment 1 Results and Discussion

Participants were slower to respond to target stimuli in the RSVP task if the target appeared during the time when it was probable that they were still processing the punch-line of the joke compared to targets that appeared when punch-line processing was likely finished. Reaction times for target detection were significantly slower when the target letter appeared 1 second before each joke’s unique “get-it” time (M = 521.76, SD = 75.44, 95% CI [475, 569]) compared to when the target letter appeared 3 seconds after (M = 471.66, SD = 65.35, 95% CI [431, 512]), t(9) = 4.51, p = .001. No differences were observed in the accuracy of reporting the identity of the target letter when the target appeared 3 seconds following the end of the joke (M = .92, SD = .09, 95% CI [.86, .98]) versus during the punch-line processing time (M = .90, SD = .08, 95% CI [.85, .95]), t(9) = -.872, p = .406.
Chapter 4: Section 2 Discussion

Experiment 1 provides initial evidence for attentional disruption, either to target processing or response, as a result of punch-line processing. Contrary to what was predicted, the current study fails to provide evidence for a clear “blink” caused by the processing of a joke’s punch-line. Target identification accuracy was high and did not substantially differ between the two RSVP target time conditions. Given the variability of the unique target times for each audio clip, one concern might be that the observed slowing of response was simply due to the dual-task cost of having to respond while still actively listening to the “one-liner” joke. This is unlikely given that, in the condition placing the target 1 second before the unique “get-it time”, only 7 out of the 51 unique target times placed the RSVP target at a time when the audio stream was still
ongoing. While not showing strong evidence for a complete freezing or “blinking” of attention during punch-line processing, which would have confirmed the intuition of magicians, the present data do suggest that there is some form of disruption to target processing or response execution.

The data indicate that attention does not completely disengage from the external world when processing the punch-line or experiencing the mirth associated with joke comprehension. Nonetheless, the results suggest that there is some disruption to target detection or response execution manifesting in slower reaction times immediately following the punchline of a joke. As stated above, this impairment is unlikely to arise strictly due to dual-task demands, as all but 7 of the unique target times during punch-line processing occurred after the audio stream was finished. Thus, for all but 7 of the jokes, if the target letter appeared during the unique “get-it” time, there was significant disruption, even in the absence of any ongoing auditory information.

One critical limitation of Experiment 1 is that there was not a condition in which participants were tasked with detecting targets following non-humorous stimuli. It is thus premature to make any strong claims about the unique ability for jokes to capture internal attention above and beyond non-humorous information. The possibility remains that following any meaningful utterance, there is a point in time when individuals are finishing up comprehension processes and that this process is thus not unique to humor processing. While this might not implicate jokes as a special case of internal attention capturing stimuli, it nonetheless does imply that ongoing processing of utterances, an undeniably internal activity, can indeed draw attention away from an external task. Experiment 1 opens the door to the possibility that the internal processing of unrelated verbal information can disrupt, or at least delay, execution of primary task responses, even when the secondary task no longer requires sustained externally directed attention.

The nature of the stimuli and methodology utilized in Experiment 1 bring up a couple of issues. First, individuals are highly variable in not only their sense of humor, but how quickly they are able to “get” jokes. The logic and success of Experiment 1 relied on placing the visual target within the period of time when an individual was “getting” each joke. It is during this time that I predicted attention to be maximally focused internally, drawing limited attentional resources away from the visual task. Without a clear way to establish participant-specific “get-
it” times for each joke, I relied instead on the average “get-it” time of a set of pilot participants. As a result, any observed effects were unlikely to be fully representative of the impact of internal processing. It is possible that a stronger effect would be observed if there was a way to individualize “get-it” times such that the target could be dynamically placed during each joke’s specific time of punch-line processing for each individual. A second methodological issue is that, in the present design, the control targets (targets placed at a time not during punch-line processing) always appeared 3 seconds after the end of the joke. It is likely that participants realized that there would always be one target per trial and as each trial advanced in time, the probability of a target appearing increased. The RT difference for targets appearing during each joke’s “get-it” time versus after jokes were finished could partially stem from anticipatory RT speeding for targets appearing later in the stream. To more effectively make claims about the disruptive nature of punchline processing, a second control condition could place targets before punch-line processing during the set-up of a joke, and compare RT’s across all 3 conditions. However this control condition would introduce the possibility of dual-task RT slowing for the targets appearing during joke set-up. Another, potentially more effective control, would only have targets appear on some of the trials, thus eliminating the anticipation and predictive nature of a target always being presented each trial.

More importantly, the ultimate goal is to explore the interplay between internal and external attention, specifically identifying the factors that may influence or draw attention inward. To this end, jokes are not necessarily the most ideal stimuli as they are sneakily complex. As discussed above, a joke has several components that could potentially impact attention. First, jokes are often surprising as the information an individual is presented with is in some way unexpected or incongruous. An individual’s semantic evaluation and subsequent recognition of abnormality could draw attention inward. Second, following the recognition that current information is surprising or incongruent, jokes often require an individual to reinterpret the context leading up to the punch-line. This process of reanalyzing and reestablishing the semantic context, an inherently internal process, may be attentionally demanding enough to shift the balance of attention between internal and external sources resulting in visual task deficits. Third, a joke, by definition, is humorous and with humor comes positive emotions. As has been discussed above, emotionally arousing information and stimuli are often afforded special status due to their semantic salience. The inability to inhibit or attentionally disengage from emotional
information may impact the effective control of attention, skewing the distribution of attention inwardly resulting in impairments to tasks requiring the allocation of attention elsewhere, namely to external stimulus recognition and response execution processes.

Finally, the predictability of the task in Experiment 1 may have allowed participants to adopt a strategy in which they were able to shift attention to the visual task at the end of each joke, effectively mitigating any observable effects. In Experiment 1, visual targets always occurred toward (and for all but 7 jokes, after) the end of each joke. It is likely that participants figured out this pattern and could dynamically shift attention away from the auditory stream in order to more closely monitor the RSVP stream. If this was the case, then it is impressive that any effects were observed at all given the suspected transience of the effect. In moving forward, it was necessary to formulate a more continuous and unpredictable task that would not allow participants to strategically shift attention according to the task dynamics.
SECTION 3: CATEGORY VIOLATION

Chapter 5: Category Violation Introduction

Experiment 1 established that the processing of humorous verbal information can disrupt the performance of a secondary unrelated visual attention task. While a complete disengagement of attention from external sources resulting in stimulus detection failures was not observed, there were clear effects on individuals’ ability to manage attention effectively resulting in slowed responses to visual targets.

The experiments in Section 2 attempt to address the concerns discussed above by employing a simpler, more controlled auditory task in conjunction with a continuous and unpredictable visual task. The continuous nature of the visual task was designed to be more sensitive to subtle disruptions to external attention caused by internal processing of information. Additionally, since the ultimate goal is not to understand joke processing per se, but rather the factors that influence internally directed attention, Experiments 2 and 3 each look at one isolated aspect of joke processing.

Section 2 specifically examines the impact of the presentation of semantically inconsistent information on a simultaneous visual attention task. To this end, the auditory stimuli were changed away from meaningful and coherent utterances in favor of lists of serially presented words. Each list of words consisted of 10 words, 9 from the same general category (e.g. “vegetables”) and one word that did not fit the current category. This methodology sought to eliminate some of the individual variability associated with comprehending meaningful utterances while maintaining a semantic context that could be violated. Additionally, as the lists did not combine into meaningful statements, they were bereft of any overarching meaning in need of reinterpretation and lacking most, if not all, emotionality. It was assumed that individuals would, on some level, recognize the semantic relationship between words leading them to subsequently notice the anomalous category-inconsistent word. If the recognition that a semantic context has been violated can capture, or at least disrupt, attention internally then performance in a visual task should suffer when events within the visual task temporally coincide with the presentation of a category-inconsistent word.

5.1. Experiment Chronology
Before moving on, it is necessary to make a quick note about experiment chronology. Experiments from here forward are organized conceptually, but not in the order in which they were carried out. Specifically, Experiment 3 was the last study that was done chronologically, but it is conceptually related to Experiment 2. The results of Experiments 4-6 helped to refine the methodology such that I was able to effectively test the impact of being presented with a category-inconsistent word with task parameters that were proven to be sensitive to the effects of another class of critical word stimuli. All of the experiments discussed below built on each other conceptually, as well as followed one another chronologically.

5.2. Stimulus Development

Categories and words for each category were drawn both from the updated list of category word norms in Van Overschelde, Rawson, & Dunlosky (2004) as well as from new category lists compiled by the author and research assistants. This resulted in a total of 665 words, all with a spoken length range of 383-1057 msec (mean: 666.51 msec). Individual audio files were created for each word and were recorded by the author using Audacity (http://audacity.sourceforge.net/) at the same volume in an even, monotone voice.

Eleven words from each category were selected for use in creating lists of words for each trial. One word was picked from each category to use as a foil word to present later during a 2-alternative forced choice section of each trial (described below). This foil word was from the same category but never heard by participants and was hardcoded into each list such that it was the same for each participant. Each list of category words was randomly matched with another list and one word from each was swapped with its partner list to provide each list with one word that was category-inconsistent. For example, the “tools” list would swap a word with “cities” such that the name of a city will be presented amongst a list of tools and the name of a tool would be presented amongst a list of cities. This resulted in lists being 10 words long, 9 of which came from the same category and 1 which was category-inconsistent. Category-inconsistent words were always either in the 4th or 8th position within the list. Given that the category-inconsistent word always appeared in the 4th or 8th position, two different versions of each list were created. One version placed the swapped word as the 4th word and the other version placed the swapped word 8th.
5.3. General Section 3 Methods

**Equipment and Software.** All equipment and software were identical to that which was used in Section 2. Additionally, participants were required to use a chinrest during the experiment in order to minimize head movements and to maintain a consistent viewing distance. Participants were placed at a viewing distance of 60 cm which resulted in the screen subtending 41.5° of visual angle horizontally and 26.6° degrees of visual angle vertically. Participants were also required to wear headphones throughout the experiment.

Statistical analyses were performed using SPSS Version 22.0 and power analyses were performed using the free software GPower Version 3.1 (http://www.gpower.hhu.de/en.html).

**Participants.** Restrictions and inclusion criteria for participation were the same as in Section 2.

**Chapter 6: Experiment 2**

Experiment 2 assessed the impact of semantic category violation on a concurrent visual attention task. Lists of category related words were presented auditorily one at a time, with one of the words in the stream being a word from outside the current category. Serially presented lists of single words were chosen as auditory stimuli to eliminate the need for sentence processing and whole verbal sequence integration. This was done in order to look at just the effects of semantic context violation without the added effect of context reinterpretation or reanalysis. The concurrent visual task was designed to require participants to simply detect the presence of targets without making stimulus judgments. A detection task was chosen in order to evaluate if the presentation of a semantic anomaly could reduce the detection of a stimulus or impact simple response execution.

**6.1. Experiment 2 Methods**

**Participants.** Twenty-four undergraduates from the University of Illinois participated in Experiment 2 (9 females, 15 males; mean age: 18.9 years). Data from 1 participant was not used due to misunderstanding of the experiment instructions.
**Task Design.** The main paradigm was a dual-task design consisting of a visual task on a computer screen in conjunction with a secondary task requiring participants to listen to and remember a stream of category-related words presented auditorily. Each trial ended with a 2-alternative forced choice (2AFC) judgment asking individuals to choose which of two words they had heard on that trial. The 2AFC portion of each trial was included to motivate participants to attend to the auditory stream instead of attending only to the visual task. The critical measure of interest was detection accuracy and response times to targets lines immediately following category consistent vs. category-inconsistent words within the stream of auditory words. Each session consisted of 56 trials, with 1 trial of practice at the beginning.

**Visual Attention Task.** Participants were instructed to monitor visual stimuli appearing one at a time at the center of a computer screen, and to indicate by key press (spacebar) when they detected target stimuli. Visual stimuli were gray vertical lines (RGB value = [100, 100, 100]) presented against a black background with target stimuli being slightly shorter vertical lines. Non-target and target visual stimuli were 2.7 cm (2.58º of visual angle) and 2.0 cm (1.91º of visual angle) respectively. Participants were told to press the spacebar as quickly as they could after detecting the shorter target lines. Stimuli appeared 1100 msec after the onset of each word in the auditory list and would remain onscreen for 150 msec. Following the presentation of visual targets, participants had an 1150 msec window in which to respond. Responses that fall outside of this 1150 msec window were recorded as misses. Targets always appeared after either the 4th or 8th word in the auditory series and only 1 target was presented per trial.

**Auditory Word Task.** Participants were instructed that on each trial they were to listen and pay attention to a series of words being presented one at a time auditorily through the headphones while simultaneously engaged in the visual attention task described above. Each trial consisted of a list of 10 words presented at a rate of one word every 1500 msec. Following each trial, participants were presented with a two-alternative forced choice (2AFC) recognition task to choose which of two words presented on screen they heard on a given trial.

**2-Alternative Forced Choice Recognition.** At the 2AFC stage, participants were presented two words on screen, one on the left and one on the right. One of the words would be
a word from the list they had heard (never the 4th or 8th word to prevent category-inconsistent words bring presented during 2AFC) and one of the words would be a category-consistent foil word that had not been heard. The foil word for each category list was determined ahead of time and hardcoded such that it was the same for each participant. Individuals were told to indicate by key press (“left arrow” for the word on the left and “right arrow” for the word on the right) which word they heard on that trial. Position (left/right) of foil word vs. target word was determined randomly on each trial. After choosing the left or the right word, the trial ended and the next trial began. Responses in the 2AFC portion of the task were not speeded and there was no time limit for responding.

**Trial Design.** As outlined in the “stimulus development” section above, two different versions of each list were created, one with the category-inconsistent word in the 4th position and one with the category-inconsistent word in the 8th position. Additionally, for each of these two versions, a version of each was created where the visual change occurred after the 4th or 8th word. This resulted in 4 versions of each list, with the timing of the presentation of the target stimulus (1100 msec after the 4th or 8th word in the list) and serial position of category-inconsistent word (4th or 8th word) fully crossed. The different versions of each list were compiled into four sets of lists such that there was an equal number of each trial type in each set (trial types described below). A version of the experiment was created for each list that differed from the other versions only in which set of lists was used in trials. Following is a breakdown of the different types of trials and the number of each type of trial encountered. “Critical” trials are indicated with an “*” as those are the trials of primary interest where the visual target appeared immediately following the presentation of a category-inconsistent word.

- Category inconsistent word 4th – Target after 4th word → 14 trials*
- Category inconsistent word 4th – Target after 8th word → 14 trials
- Category inconsistent word 8th – Target after 4th word → 14 trials
- Category inconsistent word 8th – Target after 8th word → 14 trials*

Trial/list order was randomly determined at the beginning for each participant. An equal number of participants were run in each of the 4 versions of the experiment.
### 6.2. Experiment 2 Results and Discussion

Response time (RT) results will be presented in milliseconds (msec) and accuracy results, both visual target accuracy and 2AFC accuracy, will be reported as proportion correct. “Critical trials” will refer to trials in which the visual target appeared immediately following a category-inconsistent word in the stream of auditory stimuli. “Non-critical” trials will refer to trials when the target appeared following a category-consistent word.

**Visual Target Response Times.** Experiment 2 required participants to simply press a key in response to a target on screen. All response times reflect only the time it took participants to detect the presence of a target and execute a response. Response times to visual targets were extremely similar for critical trials (M = 529, SD = 63; 95% CI [504, 554]) and non-critical trials (M = 523, SD = 56; 95% CI [500, 545]) suggesting no differential processing or attentional disruption as a result of being presented with a semantically incongruous word. It is possible that any effect would be stronger for targets in the 8\textsuperscript{th} position than the 4\textsuperscript{th}, as the semantic context and category would be more established after hearing 7 category-related words than 3 and so each target position was looked at individually. The pattern of similar response times for critical and non-critical trials extended to analyses of each target position (after the 4\textsuperscript{th} or 8\textsuperscript{th} word) with RTs being roughly equivalent between position 4 critical (M = 563, SD = 66; 95% CI [536, 589]) and non-critical trials (M = 551, SD = 60; 95% CI [527, 575]) and position 8 critical (M = 495, SD = 70; 95% CI [467, 524]) and non-critical trials (M = 497, SD = 70; 95% CI [469, 525]). These results reinforce that there was no effect of hearing a category-inconsistent word on participants’ ability to detect and execute a response to visual targets. Though the effect of semantically incongruous words did not seem to have an effect, the response times for all targets in the 4\textsuperscript{th} position, both critical and non-critical, were slower (M = 557, SD = 59; 95% CI [533, 580]) than response times to targets in the 8\textsuperscript{th} position (M = 496, SD = 57; 95% CI [473, 519]) which was statistically significant, t(23) = 8.61, p < .001. Given there was only one target per trial, participants were likely anticipating the presence of a target more when it occurred later in the trial, thus leading to faster RTs.
Visual Target Accuracy. As the current visual task only requires detection, accuracy represents whether participants responded to a target or not, without any response selection. Detection accuracy was higher in critical trials ($M = .95$, $SD = .05$; 95% CI [.93, .97]) than in non-critical trials ($M = .89$, $SD = .09$; 95% CI [.86, .93]), $t(23) = -3.44$, $p = .002$. This significant pattern appears to have been largely driven by the disparity in detection accuracy between critical and non-critical trials in the 4th position. Participants were 10% less likely to detect targets in non-critical trials in the 4th position ($M = .86$, $SD = .14$; 95% CI [.81, .92]) than in critical trials ($M = .96$, $SD = .06$; 95% CI [.93, .98]), $t(23) = 3.02$, $p = .006$. A similar, but non-significant, trend was also seen for critical ($M = .95$, $SD = .07$; 95% CI [.92, .98]) vs. non-critical ($M = .93$, $SD = .09$; 95% CI [.89, .96]) trials in the 8th position. One possibility, is that hearing a semantically inconsistent word acts to alert rather than disrupt attention. If processing a category-inconsistent word does not require, or capture, additional attentional processing then it may not disrupt or shift the balance of attention but rather temporarily heighten attention. An alerting effect in critical trials could manifest only in an increase in detection accuracy and not RTs if, when participants do detect the visual targets, they are able to respond equally fast and the alerting serves only to reduce target misses. Slightly better performance was also seen for 8th position targets as participants were also significantly more likely to detect targets in the 8th position compared to the 4th position collapsing across critical and non-critical trials, $t(23) = -2.05$, $p = .05$. This could be due to the same kind of anticipatory effect discussed for RTs in the above paragraph. A combination of alerting on critical trials and an anticipation effect for targets in the 8th position could explain why accuracy was the lowest for non-critical trial targets in the 4th position, as these were targets that received neither benefit.
Figure 4. Experiment 2 Accuracy Results. (Difference = Crit – Non-Crit)

2-Alternative Forced Choice Accuracy. Participants were generally very accurate in reporting the correct word at the 2AFC stage of each trial. No participant was less than 65% accurate and mean accuracy was 86% (SD = 6%) indicating that participants were indeed paying attention to the stream of auditory words.

Chapter 7: Experiment 3

Experiment 3 built on the findings of Experiment 2 by introducing a more difficult visual task. The auditory task in Experiment 3 was identical to that which was used in Experiment 2. As mentioned in the section above outlining experiment chronology, Experiment 3 was the last experiment conducted and was informed by the results of the experiments in Section 4. The visual task adopted in Experiment 3 is identical to the task used in Experiments 5 and 6 and differs from Experiment 2 in that it requires not only the detection of a visual target, but also target evaluation and correct response selection. Instead of simply detecting targets, participants had to detect visual stimulus changes and then report which of two changes occurred. The goal in introducing a more difficult task requiring correct response selection was to not only increase overall attentional load, but also assess if the impact of recognizing semantic incongruity impacts later stages in task performance responsible for accessing current task rules and response selection.

7.1. Experiment 3 Methods

Experiment 3 was registered on Open Science Framework (https://osf.io/). The planned sample, data exclusion criteria, general methods, analysis plan, stimulus lists, and experiment code were registered and posted online before any data were viewed.
Participants. Target sample size was N=36. Additional participants were run (to make up for unusable data) in groups of up to 3, with the understanding that if all additional participants’ data were usable then sample size could exceed N=36. Data from 39 undergraduates from the University of Illinois were included in analyses for Experiment 3 (16 females, 23 males; mean age: 19.4 years). Data from 3 participants were not used due to an extremely high miss rate in the visual attention task. Data exclusion criteria are specified below.

Planned Sample. An a priori power analysis was conducted using the free software GPower Version 3.1 to determine an adequate sample size for a matched pairs t-test (GPower (Version 3.1): t-test – Means: Difference between two dependent means (matched pairs)). Analysis of data from a similar task (Experiment 6 discussed later; reasoning and description of experiment chronology described above) yielded an effect size of $d = .601$ for the measure of most interest (response times to visual target changes occurring with critical vs. non-critical words), so a more conservative power analysis was run assuming a $d = .50$. For 80% power using a two-tailed test with $\alpha = .05$, a sample size of N=34 was required.

Data Exclusion Criteria. Participant data could have been deemed unusable for the following reasons:

- extremely poor task performance ( >50% miss rate in the visual attention task across all trials or 2AFC accuracy <= 60%)
- previous participation in prior versions of the task
- blatant disregard for or misunderstanding of experiment instructions
- failure to fully complete the study
- experimenter error
- equipment troubles

Task Design. The main paradigm was a dual-task design similar to Experiment 2, but with modifications made to the visual attention task. Experiment 3 required participants to constantly monitor a visual stimulus on a computer screen and report which of two possible changes were made to that stimulus. Individuals were also engaged in a secondary auditory task. As in Experiment 2, the critical measures of interest were response times and detection accuracy.
of visual targets as they occurred coincident with the auditory presentation of category consistent vs. category-inconsistent auditory words. Each session consisted of 56 trials, with 1 trial of practice at the beginning. Auditory word task was identical to Experiment 2 and the only main change to the visual attention task was that there was not a separate stimulus presented with each word but rather a constantly visible stimulus that would change length once per trial. As in Experiment 2, each trial included a 2AFC stage at the end of each trial which was identical to Experiment 2.

**Visual Attention Task.** Participants were instructed to monitor a vertical gray line (RGB value = \([100, 100, 100]\)) presented at the center of a computer screen on a black background, and to indicate by key press when they detected a change in the length of the line. The vertical line started at a length of 2.8 cm (2.67º of visual angle) and was continuously visible on screen. Once per trial the vertical line would change to be either 4% shorter (2.7 cm; 2.58º of visual angle) or 4% longer (2.9 cm, 2.77 º of visual angle). Instructions were to press the “down” arrow key if they noticed the line change to be shorter and press the “up” arrow key if they noticed the line change to be longer. Line changes were timed to occur 400 msec following the onset of the 4th word on ½ the trials and 400 msec following the onset of the 8th word on ½ the trials. Following the line change, participants had a 2000 msec window in which to respond. Responses that fell outside of this 2000 msec window were recorded as misses.

**Trial Design.** The same word lists (described above) were used in Experiment 3 as in Experiment 2. Four versions of Experiment 3 were created, 1 for each set of word lists. Visual stimulus change timing (400 msec after the 4th or 8th word) and serial position of category-inconsistent word (4th or 8th word) were fully crossed and each set of lists was compiled such that there was an even number of each trial type in each version of the experiment, shown below. “Critical” trials are indicated with an “*” as those were the trials of primary interest where the visual stimulus change occurred with the presentation of a category-inconsistent word.

- Category inconsistent word 4th – visual stimulus change with 4th word \(\rightarrow\) 14 trials*
- Category inconsistent word 4th – visual stimulus change with 8th word \(\rightarrow\) 14 trials
- Category inconsistent word 8th – visual stimulus change with 4th word \(\rightarrow\) 14 trials
Trial/list order was randomly determined at the beginning for each participant. Ten participants were run on version 1 of Experiment 3, 11 participants in version 2, 9 participants in version 3, and 9 participants in version 4. This unequal number of participants in each version was unavoidable due to the exclusion of unusable participant data as well as restricted participant availability.

### 7.2. Experiment 3 Results and Discussion

**Visual Target Response Times.** In Experiment 3, participants were required to not only detect a target visual stimulus, but then indicate which of two changes occurred to that stimulus by making one of two responses. The response times discussed below reflect only RTs to correct trials. Average response times to targets in critical trials (M = 676, SD = 92; 95% CI [647, 705]) and non-critical trials (M = 678, SD = 94; 95% CI [649,708]) were slower than in Experiment 2, but still extremely similar. As in Experiment 2, there were no differences between critical and non-critical trials at either target position. Experiment 3 extends the lack of an RT effect for critical vs. non-critical trials to include situations where more than a simple response to a target is necessary. Experiment 3 required participants to not only detect a change to a visual stimulus, but also select the correct response to that change. Correctly responding requires detection, a decision, and the maintenance of task rules to guide response execution. In the current task, this process was able to proceed just as quickly when individuals had just been presented with categorically consistent or inconsistent information suggesting no differential distribution or allocation of attention. As in Experiment 2, there was a trend for slower response times when the visual target followed the 4th word (M = 691, SD = 100; 95% CI [659, 722]) than when the target followed the 8th word (M = 665, SD = 100; 95% CI [634, 697]) but this difference was only marginally significant, t(38) = 1.83, p = .07. This more subtle trend could be indicative of the same anticipatory effect described above, giving a slight attentional edge to targets in the 8th position, with the increased task difficulty and requirement for a choice response mitigating this benefit.
Visual Target Accuracy. Participants were marginally more accurate in reporting the visual target change in critical trials (M = .76, SD = .13; 95% CI [.72, .80]) than in non-critical trials (M = .74, SD = .13; 95% CI [.70, .78]), t(38) = -1.93, p = .06. No significant differences were observed for accuracy in visual target detection when looking separately at critical trial vs. non-critical trial responses to targets in the 4th or 8th position, though as in Experiment 2, the lowest accuracy was observed in non-critical trials with the target in the 4th position, as can be seen below. It was suggested in the discussion of Experiment 2 that an increase in accuracy performance for targets in critical trials could result from the presentation of semantically inconsistent information serving to alert the attentional system or jolt it into readiness. Though not as pronounced as in Experiment 2, the same trend is present in Experiment 3. The smaller effect could be attributable to the timing of the visual events. In Experiment 2, the target appeared 1100 msec after auditory word onset potentially allowing an alerting effect to fully take hold. In Experiment 3, the visual stimulus changed 400 msec following auditory word onset, so any alerting effect of recognizing semantic inconsistency might have still been in the process of manifesting. Collapsing across critical and non-critical trials, participants were slightly more accurate in reporting target changes when the target was in the 8th position (M = .76, SD = .12; 95% CI [.72, .80]) than when the target was in the 4th position (M = .74, SD = .15; 95% CI [.69, .78]) though this difference was not significant, t(38) = -1.17, p = .25. As in Experiment 2, the anticipation of a target toward the end of trial might have provided the slight benefit for accuracy in detecting targets in the 8th position in Experiment 3 as well. As mentioned above, the lowest accuracy for any trial type was observed for non-critical targets in the 4th position, which could again be explained by the absence of either a critical word alerting effect or an end of trial preparatory effect.
Figure 6. Experiment 3 Accuracy Results. (Difference = Crit – Non-Crit)

2-Alternative Forced Choice Accuracy. Participants were very accurate in reporting the correct word at the 2AFC stage of each trial with no participant having lower than 75% accuracy overall. Mean accuracy was 87% (SD = .06; 95% CI [.86, .89]). There were no major differences in 2AFC accuracy for non-critical vs. critical trials (M= .88, SD = .08 and M = .87, SD = .07 respectively).

Chapter 8: Section 3 Discussion

Section 3 sought to evaluate if internal attentional processing of auditory information, and the recognition that the current semantic context has been violated, can capture attention internally or otherwise disrupt attention such that performance of a secondary visual task is impaired. To this end, I presented individuals with a series of categorically related words, placing a category-inconsistent word either early or late in this series and looked at visual task performance when critical visual events did or did not coincide with category-inconsistent information. In Experiment 2 there was no observable impact of semantically inconsistent information on the speed with which individuals could detect the presence of a target and execute a simple response. These results were extended in Experiment 3 to show that participants were equally fast to not only detect, but select a correct response when targets were presented with category-consistent or category-inconsistent information. Assuming attention is distributed between the external task and the internal processing of words, detrimental effects to visual task performance would arise if an appreciable amount of attention was taken away from the visual task or attentional processes were disrupted in favor of internally directed processing. In the current tasks, there is no evidence for a disruption or capturing of attention by internal processes related to hearing semantically inconsistent information. On the contrary, the only observed difference between critical and non-critical trials manifested in a slight benefit to the
accuracy of detecting visual targets in critical trials. This is likely due to the internal recognition of semantically incongruous information, without the need for reinterpretation, serving to alert or bring the attentional system to state of readiness. This trend was more pronounced in Experiment 2, most likely due to the increased latency between word onset and visual target presentation for Experiment 2 compared to Experiment 3. If the recognition of semantically inconsistent information does provide a kind of alerting function, this might take some amount of time to fully manifest. The shorter latency between word onset and visual stimulus onset may have only allowed the alerting function to partially take hold. Another possibility is that the alerting or orienting provided by the semantically inconsistent information benefits the kind of simple detection required in Experiment 2 more so than it does target processing and response selection required in Experiment 3. Importantly, in the current contexts, semantically inconsistent information in a non-sentential context did not disrupt attention.

One issue with the current design that may have reduced any potential effect stems from the exclusion of the category inconsistent words from the 2AFC stage of each trial. While my intention was for semantically inconsistent words to disrupt attention, excluding these words from the 2AFC portion of each trial may have led individuals to realize that they could ignore words that did not fit the category, as they would never be tested later. If this were the case, then targets appearing immediately after category-consistent words may actually receive less attention as individuals would be encoding the previously heard word into memory. This could partially account for the slight accuracy benefit for critical trial targets. However, the absence of an effect on RTs between critical and non-critical trials casts doubt on the presence of an attentional strategy of ignoring category-inconsistent words, as the effect would likely be expected to manifest in RTs as well if that were the case.

Finally, it could be that violation of a stronger semantic context, or the act of reinterpretation and reanalysis in the face of incongruous information may serve to more strongly disrupt externally directed attention, or require more attentional resources leading to bigger visual task detriments. The current studies suggest that semantically inconsistent information doesn’t necessarily disrupt attention. However, there are many levels and forms of semantic inconsistency and the potential effects these might have on attention remain open questions to be explored.
SECTION 4: TABOO WORDS

Chapter 9: Taboo Words Introduction

In Section 4 I discuss another approach attempting to isolate and identify factors that may influence the distribution of attention between internal and external sources. As was discussed in Section 3, jokes and humorous stimuli provided a convenient paradigmatic springboard for identifying potential mechanisms influencing the shifting of attention to internal processing of information. Section 3 specifically examined how the recognition of semantically incongruent information might draw attention inwardly to the detriment of attention to the external environment. Importantly, this was not done in meaningful utterances and statements, but in semantically related lists lacking a meaning above and beyond their categorical relatedness.

The experiments in Section 4 use a similar methodology to examine the attentional impact of surprising emotional information without overarching sentential meaning or semantic context. The studies in Section 4 presented participants with serially presented lists of words coupled with a visual attention task, though unlike Section 3, the auditory lists in the following experiments were not categorically related, but seemingly random. Category-inconsistent critical words were replaced by a set of words that were impactful due to their arousal value and distinctiveness rather than semantic inconsistency. Drawing from previous studies showing that the arousal value a stimulus, as opposed to valence, is predictive of attentional impact (Anderson, 2005), the goal was to find a set of extremely arousing verbal stimuli. Taboo words provide a convenient set of words that are almost universally highly arousing and emotionally impactful. The goal of Section 4 was to look in isolation at the impact of emotional information, distinct from the processing associated with semantic violation and contextual reinterpretation characteristic of jokes.

One could argue that taboo words are still semantically incongruent in the current context and thus the following experiments are not fully distinct from those in Section 3. I would argue that while it is undeniable that taboo words are often surprising, their incongruous nature is inherently tied to the semantics of the individual taboo words and not the current context of the list as a whole. Thus, the unexpectedness is more tied to the social inappropriateness, meaning, and emotionality attached to the words themselves, which is what I was interested in. As such,
the experiments in Section 4 specifically examined the impact of taboo words within a stream of neutral words in order to assess if the emotional arousal associated with taboo words was able to capture or disrupt attention internally in such a way that external task performance was impaired.

9.1. Stimulus Development

Word stimuli for the studies in Section 4 fall into two distinct categories: neutral words and taboo words. Neutral words for each experiment and pilot study were drawn from the pool of various category words used in the category violation experiments discussed in Section 3. A set of taboo words was compiled, a subset of which were drawn from Anderson (2005), and supplemented by words thought of by the author. Taboo words, as with the category related words described in Section 3, were recorded individually by the author using Audacity (http://audacity.sourceforge.net/) and were recorded at the same volume in an even, monotone voice.

Pilot Studies. For the pilot studies, all of the available category words were used with the exception of any words judged by the author to be potentially arousing. The resulting list was a pool of 632 words from various categories. A preliminary list of 22 taboo words was used in the pilot studies.

Experiments 4, 5, and 6. For experiments 4, 5, and 6 the pool of category words was trimmed down to ensure that all words presented were of comparable spoken length. All neutral words with a spoken length 1 standard deviation longer than the longest taboo word were taken out of the pool. This resulted in a set of 580 non-taboo words. Taboo words in Experiments 4, 5, and 6 were largely the same as in the pilot studies with some new taboo words added and some of the original taboo words removed in an attempt to maximize the arousal value of the words. The resulting list was a set of 28 taboo words.

9.2. General Section 4 Methods

Equipment, Software, and Participants. All equipment and software for the pilot studies and experiments in Section 4 were identical to those discussed in Section 3 unless otherwise stated. Participant restrictions and inclusion criteria were the same as in Sections 2 and 3.
Chapter 10: Taboo Word Pilot Studies

The two pilot studies discussed below were exploratory and performed to assess the impact of taboo words on a concurrent visual task with similar task parameters as Experiment 2. The auditory task was the same basic set-up as Experiments 2 and 3, shifting instead to lists of neutral words without a semantic relationship punctuated by taboo words as critical words instead of category inconsistent words. The visual task used essentially the same methodology as Experiment 2 with only slight alterations made to the timing of the visual targets. These initial studies examined if taboo word processing would negatively impact simple visual target detection and response execution. The results of the data obtained in the taboo pilot studies motivated a shift in methodology for subsequent studies.

10.1. Taboo Pilot Studies 1 and 2 Methods

Participants. Six University of Illinois undergraduate students participated in taboo pilot study 1 (4 females, 2 males; mean age: 18.5 years) and 4 University of Illinois undergraduate students participated in taboo pilot study 2 (2 females, 2 males; mean age: 19.0 years).

Task Design. Taboo pilot study 1 and taboo pilot study 2 utilized the same basic methodology as Experiment 2 described in Section 3. Using a dual-task paradigm participants were required to monitor a series of gray vertical lines appearing on screen for shorter, target lines. The visual attention task was nearly the same as in Experiment 2. Gray vertical lines (RGB value = [100, 100, 100]) would appear briefly onscreen against a black background and participants were instructed to respond (by pressing the spacebar) to shorter, target lines. The only difference for the taboo pilot studies was that the visual stimuli were only present onscreen for 100 msec. Targets always occurred after the 4th or 8th word in the list.

For taboo pilot study 1, stimuli appeared 1100 msec after the onset of each word. For taboo pilot study 2 stimuli appeared right at the end of each word (variable time after word onset due to differences in spoken length).
Following the presentation of visual targets, participants had a 1100 msec window in which to respond. Responses that fell outside of the 1100 msec window were recorded as misses. Only 1 target was presented per trial.

**Auditory Word Task.** Participants were instructed that on each trial they were to listen and pay attention to a series of words being presented one at a time auditorily through the headphones while also engaged in the visual attention task. Each trial consisted of a series of 10 words presented at a rate of one word every 1500 msec. At the start of each session, the pool of 632 neutral words was scrambled and the first 600 words of this scrambled list were used, in sets of 10, for each trial. This resulted in 60 trials each composed of 10 random words from the overall set, 9 of which would be heard during the trial and 1 that would be used during the 2AFC portion as a foil word. Three separately scrambled lists of the 22 taboo words were combined into a larger list of 66 taboo words such that no word was repeated twice in a row. The first 60 of these were used in trials such that some of the taboo words were repeated twice and some three times over the course of the session. During each trial participants would hear 9 neutral words from various categories and 1 taboo word as either the 4th or 8th word of the list.

**2-Alternative Forced Choice Recognition.** Following each trial, participants were presented with a two-alternative forced choice (2AFC) recognition task to choose which of two words presented on screen they had heard on a given trial. As in Experiment 2, one of the words was a random word from the trial (never the 4th or 8th word to prevent taboo words being presented during 2AFC) and one of the words was a random word selected from the overall pool of category words. The foil words for each trial were determined at the beginning of each session and would not be heard as an auditory stimulus in any other trial during the experiment. Individuals were told to indicate by key press (“left arrow” for the word on the left and “right arrow” for the word on the right) which word they heard on that trial. Position (left/right) of foil word vs. target word was determined randomly on each trial. After choosing the left or the right word, the trial ended and the next trial began. Responses in the 2AFC portion of the task were not speeded and there was no time limit for responding.

**Trial Design.** The timing of the target (1100 msec after the 4th or 8th word in taboo pilot study 1 or right at the end of the 4th or 8th word in taboo pilot study 2) and serial position of category-inconsistent word (as the 4th or 8th word) were fully crossed such that there were an
even number of trials in each cell. Following is a breakdown of the different types of trials and
the number of each type of trial encountered. “Critical” trials are indicated with an “*” as those
are the trials of primary interest where the target is presented immediately following a category-
inconsistent word.

- Taboo word 4th – Target after 4th word → 15 trials*
- Taboo word 4th – Target after 8th word → 15 trials
- Taboo word 8th – Target after 4th word → 15 trials
- Taboo word 8th – Target after 8th word → 15 trials*

10.2. Taboo Pilot Studies 1 and 2 Results and Discussion

Analyses for the pilot studies were exploratory and based on a limited group of
participants (6 individuals in pilot study 1 and 4 individuals in pilot study 2) and were thus
performed mainly to get an idea of any potential trends or patterns. As with the category-
violation studies, critical trials refer to trials in which the visual target was presented
immediately following the auditory presentation of a taboo word. Non-critical trials refer to
trials when the target was presented with either an earlier or later word in the auditory list.

Unlike the category-violation studies, participants in pilot study 1 were actually faster to
respond to targets in critical trials (M = 474, SD = 56; 95% CI [430, 519]) compared to non-
critical trials (M = 519, SD = 46; 95% CI [483, 556]). This pattern was consistent for a majority
of the participants, suggesting that instead of impairing or shifting the distribution of attention,
the taboo words might have been serving to alert participants leading to faster responses.
Target detection accuracy was high for both non-critical trials (M = .91, SD = .10; 95% CI [.83,
.99]) and critical trials (M = .94, SD = .08; 95% CI [.88, 1.0]) suggesting that the detecting the
visual targets was extremely easy. Accuracy in reporting the correct word at the 2AFC stage was
also high (M = .94, SD = .06; 95% CI [.89, .99]).

Pilot study 2 yielded much of the same results except for participants responding equally
fast in both critical trials (M = 470, SD = 11; 95% CI [459, 481]) and non-critical trials (M =
475, SD = 17; 95% CI [459, 492]). Changing the visual stimulus onset timing may have
eliminated any alerting effect that may have been influential in the first taboo pilot study, though
there was no consistent pattern across individual participants. Accuracy in reporting the target
was even higher than in taboo pilot study 1 and was almost equal for critical (\(M = .96, SD = .02; 95\% \text{ CI} [.94, .97]\)) and non-critical trials (\(M = .95, SD = .04; 95\% \text{ CI} [.91, .99]\)). There was a slight trend for individuals be more accurate in detecting targets in the 8\textsuperscript{th} position compared to the 4\textsuperscript{th}, though no generalizations can be made due to the limited number of individuals in the pilot study. 2-alternative forced choice accuracy was also extremely high (\(M = .96, SD = .03; 95\% \text{ CI} [.93, .99]\)) indicating that individuals were paying attention to both the visual task and the auditory stream.

The ultimate goal of Section 4 was to look in isolation at the effect emotionally arousing words might have on the balance of attention between internal and external sources of information. Taboo pilot studies 1 and 2 used two different visual stimulus timings and the results of both pointed to no negative effects of taboo word processing on attention. However, there are aspects of the current experimental design that may have led to the null effect. First, the visual task required participants to only monitor briefly presented visual stimuli. It is possible that individuals might have been able to dynamically shift attention between the external environment and internal verbal processing, as the pattern of visual stimulus presentation was somewhat predictable and only required brief visual attention to each individual stimulus for success. Dynamically shifting attention from one task to another might eliminate any effects as the predictable nature of the task could allow strategy to overcome any impairing effects. A more demanding task requiring the constant monitoring of a stimulus for success would be more sensitive to subtle changes in attention. Second, the ultimate goal is to demonstrate that the concurrent processing of emotional information can be disruptive to attention. Success in this goal requires that the processing of emotional information overlap in time with the presentation of a visual event requiring focused attention. The timing between the presentation of the taboo words and the onset of the visual targets may have actually been too long, allowing for taboo word processing to be complete before a visual target appeared. Changing the timing of the visual target with respect to the critical words may more effectively place the target during the time when the word is first being comprehended and thus most likely to impair attention. Finally, observing any effect requires participants to distribute attention between both tasks such that simultaneous performance of both is taxing. The 2AFC choice design may have been too simple and thus not require an appreciable amount of attention, allowing participants to focus attention more strongly on the visual task and not on listening,
comprehending, and remembering each auditory stimulus. A more difficult memory task requiring memory of all the words in the list would more strongly motivate participants to attend to both the auditory task and the visual task evenly. At this point in the progression of experiments, I thought it necessary to revisit the methodology and attempt to refine the overall structure of the experiment.

**Chapter 11: Experiment 4**

Based on the results of the taboo pilot studies, it was necessary to alter the general methodology away from that used in both the taboo pilot studies and Experiment 2 in order to more effectively investigate the phenomena of interest. A few primary changes were made to the overall structure of the experiment.

First, a slightly different and more selective set of taboo words was used in an attempt to maximize the arousal value of the taboo words under the assumption that words of higher arousal value would be more attentionally disrupting and would be more likely impact attention (Anderson, 2005).

Second, the timing of the presentation of the visual stimulus was changed such that the stimulus change would always occur 400 msec after the onset of the words. The new onset timing of the visual stimuli was informed by findings in the event-related potential literature showing that the brain’s electrophysiological response to meaningful stimuli is maximal between 200 and 600 msec following the onset of a stimulus (Kutas & Federmeier, 2011). Using this time range as a best guess of when individuals are comprehending the meaning of verbal stimuli, we decided to place visual targets at this point to maximize the probability that the visual change would occur during the time when meaning could influence attentional processes. The visual stimulus still required only the detection and response to the presence of a change.

The final change made to the experiment structure was that the 2AFC portion of each trial was replaced with mass recognition. During this stage of each trial, participants were presented with a collection of words on screen and had to correctly select, from a group of foil words, which words they had heard on that trial. As mentioned above, the motivation for switching away from the 2AFC was first to more strongly motivate participants to pay attention to the auditory stream, as success in the new mass recognition task required recognizing all the
words instead of just a single word. Additionally, mass recognition afforded the opportunity to analyze recognition performance at each serial word position to investigate if sequential proximity to the critical word (i.e. taboo word) would affect recognition memory.

11.1. Experiment 4 Methods

Participants. Sixteen University of Illinois undergraduate students participated in Experiment 4 (9 females, 7 males; mean age: 19.3 years).

Task Design. Experiment 4 differs from the taboo pilot studies in that Experiment 4 required participants to monitor a constantly visible stimulus for changes while engaged in a secondary auditory task. Once per trial, the gray vertical line would briefly change length to become shorter for 100 msec and then change back to the original length. Additionally, the 2AFC portion of each trial was replaced by a mass recognition task where participants were presented with a grid of 20 boxes, each containing a word, and had to click on the words they remembered hearing on that trial.

Visual Attention Task. Participants were instructed to monitor a vertical gray line (RGB value = [100, 100, 100]) presented at the center of a computer screen on a black background, and to indicate (by pressing the spacebar) when they noticed the line briefly change length. The vertical line (2.7 cm; 2.58° of visual angle) was continuously visible on screen and, once per trial, would briefly change to be 25% shorter (2.0 cm; 1.91° of visual angle). The line would shorten for 100 msec after which it would return to its original length. Participants were instructed to press the spacebar as quickly as they could after detecting the line change. Line changes were timed so they occurred 400 msec following the onset of the 4th word on ½ the trials and 400 msec following the 8th word on ½ the trials. Following the line change, participants had a window of 1100 msec during which they could respond. Responses outside of the 1100 msec window were recorded as misses.

Auditory Word Task. The auditory task in Experiment 4 was essentially the same as in previous experiments. Participants were told that in addition to the visual task, they were to listen and pay attention to a series of words to be remembered later. Each trial consisted of a series of 10 words presented at a rate of one word every 1500 msec. Participants were told that
at the end of each trial they would have to select which words they heard on a given trial from a
group of words, some of which they had heard and other they had not heard.

Neutral words were drawn from the 580 words described above. Words were drawn
from the overall list in groups of 20 randomly and without replacement until all words had been
used once. Twenty words were set aside for each trial, 9 of which that would be heard during the
trial and presented at recognition and 11 that would only be presented as foils during the
recognition stage (the taboo word for each trial was not shown at recognition). A set of 20 words
was set aside at the beginning of each session and were presented in a buffer trial in the middle
before the overall list was reset to ensure that no words were presented on back to back trials.
The result was that all words were drawn randomly without replacement and used once, then
buffer words were used, then all words were randomly drawn without replacement a second
time. Thus each word was encountered only twice as either an auditory stimulus or a foil word
at recognition. This allowed for 56 experiment trials, not counting the buffer trial in the middle.
Taboo words were heard on every trial as either the 4th or 8th word in the series and each of the
28 taboo words was heard twice controlling that no word was heard on back to back trials.

**Word Recognition.** Following each trial, participants were presented with a grid of 20
boxes, each containing a word, and told to click on all of the words that they heard on that trial.
Participants were presented with 9 out of the 10 words they heard on that trial (excluding the
taboo word) and 11 foil words that were not heard which served as distractors. Words were
displayed in a 4x5 grid with each word in its own box. Grid position for each word was
determined randomly on each trial. Participants used the mouse to click on all the words they
remembered hearing on that trial, changing the box surrounding each word from white to orange,
indicating selection. Once participants were finished selecting words, they hit the “Return” key
to lock in their responses, ending the trial.

**Trial Design.** Serial position of the taboo word (4th or 8th word) and timing of the visual
stimulus change (400 msec after the onset of the 4th or 8th word) were fully crossed such that
there was an even number of trials in each cell. Following is a list of each type of trial and the
number of trials of each type. “Critical” trials, those where the visual stimulus change occurs
with the presentation of a taboo word, are indicated with an “*”.
• Taboo word 4\textsuperscript{th} word – visual stimulus change with 4\textsuperscript{th} word $\rightarrow$ 14 trials*
• Taboo word 4\textsuperscript{th} word – visual stimulus change with 8\textsuperscript{th} word $\rightarrow$ 14 trials
• Taboo word 8\textsuperscript{th} word – visual stimulus change with 4\textsuperscript{th} word $\rightarrow$ 14 trials
• Taboo word 8\textsuperscript{th} word – visual stimulus change with 8\textsuperscript{th} word $\rightarrow$ 14 trials*

11.2. Experiment 4 Results and Discussion

Visual Target Response Times. Participants were required only to detect the targets in Experiment and so response times reflect only simple detection and response execution. Response times to targets were roughly equal in critical trials ($M = 458$, $SD = 65$; 95\% CI [426, 489]) vs. non-critical trials ($M = 451$, $SD = 68$; 95\% CI [418, 484]) providing no evidence for differential distribution of attention between internal and external sources of information as a result of taboo word processing. The same trend emerged as in the category-violation where response times were slower to targets in the 4\textsuperscript{th} position ($M = 474$, $SD = 62$; 95\% CI [443, 504]) compared to response times to targets in the 8\textsuperscript{th} position ($M = 436$, $SD = 76$; 95\% CI [399, 473]). Again, one likely explanation is that with attention not otherwise engaged in effortful processing, participants were able to anticipate later targets as there was less uncertainty as to when they would appear. There were no meaningful differences between critical and non-critical RTs to targets appearing in the 4\textsuperscript{th} vs. 8\textsuperscript{th} position. The ability for taboo words to be impactful rests on their ability to be surprising and emotionally salient. It is possible that a combination of hearing each taboo word more than once and also hearing a taboo word every trial diminished the impact and arousal value of the taboo words. Habituation to distracting meaningful stimuli within modality (a person’s own name or emotional words on screen) has been previously demonstrated (Harris & Pashler, 2004) and so it seemed possible that the effects of taboo words might have been limited to early in the experiment. To investigate if the impact of the taboo words diminished over time, RTs were analyzed for the first half and the second half of the experiment. In the first half of the experiment, response times to targets in critical trials were significantly slower ($M = 464$, $SD = 70$; 95\% CI [430, 498]) than response times to targets in non-critical trials ($M = 440$, $SD = 73$; 95\% CI [403, 474]), $t(15) = 2.18$, $p = .045$. This pattern somewhat reversed in the second half of the experiment with participants responding marginally faster in critical trials ($M = 452$, $SD = 72$; 95\% CI [417, 487]) compared to non-critical trials ($M = 465$, $SD = 67$; 95\% CI [432, 498]), though this difference was not significant, $t(15) = -1.37$, $p = 191$. 
The increased RTs to critical trial targets in the first half of the experiment demonstrates not only that the processing of taboo words can influence attention, but that this impact is reliant on the taboo words maintaining their status as surprising and emotionally salient.

**Visual Target Detection Accuracy.** Overall, participants were very accurate in detecting the visual targets (M = .96, SD = .05; 95% CI [.94, .99]). There were minimal, non-significant, differences in reporting accuracy between critical (M = .96, SD = .07; 95% CI [.92, .99]) and non-critical trials (M = .97, SD = .04; 95% CI [.95, .99]), a pattern which was consistent between the first half and the second half of the experiment. Participants were slightly better at detecting targets appearing in the 8th position (M = .95, SD = .07; 95% CI [.92,.99]) vs. 4th position (M = .97, SD = .04; 95% CI [.95, .99]), but this difference was minimal and non-significant. Post-experiment debriefing revealed that individuals thought that Experiment 4 was extremely easy. The results clearly show this. Accuracy in detecting the critical visual events was near ceiling and such high performance would likely obscure any effects. It is also possible that taboo words may influence attention beyond the stage of detection and increasing task difficulty may drop accuracy overall without any differential effect on accuracy. Regardless, Experiment 4 demonstrated that the processing of taboo words does not differentially impact individuals’ ability to detect visual targets compared to the processing of other non-taboo words.
Figure 8. Experiment 4 Accuracy Results. (Difference = Non-Crit – Crit)

Mass Recognition Performance. Accuracy in reporting each word in the auditory lists was typical of serially presented lists in that participants showed a slight benefit for the first and last few words of each trial. Recognition performance did not differ based on if a critical word was heard as the 4th or 8th word in the list. Proportion correct at each serial word position, separated by if the critical word was heard 4th or 8th, is shown below.

Figure 9. Experiment 4 Mass Recognition Results.
Chapter 12: Experiment 5

Experiments 2, 4, and the taboo pilot studies showed no significant impairment to visual attention task performance as a result of being presented with either semantically incongruent or emotionally arousing (i.e. taboo) words. Any disruption to externally directed attention caused by a shift of attention to internal processing of unrelated secondary task information was either absent, or not critical to the performance of a visual task requiring only simple detection. The recognition of semantically incongruent or emotionally arousing information may not impact simple detection and response execution, but instead more executive processes responsible for the maintenance of task rules and correct response selection. These more high level processes of attentional control require much more efficient inhibition and selection of information in order to be successful. It seemed likely that a task requiring not only visual target detection, but also evaluation and subsequent correct response selection might be more vulnerable to the kind of interference or distraction provided by the recognition of semantic incongruity or emotionally salient information. In order to examine this possibility, Experiment 5 switched away from a simple visual detection task and instead required participants to monitor a constantly visible stimulus, monitoring it for changes. Upon detecting changes, participants were asked to make a speeded response indicating which of two changes had occurred. The change was extremely subtle, and once the stimulus changed it would stay in its changed state such that participants were required to directly observe the change in order to be successful, as inferring the change after was nearly impossible. This achieved the goal of having the task not only require more executive attentional processes, but also made it much more attentionally demanding. The auditory task and then mass recognition portion of the experiment were the same as in Experiment 4.

12.1. Experiment 5 Methods

Participants. Twenty University of Illinois undergraduate students participated in Experiment 5 (17 females, 3 males; mean age: 19.2 years). Data from 3 participants were not included in analyses due to extremely poor performance in the visual attention task (>50% miss rate).
**Task Design.** Experiment 5 uses the visual attention task from Experiment 3 (discussed in Section 3) and a modified version of the auditory word task from Experiment 4. In Experiment 5, participants monitored a constantly visible vertical line stimulus for changes, and then indicated which of two possible changes occurred. The auditory word task was changed such that a taboo word was only heard on ½ the trials. Word memory was assessed using the same mass recognition task described in Experiment 4.

**Visual Attention Task.** Participants were told to monitor a vertical gray line (RGB value = [100, 100, 100]) presented at the center of a computer screen on a black background, and to indicate by key press when they detected a change in the length of the line. The vertical line was 2.8 cm (2.67° of visual angle) and was continuously visible on screen. Once per trial the vertical line would change to be either 4% shorter (2.7 cm; 2.58° of visual angle) or 4% longer (2.9 cm, 2.77 ° of visual angle). Participants were instructed to press the “down” arrow key if the line shortened and to press the “up” arrow key if the line lengthened. Line changes were timed to occur 400 msec after the beginning of the 4th word on ½ the trials and 400 msec after the beginning of the 8th word on ½ the trials. Participants had a 2000 msec window following the line change during which they could respond, else that trial would be counted as a miss.

**Auditory Word Task.** The auditory task in Experiment 5 was the same as in Experiment 4 except that taboo words were only present on ½ the trials. The 56 experiment trials were evenly divided into two classes of trials: taboo trials and non-taboo trials. In non-taboo trials all 10 words heard during the trial were neutral words. In taboo trials, 9 of the auditory stimuli were neutral words while 1 of the words was a taboo word. This resulted in each taboo word being heard only once. Taboo words always occurred in the 4th or 8th position within the list.

**Word Recognition.** The same mass recognition task was used in Experiment 5 as in Experiment 4. Following each trial, participants were presented with a 4x5 grid of 20 boxes, each containing a word, and told to click on all of the words they had heard on that trial. Depending on the trial type, participants would either be shown 9 words they heard during the trial and 11 foils (taboo trials) or all 10 words they heard during a trial and 10 foil words (non-taboo trials). Taboo words were never presented during recognition.
Trial Design. There were an equal number of taboo trials and non-taboo trials (28 taboo and 28 non-taboo). Within the taboo trials, list position of the taboo word (4th or 8th word in the list) and placement of the visual stimulus change (400 msec after the 4th or 8th word) were fully crossed. Within the non-taboo trials there were no critical words to balance and thus these trials varied only on timing of the visual stimulus change (400 msec after the 4th or 8th word). Below is an outline of the different trial types and the number of each type of trial presented. Critical trials (trials where the visual stimulus change occurred coincident with a taboo word) are marked with an “*” as these were the trials of most interest.

- Taboo word 4th word – visual stimulus change with 4th word \( \rightarrow \) 7 trials*
- Taboo word 4th word – visual stimulus change with 8th word \( \rightarrow \) 7 trials
- Taboo word 8th word – visual stimulus change with 4th word \( \rightarrow \) 7 trials
- Taboo word 8th word – visual stimulus change with 8th word \( \rightarrow \) 7 trials*
- All non-taboo words – visual stimulus change with 4th word \( \rightarrow \) 14 trials
- All non-taboo words – visual stimulus change with 8th word \( \rightarrow \) 14 trials

Trial order was pseudo-randomly determined such that two versions of the experiment were created, each with a unique random order of trials. The pseudo random trial order for each version were both generated and then modified so that the first taboo trial was the 6th trial overall in one version and the 7th trial overall in the second version. This was done in order to afford the opportunity to investigate if any impairment to visual target detection caused by the simultaneous presentation of a taboo word would be exacerbated if several non-taboo trials preceded a participant’s first encounter with a taboo word. An equal number of participants were run in each version of the experiment.

12.2. Experiment 5 Results and Discussion

Visual Target Response Times. Unlike the previous experiments, participants were significantly slower to respond to targets in critical trials (M = 773, SD = 153; 95% CI [706, 839]) compared to non-critical trials (M = 684, SD = 128; 95% CI [628, 740]), \( t(19) = -3.92, p = .001 \). Experiment 5 introduced a choice to the response such that participants had to detect and then correctly indicate which of two changes to the visual stimulus occurred. Also unlike previous experiments, there was virtually no difference in RTs to targets in the 4th (M = 704, SD
= 141; 95% CI [643,766]) vs 8th position (M = 704, SD = 130; 95% CI [647,761]) when collapsing across critical and non-critical trials. This is likely due to the increase in task complexity requiring participants to evaluate the visual stimulus change before being able to program a response. Looking at each target position individually, participants were slower to respond to targets in critical trials at both the 4th and 8th positions. This pattern was more exaggerated for 4th position targets as critical trial RTs were much slower (M = 810, SD = 203; 95% CI [721, 899]) compared to RTs to targets in 4th position non-critical trials (M = 671, SD = 131; 95% CI [613,728]), t(19) = -4.74, p < .001. Oddly, the difference in 8th position target RTs in critical and non-critical trials showed a similar pattern, but was not significantly different (critical M = 725, SD = 174; 95% CI [648, 801]; non-critical M = 697, SD = 136; 95% CI [638, 757]), t(19) = -.798, p = .435. Importantly, Experiment 5 shows a clear difference between critical and non-critical trial response times demonstrating a difference in the distribution or effective control of attention when processing taboo words versus non-taboo words.

![Figure 10. Experiment 5 RT Results. (Difference = Crit – Non-Crit)](image)

**Visual Target Detection Accuracy.** Accuracy in detecting the visual targets was lower than in previous experiments due to the increased difficulty of the task, but did not differ for critical (M = .73, SD = .20; 95% CI [.64, .82]) compared to non-critical trials (M = .73, SD = .14; 95% CI [.67, .80]), t(19) = .18, p = .86, suggesting no difference in individuals’ ability to detect the more difficult targets when processing taboo vs. non-taboo words. The lack of a difference between critical and non-critical trials was consistent for targets at both the 4th and 8th position. There was a slight advantage in target detection accuracy for all targets, collapsing across critical and non-critical trials, in the 4th position (M = .74, SD = .17; 95% CI [.67, .82]) compared to the 8th position (M = .72, SD = .16; 95% CI [.65, .79]), though this was not significant, t(19) = .67, p
= .51. This could be due to lower cognitive load than when targets are in the 8\textsuperscript{th} position as a result of fewer words to remember at that point, however this is only speculation.

**Figure 11. Experiment 5 Accuracy Results.** *(Difference = Non-Crit – Crit)*

**Mass Recognition Performance.** Consistent with Experiment 4, participants showed an advantage in recognition memory for the first few and last few words in the sequence. Recognition accuracy was similar for trials with and without taboo words. Mean proportion of words correctly recognized at each serial position for each trial type (no taboo, taboo word 4\textsuperscript{th}, or taboo word 8\textsuperscript{th}) can be seen below.

**Figure 12. Experiment 5 Mass Recognition Results.**

**Chapter 13: Experiment 6**

Experiment 6 was essentially a direct replication of Experiment 5 and was done to verify, strengthen, and more accurately represent the previous results. The visual attention task and auditory word task were identical. The only difference between the two experiments was that Experiment 6 included taboo words during mass recognition, which were not included in
Experiments 4 and 5. This was done to control for the possibility that individuals could learn that taboo words would never be present during recognition and thus would not attempt to keep the taboo words in memory, eliminating any potential effects of taboo words on visual task performance or recognition memory.

13.1. Experiment 6 Methods

Experiment 6 was registered on Open Science Framework (https://osf.io/). The planned sample, data exclusion criteria, general methods, analysis plan, stimulus lists, and experiment code were registered and posted online before any data was viewed.

**Participants.** Target sample size was N=36. It was decided ahead of time that if any data were unusable (according to the exclusion criteria listed below) additional participants would be run in groups of up to 3, with the understanding that if all additional participants’ data were usable then sample size may exceed N=36. Data from 38 University of Illinois undergraduate students (26 females, 12 males; mean age: 19.4 years) were included in analyses for Experiment 6. Data from 6 participants were not included in analyses due to extremely poor performance in the visual attention task (>50% miss rate).

**Planned Sample.** An *a priori* power analysis was conducted using the free software GPower Version 3.1 to determine an adequate sample size for a matched pairs t-test (GPower (Version 3.1): t-test – Means: Difference between two dependent means (matched pairs)). Registration of Experiment 6 and estimates of effect size began before data collection was complete for Experiment 5. Thus, effect size estimates for the power analysis are based on the first 16 usable participants that participated in Experiment 5. Analysis of Experiment 5 data yielded an effect size of \(d = 0.741\) for the measure of most interest (response times to visual target changes occurring with taboo vs. on-taboo words), so a more conservative power analysis was run assuming a \(d = .50\). For 80% power using a two-tailed test with \(\alpha = .05\), a sample size of N=34 is required.

**Data Exclusion Criteria.** Participant data could have been deemed unusable for the following reasons:
- extremely poor task performance ( >50% miss rate in the visual attention task across all trials or (Hit Rate – False Alarm Rate) <= .2 for word recognition task across all trials)
- previous participation in prior versions of the task
- blatant disregard for or misunderstanding of experiment instructions
- failure to complete the study
- experimenter error
- equipment troubles

**Task Design.** The visual attention task and auditory word task were identical to Experiment 5. The trial types and the number of each trial were also the same as in Experiment 5. As a result of taboo words being included in the mas recognition portion of each trial participants were presented with all 10 words they heard on a given trial and 10 foil words that were not heard which served as distractors. Aside from the inclusion of taboo words, the mass recognition portion of Experiment 6 was identical to Experiment 5.

**13.2. Experiment 6 Results and Discussion**

**Visual Target Response Times.** As in Experiment 5, response times were significantly slower to targets in critical trials (M = 760, SD = 188; 95% CI [700, 819]) compared to non-critical trials(M = 676, SD = 99; 95% CI [645, 708]), t(37) = -3.71, p = .001 demonstrating impairments to visual task performance as a result of hearing taboo words. There was no meaningful difference in RTs to targets in the 4th position (M = 702, SD = 107; 95% CI [668, 736]) vs. the 8th position (M = 691, SD = 137; 95% CI [648, 735]). The pattern of slower response times to targets in critical trials was consistent for targets in the 4th position (critical M = 741, SD = 167; 95% CI [688, 794]; non-critical M = 687, SD = 103; 95% CI [654, 719]) t(37) = -2.21, p = .03, and 8th position (critical M = 769, SD = 250; 95% CI [689, 849]; non-critical M = 665, SD =115; 95% CI [628, 701]), t(37) = -3.25, p = .002. These results replicate, and refine those shown in Experiment 5 providing more conclusive evidence that the processing of emotionally meaningful information can draw attention away from an unrelated visual attention task.
Visual Target Detection Accuracy. Accuracy in reporting the visual targets was essentially equal for critical trials (M = .73, SD = .13; 95% CI [.69, .77]) and non-critical trials (M = .73, SD = .13; 95% CI [.69, .77]) replicating the results of Experiment 5 and providing more evidence that the processing of taboo words does not impair an individual’s ability to detect visual targets. There was an advantage for targets appearing in the 4th position (M = .76, SD = .12; 95% CI [.72, .80]) compared to targets appearing in the 8th position (M = .70, SD = .15; 95% CI [.65, .75]) which was significant, t(37) = 2.76, p = .009. This same pattern was observed in Experiment 5. In Experiment 4, prior to the increase in visual task difficulty, detecting visual targets may have been easy enough such that only a small amount of attention was needed, leaving more attention for the auditory word task. By increasing the difficulty of the visual task, the auditory word task may have also become more taxing over the course of a trial as it was more difficult to maintain an increasing number of words in memory. The increased cognitive load at the end of trial resulting from a more difficult task combined with more information in memory likely made participants miss and increased number of visual targets. Detection accuracy was not significantly different for critical vs. non-critical trials for targets appearing the 4th position (t(37) = -1.05, p = .23) or the 8th position (t(37) = .78, p = .44).
**Mass Recognition Performance.** Mean recognition performance for words at each serial position can be seen below. As in Experiment 4 and 5, words at the beginning and end of each list received a slight recognition benefit. Experiment 6 was unique in that taboo words were included at the recognition stage. Accuracy in recognizing the taboo words was extremely high as can be seen in the spikes in accuracy for the 4th word and 8th word in trials where the taboo word was heard in those positions. Recognition accuracy is also noticeably lower for the first few words in trials where the taboo word is heard in the 8th position. To investigate if this difference was significant, recognition accuracy for the first 3 words was averaged for each type of trial and a repeated measures ANOVA was run with taboo word position (No Taboo, Taboo 4th, and Taboo 8th) as a within subject factor. There emerged a main effect of taboo word position (F(2,74) = 8.13, p = .001) with post-hoc pairwise comparisons using a Bonferroni correction revealing that, while recognition accuracy for the first 3 words in trials where the taboo word appeared 4th (M = .69, SD = .17, 95% CI [.64, .74]) or not at all (M = .68, SD = .16, 95% CI [.63, .73]) did not differ (p = 1.00), average recognition accuracy for the first 3 words in trials where a taboo word was heard 8th (M = .63, SD = .19, 95% CI [.57, .69] was significantly different from trials in which a taboo word was heard 4th (p = .012) and trials where no taboo word was heard (p = .006). One explanation for this is what I will call a “primacy wipeout.” Given the arousing quality of the taboo words, they are highly emotionally salient and easy to remember. The arousing nature of the taboo words seems to be a double edged sword in memory: giving a recognition boost to the taboo words but interfering with memory for the first few words in the list. The interference caused by the recently heard taboo words seems to have eliminated the primacy benefit usually awarded the first few items in a serial list. It would be reasonable to assume that if the taboo words interfere with recognition memory in general due to their internal salience, this would impact memory for the words following a taboo word as well, and the interference would be much more general. This does not appear to have been the case. The words following the taboo word when it appears 4th are likely benefit from being heard more recently and are thus more resistant to interference. Additionally, the “primacy wipe-out” by taboo words in the 8th position does not completely eliminate memory for the first few items, but simply reduces the primacy benefit such that those items are just as likely as any other word in the list to be remembered, as they are now all competing against the much more emotionally salient taboo word for successful recognition.
Chapter 14: Section 4 Discussion

Section 4 examined the potential impact of hearing taboo words embedded within an auditory task on concurrent visual task performance. Specifically, the question of interest was whether the unexpectedness and emotional salience of a taboo word would capture or draw attention internally in a way that would impair visual task performance. The taboo words presented in the current study differed only in semantics from the other words presented in that all words were presented in the same voice and at the same pitch and volume departed from other auditory stimuli only in their meaning. Auditory presentation of taboo words negatively
impacting performance on an unrelated visual task would demonstrate that attentional resources are shared between internal and external sources of information and that meaningful information can influence the distribution of attention such that some amount of attention is taken away from the processing of external stimuli and focused instead on internal sources. This is what was observed in both Experiments 5 and 6, and the first half of Experiment 4. Responding to a target stimulus was slowed when the presentation of that target was immediately preceded by a taboo word in the auditory stream. Importantly, hearing taboo words had no bearing on an individual’s ability to detect visual targets, as evidenced by relatively equivalent accuracy in critical and non-critical trials. Instead, the interference was observed at the target processing and response stage. Taboo words appear to exert their influence by being internally salient in a way that interferes with either the processing of visual stimuli or, in the case of Experiments 5 and 6, the maintenance of task set and efficient response selection. One caveat to this, is that for emotional information to be effective in influencing attention, it seemingly has to retain its meaningfulness and arousing nature. In Experiment 4, the negative effects on attention were only observed the first half of the experiment suggesting that either each taboo was only impactful the first time it was heard or that individuals had habituated to the presence of surprising taboo words, depriving them of their special, emotionally salient status. In sum, emotional information, as long as it remains arousing, has the ability to negatively impact the effective distribution of attention such that interference caused by the emotional salience of information can impair unrelated visual task performance and the effective maintenance of task set and attentional control necessary for unimpeded task performance.
SECTION 5: GENERAL DISCUSSION

The goal of this thesis was to investigate how individuals are able to balance or manage attention between both internal and external sources of information. If the notion of a shared resource pool of attention is true, then both the external detection and selection of information and the comprehension and evaluation of verbal information should both draw from the same common pool. Thus, if attention is dedicated to one process, the other process will suffer. I sought to examine how the processing of speech, specifically incongruous or highly meaningful speech, might take attention away from an unrelated visual attention task. Experiment 1 demonstrated that immediately following the punchline of a joke, individuals are slower to respond to the presence of a target in an RSVP stream. In Experiments 2 and 3, it was shown that being presented with a semantically inconsistent word in a stream of non-sentential, category-consistent words did not negatively affect performance on a visual attention task but instead provided a slight boost to accuracy in detecting targets. Finally, Experiments 4, 5, and 6 assessed the impact of hearing taboo words on visual task performance, showing that taboo words, as long as they retain their arousing status, can negatively impact performance on an unrelated visual task. As a whole, the current data suggest that when attention is split between the internal processing of auditory information and an external visual task, surprising or meaningful auditory information can impact visual attention and that the effects vary as a function of the nature of the surprising information.

As interesting as it is to point to jokes specifically as a unique, attentionally disruptive stimulus, the methodology used in Experiment 1 prevents any strong claims. As mentioned above, the attentionally demanding “wrap-up” processing immediately following a joke may not be specific to jokes in particular, but may instead just be a normal consequence of hearing any kind of utterance. To show that jokes are special in their ability to demand internal attention, for whatever reason, it would have to be shown that individuals are not slower to respond to RSVP targets following non-humorous utterances. Furthermore, given that there are a number of features of jokes that could affect attention, simply demonstrating that jokes disrupt attention doesn’t really answer the questions of “why?” It could be semantic incongruity, the reinterpretation of information, or the inherent emotionality that makes jokes disruptive. Any one of these mechanisms could be attentionally demanding or disruptive to the central executive
processes necessary for attentional control and the maintenance of current goals and cognitive priorities.

Surprisingly, the recognition of semantic inconsistency, even in the fairly artificial context of hearing a category-inconsistent word among category-related words, was shown to affect visual attention, though not in the way predicted. I predicted that the recognition of semantically inconsistent information would capture attention much in the same way that a suddenly appearing object or abrupt noise would capture attention, resulting in either slower responses to or decreased detection of visual targets. The observed effect of no RT differences and a slight to moderate boost to target detection accuracy in critical trials was unexpected. One possibility is that the recognition of semantic inconsistency did not internally capture attention in a way that inhibited attention to the external environment but did lead to a momentary shift of attention away from the visual task to the auditory task. Recent evidence suggests that the brief deactivation and reactivation of a task set can prevent what has been called “goal habituation” in which the activation and strength of current task goals and representations diminish over time leading to poorer performance (Ariga & Lleras, 2011). In essence, by punctuating the performance of a task requiring sustained attention by an intermittent secondary task, you keep the primary task goals in a state of active readiness by deactivating and reactivating an attentional set preventing goal habituation. It is possible that instead of capturing attention, the recognition of semantic inconsistency in the auditory stream simply allowed for the momentary deactivation of visual task-set leading to a boost in performance as a result of preventing visual task goal habituation. One limitation of this explanation is that the duration of and length of sustained attention required for each trial was quite short, especially when critical words and targets were in the 4th position, making the possibility of goal habituation unlikely. A more likely explanation is that the recognition of semantic inconsistency served as a kind of alert, providing a general boost to arousal leading to increased overall attention. Non-informative alerting cues have been shown to provide a boost to attention performance by both raising the general state of arousal and keeping an individual focused by providing an alert that is not interesting enough to draw attention but nonetheless refocuses and maintains attention on current task goals (Fernandez-Duque & Posner, 1997; Manly et al, 2004). This seems to be the most likely explanation. A boost in accuracy performance was observed in the absence of an RT benefit suggesting that the recognition of semantic inconsistency simply alerted the central
executive to stay on task resulting in increased detection. When individuals were able to maintain focused attention and detect the presence of visual targets, responses were equally fast. The possibility still remains that the recognition of semantic inconsistency in a more meaningful context that also requires the reinterpretation of context may be more demanding of internally directed attention, leading to more deleterious effects to externally directed attention. In the current setting however, the simple recognition of semantic inconsistency seems to serve as an alert, either raising the overall level of arousal or orienting individuals to maintain focus on the visual task.

The effect of taboo words was much more in line with my initial predictions. In the current experiments, the strongest observed effect on visual attention performance resulted from participants being presented with auditorily presented taboo words which were irrelevant to the visual task. In Experiment 4, this effect was only observed in the first half of the experiment suggesting that the repetition of, or habitation to taboo words renders them ineffective as emotionally and attentionally impactful. By and large, the results show that emotional and/or highly arousing information, in this case taboo words, can impact attention such that the processing of emotional information in one task can carry over to an individual’s ability to perform a secondary unrelated task. A similar kind of impairment has been shown within task and modality, as highly arousing taboo/sexual words have induced an attentional blink, reducing detection of word targets appearing after irrelevant taboo/sexual distractor words (Arnell, 2007). Importantly, this effect was fairly transient as it was most robust at short lags between critical distractor and target words (~300-500 msec) and dissipated quickly. The effect was also predicted by later memory for the critical distractors suggesting that it was the process of attending to and encoding the critical distractors into memory that was responsible for not consciously detecting the targets (Arnell, 2007). These results help to explain the timing aspects of my studies as negative effects on attention were only observed once the visual targets were placed after taboo words at a time similar to that used in the previous studies showing an attentional blink.

The observed effect could result from delayed disengagement from emotional information as has been previously observed (Fox et al, 2001), the disruptive nature of the semantic salience of emotional information, or a combination of both. In situations when
attention must be managed and all sources of information must be evaluated in an efficient manner, the emotionality and tendency for emotional information to prove difficult to inhibit could cause attention to “stick” to certain stimuli which could disrupt the evaluation of unrelated secondary task stimuli. The process of interfacing with long term memory in the service of retrieving task rules to select the correct response, all while monitoring auditory information, requires that attention be strategically allocated and managed efficiently. If emotional information is more difficult to disengage from, or is simply more internally salient and more difficult to inhibit, then this might interfere with an individual’s ability to perform a visual task. This interference could potentially slow the process of recognizing visual targets or it could interfere with response selection and execution. Given what was found in Experiment 4, it seems more likely that arousing information does not interfere with the process response selection, as taboo words slowed response times for even a simple detection task in the first half of the experiment when they retained their arousing qualities.

One potential concern with Experiments 2-6 overall is that participants could have learned that the oddball auditory stimuli were predictive of the visual stimulus change. While the visual stimulus change only occurred with oddball words on 50% of trials, if participants were to group the words into broad “oddball” or “neutral” categories, then the probability of a visual target appearing after an oddball word was higher than the probability of a visual target appearing after any of the neutral words. This, in turn, could have allowed participants to predict the appearance of a visual target when hearing an oddball word, in essence making the auditory oddball words cues. I believe this possibility only strengthens my findings in Experiments 5 and 6, as predictability would almost certainly lead to a performance boost. For an impairing effect to manifest even when the taboo words were predictive, would suggest that the disruption was enough to overcome a boost to performance brought on by predictability. This could also partially explain the lack of impairment in Experiments 2 and 3 and the smaller/dissipating effect in Experiment 4. If the disruptive effects of the oddball words vary in strength given the characteristics of the stimuli, then a mere semantic oddball may not have enough disruptive strength to push through the boost to performance gained by the predictability of visual targets following an oddball. In line with this idea, the predictability of the visual targets following oddball words could have been responsible for the slight benefit to accuracy observed for critical trials in Experiments 2 and 3. Thus the performance boost to accuracy observed in Experiments
2 and 3 could stem not from a general alerting brought on by the recognition of semantic inconsistency, but rather recognition of the underlying visual target predictability inherent in the study design. Furthermore, given that the taboo words were much more likely in Experiment 4 than in Experiments 5 and 6, the probabilistic relationship between taboo oddballs and visual targets may have been much more apparent, leading to mitigated effects.

To emphasize a point made previously, it is compelling that taboo words were able to impair performance in the visual task given that they only differ from the other words in meaning. Admittedly, taboo words are often said with different prosody than the surrounding speech. Emphasizing or stressing a word in an utterance could indeed make any word stand out by altering the acoustic qualities of the word’s sound. In the current context however, the taboo words were not emphasized, stressed, or said in a way that was different from the other words in the list. This is a key distinction to make. It was not the acoustic or perceptual features of the taboo words that made them distinct but rather their semantics. As such, any attentional effects stemming from hearing the taboo words could only be attributed to the meaning that these taboo words invoke. Attentional disruption stemming not from any kind of perceptual distinctiveness but rather semantic distinctiveness is what underlies my claim of internal attention capture and disruption.

Briefly bringing the discussion back to the original inspiration for the experiments, it is important to consider what it means for the results observed in Experiments 5 and 6 to manifest in slower RTs rather than accuracy and how the observed effects may relate to a real-world situation (like a magician’s performance). Commonly in challenging tasks, there is a tradeoff in speed and accuracy such that as speed is emphasized, accuracy performance decreases and as accuracy is emphasized, speed performance decreases. If an effect shows up in accuracy (due to errors or misses) it is generally due to the fact that not enough time was given, or the individual did not take enough time, to gather adequate information to make a correct response. If an effect shows up in RT, then this is indicative of an individual requiring more time in one condition than another to be equally accurate. For my results to manifest in RTs suggests that the processing of taboo words delayed the time it took to make an equally accurate response. As stated above, I believe that this is due to the inability for individuals to efficiently disengage attention away from the internal processing of the taboo words in order to shift attention to the processing of the
visual targets. This kind of internal attention capture or holding may be functionally different than typical demonstrations of attention capture due to the non-overlapping nature of the internal capturing stimulus and the external target stimulus. To the extent that attention shifts between being more focused on the auditory task and the visual task, emotional information exerts its influence by shifting the balance such that the processing of the visual targets is delayed relative to the processing of non-emotional information. However, it is unlikely that attention would be fully captured by internal sources and thus some amount of attention is no doubt still left over for perceptual sources. This leftover attention to the external environment is seemingly sufficient enough to still detect spatially predictable visual targets. Another functional limitation of this kind of internal attention capture is that, due to the inherent non-perceptual nature of the capturing stimulus, there is no potential for overt attention capture, such as moving the eyes or turning the head, which can often be very effective in leading to the complete failure to detect an external stimulus. In sum, internal attention capture may be an effective method of disrupting the balance and distribution of attention but is subject to functional limitations due to the necessity for an individual to still allocate some attention to external, perceptual sources.

Nonetheless, I believe that the detrimental impact of emotional information observed in my experiments can easily be related to the situations described by magicians. One objection might be that for emotional information (such as a joke) to be successful as an effective form of misdirection, a performer would need their audience to completely miss the method, not just be delayed in attending to it. While this is true, I would point out the difference between my laboratory experiments and the observation of a magic trick. In my experiments, the participants were fully aware of both tasks and what is to be expected from each. The visual target is clearly described and always occurred in the same spatial location. Another way of putting it is that, while the concurrent processing of internal and external information is still at play, there is a certain level of predictability and certainty when performing the laboratory task. When observing a magic trick, the audience is seemingly tasked with listening to the patter, including jokes, of the performer as well as watching their physical actions. Successful detection of the method of a trick requires participants to attend to exactly the right place at exactly the right time in order to catch the method. If the method action were to always occur in the same spatial location, and observers were aware of this, then we might very well see delayed detection of the method similar to what was demonstrated in the lab. However, in the actual performance of a
trick, the delay of attentional shifting caused by internal processing of emotional information would likely have a very different effect. Delayed attentional disengagement from the processing of emotional information in conjunction with location and temporal uncertainty of “targets”, can no doubt function as an effective form of attentional manipulation and control.

My results show that emotional information can interfere with an individual’s ability to efficiently manage attention internally, and that the internal salience of emotional information is more difficult to disengage from once attended leading to the slower deployment of attention to an external visual task. Importantly, the fact that these effects arise due to the internal processing of the semantics of a stimulus and not by any bottom-up stimulus characteristics is a unique demonstration of the interactivity of internally and externally directed attention. In this thesis I set out to explore the ways in which attention must be managed between not only external sources of information, but internal processing as well. I believe that my results provide a clear demonstration of the interplay between our internal evaluation of information and our ability to direct attention to the outside world. The ways in which stimuli in the external environment can take attention away from other external stimuli has been studied extensively. I sought to instead investigate situations where attention is captured or drawn internally by the semantic evaluation of information. The results demonstrate that attention is shared between the internal and external environments, and that the ways in which the internal evaluation of information can impact attention are varied. To the extent that attention is to serve us in our current goals, we must explore not only how we handle sources of information in the external environment but how our own thoughts and the meaning we derive from the world influences our pursuit of these goals. Revisiting the quote by William James presented in the beginning of this thesis, I conclude by saying that attention seems not to be “the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought” but rather a complex, synergistic relationship between the “possible objects” and “trains of thought.”
REFERENCES


APPENDIX OF EXPERIMENT STIMULI

Category Word Lists for Experiments 2 and 3

Set 1

- Alcohol -  
  beer  
  bourbon  
  champagne  
  sword  
  margarita  
  martini  
  rum  
  scotch  
  tequila  
  vodka  
  (Foil: gin )

- Candy -  
  bubblegum  
  twizzlers  
  jolly rancher  
  elm  
  snickers  
  pixie stix  
  skittles  
  M&Ms  
  starburst  
  twix  
  (Foil: butterfinger )

- Clothing -  
  blouse  
  shorts  
  shirt  
  sweater  
  skirt  
  socks  
  suit  
  hat  
  dress  
  (Foil: jacket )

- Dogs -  
  beagle  
  terrier  
  chihuahua  
  rottweiler  
  dalmatian  
  labrador  
  pug  
  spaniel  
  bulldog  
  (Foil: poodle )

- Birds -  
  bluejay  
  dove  
  crow  
  pigeon  
  robin  
  seagull  
  hummingbird  
  license plate  
  parakeet  
  parrot  
  (Foil: hawk )

- Cities -  
  Baltimore  
  Chicago  
  Dallas  
  piyers  
  Detroit  
  Miami  
  Los Angeles  
  Philadelphia  
  San Diego  
  (Foil: Boston )

- Colors -  
  black  
  blue  
  grey  
  Indiana  
  orange  
  purple  
  red  
  yellow  
  brown  
  magenta  
  (Foil: pink )

- Drink -  
  coffee  
  coke  
  fanta  
  sprite  
  juice  
  lemonade  
  pepsi  
  car  
  tea  
  water  
  (Foil: milk )

- Body Parts -  
  arm  
  ear  
  elbow  
  foot  
  head  
  toe  
  hand  
  penny  
  leg  
  nose  
  (Foil: eye )

- Clergy -  
  bishop  
  preacher  
  nun  
  pastor  
  pope  
  monk  
  priest  
  dandelion  
  reverend  
  cleric  
  (Foil: minister )

- Countries -  
  England  
  Finland  
  France  
  diabetes  
  Ireland  
  Norway  
  Scotland  
  Sweden  
  Switzerland  
  (Foil: Italy )

- Earth Formations -  
  canyon  
  desert  
  glacier  
  skillet  
  mountain  
  ocean  
  plateau  
  river  
  volcano  
  waterfall  
  (Foil: valley )
- Elements -  
calium  
carbon  
helium  
dormitory  
magnesium  
nitrogen  
oxgen  
phosphorus  
kassium  
sulfur  
(Foil: sodium )  
- Fish -  
salmon  
catfish  
dolphin  
hurricane  
goldfish  
carp  
perch  
halibut  
shark  
trout  
(Foil: trout )  
- Instruments -  
clarinet  
trumpet  
flute  
drum  
piano  
saxophone  
cello  
itestine  
tuba  
violin  
(Foil: trombone )  
- Months -  
April  
August  
December  
November  
January  
July  
March  
October  
September  
(Foil: June )  
- Fabric -  
cotton  
denim  
leather  
wool  
polyester  
satin  
silk  
bronze  
flannel  
linen  
(Foil: nylon )  
- Fruits -  
apple  
banana  
grape  
stocking hat  
watermelon  
orange  
peach  
pear  
pineapple  
strawberry  
(Foil: lemon )  
- Measurements -  
centimeter  
foot  
inch  
centipede  
meter  
mile  
nanometer  
yard  
millimeter  
decimeter  
(Foil: micrometer )  
- Parts of Speech -  
adjective  
adverb  
vowel  
pronoun  
contraction  
clause  
preposition  
celery  
verb  
consonant  
(Foil: noun )  
- Family -  
aunt  
brother  
cousin  
sister  
grandma  
grandpa  
mother  
reggae  
son  
uncle  
(Foil: father )  
- Furniture -  
bed  
chair  
couch  
recliner  
lamp  
ottoman  
sofa  
confused  
table  
futon  
(Foil: dresser )  
- Military Title -  
admiral  
cadet  
captain  
cookie  
commander  
colonel  
lieutenant  
sergeant  
soldier  
major  
(Foil: general )  
- Precious Metals -  
diamond  
emerald  
gold  
ginger  
opal  
pearl  
jade  
ruby  
sapphire  
amethyst  
(Foil: silver )
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<th>Profession</th>
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<th>States</th>
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- Weather -
  blizzard
  fog
  tsunami
  flounder
  lightning
  rain
  sleet
  snow
  thunderstorm
  tornado
  (Foil: hail )
- dance -
  ballet
  ballroom
  cha-cha
  February
  flamenco
  interpretive
  mamba
  swing
  tango
  waltz
  (Foil: salsa )
- dwelling -
  apartment
  cabin
  tent
  houseboat
  duplex
  hotel
  house
  hydrogen
  hut
  mansion
  (Foil: condo )
- footwear -
  boots
  slippers
  clogs
  flip flops
  loafers
  moccasins
  cleats
  collie
  sneakers
  socks
  (Foil: sandals )
- car parts -
  airbag
  trunk
  dashboard
  steering wheel
  transmission
  speedometer
  seatbelt
  cardinal
  ignition
  windshield
  (Foil: headlights )
- desserts -
  brownie
  cake
  cobbler
  corporal
  custard
  doughnut
  ice cream
  jellyroll
  pie
  pudding
  (Foil: fudge )
- emotions -
  afraid
  angry
  anxious
  desk
  disgusted
  happy
  jealous
  sad
  stressed
  surprised
  (Foil: nervous )
- headgear -
  helmet
  turban
  beanie
  top hat
  bonnet
  crown
  hairnet
  blueberry
  ballcap
  beret
  (Foil: hood )
- crime -
  arson
  assault
  bribery
  theft
  extortion
  fraud
  murder
  pants
  trespassing
  vandalism
  (Foil: kidnapping )
- disease -
  AIDS
  alzheimers
  chicken pox
  parkinsons
  hepatitis
  leukemia
  malaria
  Germany
  shingles
  smallpox
  (Foil: measles )
- flower -
  carnation
  marigold
  orchid
  rabbi
  poinsettia
  lily
  daffodil
  tulip
  rose
  daisy
  (Foil: petunia )
- injuries -
  blister
  scrape
  burn
  dentist
  cut
  fracture
  bruise
  scratch
  puncture
  sprain
  (Foil: splinter )
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<td>pound</td>
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### Set 2

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<td>jolly rancher</td>
<td>shirt</td>
<td>chihuahua</td>
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<td>sword</td>
<td>M&amp;Ms</td>
<td>sweater</td>
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<td>snickers</td>
<td>skirt</td>
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<td>pixie stix</td>
<td>socks</td>
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<td></td>
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<td>dress</td>
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<th>- Colors -</th>
<th>- Drink -</th>
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<td>grey</td>
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<td>Denver</td>
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<td>juice</td>
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- insect -
ant  bee  beetle  kilometer  fly  grasshopper  mosquito  moth  spider  wasp  (Foil: butterfly )
- metals -
  aluminum  brass  tin  titanium  copper  iron  lead  fleece  platinum  steel  (Foil: chrome )
- music -
  rock&roll  blues  classical  daughter  heavy metal  country  opera  punk  rap  techno  (Foil: jazz )
- part of bldg -
  attic  basement  bathroom  roof  ceiling  door  hallway  geology  stairs  window  (Foil: floor )
- kitchen utensil -
bowl  fork  whisk  lake  plate  pot  pan  spatula  spoon  strainer  (Foil: ladle )
- money -
bowl  fork  whisk  lake  plate  pot  pan  spatula  spoon  strainer  (Foil: ladle )
- religion -
Atheism  Buddhism  Christianity  Scientology  Judaism  Islam  Paganism  Shinto  Taoism  (Foil: Hinduism )
Set 3

- Alcohol -
  beer
  bourbon
  champagne
  scotch
  margarita
  martini
  rum
  sword
  tequila
  vodka
  (Foil: gin )

- Birds -
  bluejay
  dove
  crow
  license plate
  robin
  seagull
  hummingbird
  pigeon
  parakeet
  parrot
  (Foil: hawk )

- Body Parts -
  arm
  ear
  elbow
  penny
  head
  toe
  hand
  foot
  leg
  nose
  (Foil: eye )

- Candy -
  bubblegum
  twizzlers
  jolly rancher
  M&Ms
  snickers
  pixie stix
  skittles
  elm
  starburst
  twix
  (Foil: butterfinger )

- Clothing -
  blouse
  shorts
  shirt
  burglary
  skirt
  socks
  suit
  sweater
  hat
  dress
  (Foil: jacket )

- Cities -
  Baltimore
  Chicago
  Dallas
  Los Angeles
  Denver
  Detroit
  Miami
  San Diego
  Philadelphia
  (Foil: Boston )

- Clergy -
  bishop
  preacher
  nun
  dandelion
  pope
  monk
  priest
  pastor
  reverend
  cleric
  (Foil: minister )

- Colors -
  black
  blue
  grey
  yellow
  orange
  purple
  red
  indiana
  brown
  magenta
  (Foil: pink )

- Countries -
  England
  Finland
  France
  Spain
  Ireland
  Norway
  Scotland
  diabetes
  Sweden
  Switzerland
  (Foil: Italy )

- Drink -
  coffee
  coke
  fanta
  car
  juice
  lemonade
  pepsi
  sprite
  tea
  water
  (Foil: milk )

- Dogs -
  beagle
  terrier
  chihuahua
  high heels
  dalmatian
  labrador
  pug
  rottweiler
  spaniel
  bulldog
  (Foil: poodle )

- Earth Formations -
  canyon
  desert
  glacier
  river
  mountain
  ocean
  plateau
  skillet
  volcano
  waterfall
  (Foil: valley )
- **Elements** -
calcium
carbon
helium
phosphorus
magnesium
nitrogen
oxygen
dormitory
potassium
sulfur
(Foil: sodium )

- **Fish** -
salmon
catfish
dolphin
halibut
goldfish
carp
perch
hurricane
shark
tout
(Foil: trout )

- **Instruments** -
clarinet
crichton
flute
intestine
piano
saxophone
cello
drum
tuba
violin
(Foil: trombone )

- **Measurements** -
centimeter
foot
inch
yard
meter
mile
nanometer
centipede
millimeter
decimeter

- **Military Title** -
admiral
cadet
captain
sergeant
commander
colonel
lieutenant
cookie
soldier
major
(Foil: general )

- **Months** -
April
August
December
disco
January
July
March
November
October
September
(Foil: June )

- **Parts of Speech** -
adjective
adverb
vowel
celery
contraction
clause
pronoun
verb
consonant
(Foil: noun )

- **Precious Metals** -
diamond
emerald
gold
ruby
opal
pearl
jade
ginger
sapphire
amethyst
(Foil: silver )

- **Fabric** -
cotton
denim
leather
bronze
polyester
satin
silk
wool
flannel
linen
(Foil: nylon )

- **Fruits** -
apple
banana
grape
pear
watermelon
orange
peach
stocking hat
pineapple
strawberry
(Foil: lemon )

- **Furniture** -
bed
chair
couch
confused
lamp
ottoman
sofa
recliner
table
futon
(Foil: dresser )

- **Family** -
aunt
brother
cousin
reggae
grandma
grandpa
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(Foil: father )

- **Fish** -
salmon
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<th>- Measurements -</th>
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<td>cadet</td>
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<td>captain</td>
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<td>sergeant</td>
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<td>lamp</td>
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<td>cheetohs</td>
<td>California</td>
<td>tomato</td>
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<td>cheese balls</td>
<td>Colorado</td>
<td>peas</td>
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<tr>
<td>lawyer</td>
<td>golf</td>
<td>green</td>
<td>corn</td>
</tr>
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<td>dogitos</td>
<td>Maine</td>
<td>cauliflower</td>
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<td>fireman</td>
<td>granola</td>
<td>Missouri</td>
<td>cucumber</td>
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<td>peanuts</td>
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<td>pretzels</td>
<td>Texas</td>
<td>lettuce</td>
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<tr>
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<td>pringles</td>
<td>Virginia</td>
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<td>cumin</td>
<td>chainsaw</td>
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<td>book</td>
<td>garlic</td>
<td>drill</td>
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<td>nail</td>
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<td>parsley</td>
<td>hammer</td>
<td>van</td>
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<td>paprika</td>
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<td>basil</td>
<td>tape measure</td>
<td>airplane</td>
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<tr>
<td>textbook</td>
<td>platinum</td>
<td>level</td>
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<td>essay</td>
<td>salt</td>
<td>shovel</td>
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<td>cinnamon</td>
<td>(Foil: wrench)</td>
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<th>Sports</th>
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<td>chemistry</td>
<td>football</td>
<td>cedar</td>
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<td>cookies</td>
<td>kit kat</td>
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<td>spruce</td>
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<td>volleyball</td>
<td>sycamore</td>
<td>spear</td>
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<td>(Foil: physiology)</td>
<td>(Foil: soccer)</td>
<td>(Foil: oak)</td>
<td>(Foil: bomb)</td>
</tr>
</tbody>
</table>
- Weather -
blizzard
fog
tsunami
snow
lightning
rain
sleet
flounder
thunderstorm
tornado
(Foil: hail)

- dance -
ballet
ballroom
cha-cha
February
flamenco
interpretive
mamba
swing
tango
waltz
(Foil: salsa)

- dwelling -
apartment
cabin
tent
hydrogen
duplex
hotel
house
houseboat
hut
mansion
(Foil: condo)

- footwear -
boots
slippers
clogs
flip flops
loafers
moccasins
cleats
collie
sneakers
socks
(Foil: sandals)

- car parts -
airbag
trunk
dashboard
steering wheel
transmission
speedometer
seatbelt
cardinal
ignition
windshield
(Foil: headlights)

- desserts -
brownie
cake
cobbler
jellyroll
custard
doughnut
ice cream
custard
pie
pudding
(Foil: fudge)

- emotions -
afraid
angry
anxious
desk
disgusted
happy
jealous
sad
stressed
surprised
(Foil: nervous)

- headgear -
helmet
turban
beanie
blueberry
bonnet
crown
hairnet
top hat
ballcap
beret
(Foil: hood)

- crime -
arson
assault
bribery
pants
extortion
fraud
murder
theft
trespassing
vandalism
(Foil: kidnapping)

- disease -
AIDS
alzheimers
chicken pox
parkinsons
hepatitis
leukemia
malaria
Germany
shingles
smallpox
(Foil: measles)

- flower -
carnation
marigold
orchid
tulip
poinsettia
lily
daffodil
rabbir
rose
daisy
(Foil: petunia)

- injuries -
blister
scrape
burn
dentist
cut
fracture
bruise
scratch
puncture
sprain
(Foil: splinter)
- insect -  |  - metals -  |  - music -  |  - part of bldg -
---|---|---|---
ant  |  aluminum  |  rock&roll  |  attic  
bee  |  brass  |  blues  |  bathroom  
beetle  |  tin  |  classical  |  geology  
moth  |  fleece  |  punk  |  ceiling  
fly  |  copper  |  heavy metal  |  door  
grasshopper  |  iron  |  country  |  hallway  
mosquito  |  lead  |  opera  |  roof  
kilometer  |  titanium  |  daughter  |  stairs  
spider  |  platinum  |  rap  |  window  
wasp  |  steel  |  techno  |  (Foil: floor )
(Foil: butterfly )  |  (Foil: chrome )  |  (Foil: jazz )  |  

- kitchen utensil -  |  - money -  |  - organs -  |  - religion -
---|---|---|---
bowl  |  dime  |  appendix  |  Atheism  
fork  |  dollar  |  bladder  |  Buddhism  
whisk  |  euro  |  brain  |  Christianity  
spatula  |  finger  |  lung  |  webpage  
plate  |  pound  |  heart  |  Judaism  
pot  |  yen  |  kidney  |  Islam  
pan  |  franc  |  stomach  |  Paganism  
lake  |  quarter  |  guitar  |  Scientology  
spoon  |  schilling  |  pancreas  |  Shinto  
strainer  |  nickel  |  spleen  |  Taoism  
(Foil: ladle )  |  (Foil: peso )  |  (Foil: liver )  |  (Foil: Hinduism )
### Word Lists for Experiments 4, 5, and 6

#### Non-Taboo “Neutral” Words

| Alaska     | alzheimers           | book       | cinnamon |
| April      | amethyst            | boots      | clarinet |
| August     | angry               | Boston     | classical |
| Baltimore  | ant                 | bourbon    | clause |
| Colorado   | anxious             | bowl       | cleats |
| December   | apartment           | brain      | cleric |
| Denver     | appendix            | brass      | clogs |
| Detroit    | apple               | bribery    | cockroach |
| England    | arm                 | broccoli   | coffee |
| Finland    | article             | bronze     | coke |
| Florida    | assault             | brother    | collie |
| France     | attic               | brown      | colonel |
| Germany    | aunt                | brownie    | commander |
| Houston    | axe                 | bruise     | condo |
| Illinois   | axle                | bubblegum  | conjunction |
| Indiana    | ballcap             | buckeye    | consonant |
| Ireland    | ballet              | bulldog    | contraction |
| Islam      | ballroom            | burglary   | cookie |
| Italy      | banana              | burn       | cookies |
| January    | banker              | bus        | copper |
| July       | baseball            | butterfinger | corn |
| June       | basement            | butterfly  | corporal |
| M&Ms       | basil               | cabin      | cotton |
| Maine      | basketball          | cadet      | couch |
| Miami      | bathroom            | cake       | country |
| Missouri   | beagle              | calcium    | cousin |
| New York   | beanie              | California | crackers |
| Norway     | bed                 | canyon     | crossbow |
| November   | bedroom             | captain    | crow |
| October    | bee                 | car        | crown |
| Ohio       | beer                | carbon     | cucumber |
| Pennsylvania | beets              | cardinal  | cuumin |
| Philadelphia | bicycle            | carp       | custard |
| Portland   | birch               | carrot     | cut |
| Scotland   | bishop              | catfish    | daffodil |
| September  | black               | cauliflower | daisy |
| Shinto     | bladder             | cedar      | Dallas |
| Spain      | blaster             | ceiling    | dalmation |
| Sweden     | blizzard            | celery     | dandelion |
| Switzerland | blues               | cello      | dashboard |
| Taoism     | blue                | centimeter | daughter |
| Texas      | blueberry           | centipede  | decimeter |
| Virginia   | bluegrass           | cha-cha    | denim |
| accountant | bluejay             | chair      | dentist |
| adjective  | bluegrass           | cheetohs   | desert |
| admiral    | blueberries         | chef       | desk |
| adverb     | blueberries         | chemistry  | diamond |
| afraid     | blues               | Chicago    | dictionary |
| airbag     | boat                | chihuahua  | dime |
| airplane   | bolt                | chrome     | disco |
| aluminum   | bonnet              |            |        |
pretzels  
priest  
pringles  
pronoun  
pudding  
pug  
punk  
purple  
quarter  
rabbi  
radiator  
rain  
rap  
recliner  
red  
reggae  
relaxed  
reverend  
river  
roach  
robin  
rock&roll  
roof  
rose  
rosemary  
salmon  
salsa  
salt  
sapphire  
satin  
saxophone  
schilling  
scotch  
scrap  
scratch  
screwdriver  
seagull  
seatbelt  
sergeant  
shack  
shameful  
shark  
shingles  
shirt  
shorts  
shovel  
silk  
silver  
sister  
skillet  
skirt  
skittles  
sleet  
slippers  
snapper  
sneakers  
snickers  
snow  
soccer  
socks  
sodium  
sofa  
softball  
soldier  
son  
spaniel  
spatula  
spear  
speedometer  
spider  
splitter  
spoon  
sprain  
sprite  
spruce  
stairs  
startburst  
steel  
stomach  
strainer  
strawberry  
stressed  
suit  
sulfur  
surprised  
sweater  
swing  
sword  
sycamore  
table  
tango  
tap  
taxi  
te  
teacher  
techno  
tennis  
tent  
tequila  
terrier  
textbook  
thief  
tin  
titanium  
toe  
tomato  
tornado  
train  
trombone  
tROUT  
truck  
trumpet  
trunk  
tsunami  
tuba  
tulip  
turban  
twix  
twizzlers  
uncle  
Utah  
valley  
van  
verb  
violin  
vodka  
volcano  
volleyball  
vowel  
walls  
waltz  
wasp  
water  
waterfall  
watermelon  
webpage  
whisk  
willow  
window  
windshield  
windshield  
window  
wine  
wool  
wrench  
yard  
yellow  
yen
Taboo Words
(*indicates word that was intentionally presented first in Experiments 5 and 6)

anus
asshole
bastard
bitch
blowjob
boner
cock
cunt*
dick
dildo
fart
fuck
herpes
jizz
nutsack
orgasm
penis
piss
pussy
queef
sex
shit
skank
slut
tits
twat
vagina
whore