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Emotion and Pain Effects on Tunnel Memory

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Emotion and Pain Effects on Tunnel Memory

A Thesis

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Alexandra Nicolette Robinson-Norris

ABSTRACT

Previous work by Andreano and Cahill (2006) has shown the Cold Pressor Stress (CPS) to enhance memory. A similar enhancement can occur with non-physical stressors. Puga & Bohannon (2013) found emotional slides to have an enhancing effect on preceding information. Although it is clear that physical and visual stressors can enhance memory, it is still unclear whether peripheral or central items are better remembered after arousing situations. Safer et al. (1998) suggested that during encoding, arousal creates a "tunnel memory" effect. Participants accurately remember central items but tend to disregard those in the periphery. The study focused on combined visual and physical stressors and their effects on memory, specifically in terms of perceptual centrality. Immersing their arm in a warm or ice water bath, participants (N=141) viewed a 16 image slideshow. The slideshow consisted of images of various rooms and items around a house, and the critical slide was emotional or non-emotional. A significant slide type by perceptual centrality interaction resulted. More central items from the emotional slide were remembered compared to the number of peripheral items. Participants experienced tunnel memory when exposed to the visual stressor.

INTRODUCTION

Is There Evidence That Emotional Arousal Modulates Memory?

A flashbulb memory is an elaborate and detailed memory for a shocking public event that seems impervious to forgetting. (Brown and Kulik, 1977). High consequentiality or surprise at encoding can lead to flashbulb memory formation, but affect also plays a substantial role. The stronger a person's emotional reaction, the better the memory tends to be. Individuals who experienced greater emotional reactions, were more consistent in their memories about the 1986 Challenger explosion. These participants also displayed higher confidence ratings and more extensive memories compared to individuals who did not experience intense emotional reactions (Bohannon & Symons, 1992). Hornstein, Brown, & Mulligan (2003) found similar results for the death of Diana, Princess of Wales. Researchers asked participants to recall the circumstances in which they first heard the news of Princess Diana's death. Memory accuracy was assessed at three and eighteen months post-event and was operationalized in terms of consistency. Along with rehearsal, emotional intensity affected the consistency of participants' recollections.

In response to emotionally stimulating information, arousal levels may increase and affect memory. Many studies acknowledge arousal's role in the formation of flashbulb memories. Nearly one year following British Prime Minister Margaret Thatcher's resignation, 86% of United Kingdom (UK) participants displayed evidence of flashbulb memories. Only 29% of non-UK participants exhibited flashbulb memories

during that time. Individuals who found the resignation event inherently relevant and arousing had longer lasting memories compared to those who did not (i.e. non-UK participants). Along with level of importance, level of affect and thus arousal determined whether an individual experienced a flashbulb memory (McClelland, Rawles, & Logie, 1994).

Flashbulb memories are not limited to public events; they also encompass private events such as coming out (Rossi, 2010). According to Berntsen and Rubin (2006), humans are social creatures that need to assign meaning to their experiences. Doing so helps in stabilizing and understanding one's self-concept. Two main theories exist and attempt to explain the mechanism of flashbulb memory recall. Brown and Kulik (1977) argue that emotional affect at encoding leads to improved memory. California residents better recalled their experiences of the 1989 Loma Prieta earthquake compared to individuals from Atlanta. The more emotionally significant the event was, the more detailed the narrative was. In opposition to the affect theory is the reconstructive recall hypothesis. Hirst et al. (2009) asked participants to recall their circumstances in which they learned of the terrorist attacks on September 11, 2001. Participants were asked one week, eleven months, and 35 months post-event. As time progressed, forgetting decreased and flashbulb memory content stabilized, specifically for emotional information. It is clear that arousal impacts memory, but in what way and how remain debatable.

Arousal can influence the scope and longevity of flashbulb memories. While some flashbulb memories are ephemeral, others persist for lengthy periods. Schmolck et al., (2000) assessed college students' memories for hearing about the verdict concerning OJ

Simpson's murder trial. The students were tested at fifteen and then 32 months post-event. Even after 32 months, some students still possessed flashbulb memories regarding the trial. Many researchers debate the factors that cause flashbulb memories to remain intact. Some ascertain that consequentiality and confidence are primary factors, while others believe initial affect is necessary (Pillemer, 1984). Various theories exist and attempt to explain the underlying cause of flashbulb memories and what causes them to become so enduring and extensive.

The "arousal hypothesis" suggests that individuals experiencing high affect at time of encoding, will experience improved memory for a shocking and emotionally stimulating event. (Bohannon, 1988; Christianson, 1992; Gold, 1987). Strong emotions arise when individuals receive news of personally relevant or distressing events. In response to the stimulating news, heightened emotion leads to arousal and links current information with stimuli that triggered the flashbulb memory. What aspects of a flashbulb memory triggering event are remembered varies, as suggested by multiple researchers. Bohannon, Gratz, & Cross (2007) assessed adults' memories for publicly shocking events. If the stimulating event was heard from another person, the participants better remembered the circumstances of their discoveries. Compared to these participants, individuals who heard the news through the media reported more factual details. Arousal and emotion appear to affect what aspects of an event are recalled and could play a significant role in terms of perceptual centrality.

According to Loftus (1991) increased attention to an event does not solely account for enhanced memory for central details of an arousing event. Loftus had participants

watch a slideshow with a neutral, unusual, or arousing critical slide in the middle of the show. Eye fixation was measured while participants viewed the critical slide (a lady bleeding and lying next to her bike). Based on similar eye fixation times, participants were compared for memory differences. No difference in the amount of eye fixations accounted for the number of central details recalled. Participants recalled similar amounts of central details from the arousing slide (Loftus, 1991). Loftus's results suggest that memory increases for emotionally arousing events. This finding has been backed by biologically based studies as well.

Physiological Evidence

Puga & Bohannon (2013) found that participants exposed to a slideshow including horrible emergency room photos displayed heightened memory for neutral, pre-critical slides. The finding was explained by an evolutionary mechanism: information predicting threat has a mnemonic advantage. Physical stressors, such as a two-minute cold pressor stress (CPS), can also lead to heightened memory (Andreano & Cahill, 2006). Affecting the amygdala and hippocampus, stress hormones modulate the enhancement effect that stress can have on memory. Enhanced memory results when low doses of glucocorticoid hormones are applied at post-training. When given in large doses, these hormones impair memory. To assess this quadratic relationship for endogenously released glucocorticoid hormones, Andreano and Cahill (2006) had participants read Bartlett's "War of the Ghosts." After the story, participants placed their arm in a CPS or warm water bath. One week later, participants attempted to recall the neutral story. The CPS resulted in increased cortisol levels for both sexes but only improved memory for

male subjects. Results of the study demonstrated an inverted-U curve between endogenous stress hormones and human memory (Andreano & Cahill, 2006).

Looking at the interaction of cortisol and level of arousal, Andreano, Gorski, & Le (2003) had participants view an emotional or neutral slideshow. Cortisol levels were measured, and participants then immersed their arm in a CPS or warm water bath. One week later, participants were asked to recall the slides they had seen. The CPS improved memory for the emotional slides but not for the neutral slides. Amount of arousal at encoding interacts with the post-learning stress hormone to modulate memory consolidation. Different amounts of arousal at encoding could account for inconsistencies in the literature concerning CPS, arousal, and memory (Cahill, Gorski, & Le, 2003).

A study by Buchannan, Tranel, & Adolphs (2006) studied the effects of stress on memory by subjecting participants to a CPS or warm water bath after they learned arousing or neutral words. Following the bath, participants completed a recall task. Participants were divided up based on their cortisol response; some individuals showed no increase (non-respondent group). Compared to the control and non-respondent groups, individuals who showed increases in cortisol levels recalled fewer words. In particular, participants recalled the moderately arousing words less often. Cortisol levels affect memory retrieval which indicates stress's effects on memory (Buchanan, Tranel, Adolphs, 2006). Unlike research with emotionally stimulating material, increased cortisol levels do not seem to enhance memory for neutral and arousing information. Type of stimuli could account for discrepancies between studies. Compared to visual information

that was neutral, neutral auditory information was better recalled in arousing situations (Beckwith et al., 1986).

Daniela & Smeets (2009) assessed the effects of CPS on O-Span task and digit span task performance. These tasks differed on the amount of maintenance and executive functioning involved. Before the study and two weeks post-study, salivary cortisol levels were taken as a measure of hypothalamic pituitary adrenocortical (HPA) function. Acute stress triggered by the CPS impaired performance for the backward digit span task but not for the forward digit span task. Performance on the O-Span task was also impaired in the acute stress condition. Results indicate that stress impairs working memory for tasks that require executive functioning but not for tasks that involve maintenance (Daniela & Smeets, 2009).

CPS can enhance and impair memory as evidenced by a study performed by Duncko (2007). Participants were exposed to a CPS or warm water bath for 60 seconds, followed by completion of the Sternberg item recognition task. Salivary cortisol levels and heart rate measures were taken to assess HPA and sympathetic nervous system activity. Participants subjected to the CPS displayed faster reaction times but made more false alarms for the Sternberg task. The faster reaction times indicate the evolutionary benefit of a fast response. A streamlined information processing advantage is necessary in threatening situations (Duncko, 2007).

Stress-induced cortisol is advantageous for recall of emotional information. Smeets, Otgaar, Candel, & Wolf (2008) studied the effects of stress and stress-induced cortisol on encoding, consolidation, and retrieval processes. Participants were exposed to

either a CPS or warm water bath before encoding, during consolidation, or at retrieval. Twenty-four hours later, participants were given the Deese-Roediger-McDermott word list learning paradigm. Stress during consolidation resulted in enhanced true memory (words from the list). In particular, memory for emotional words was enhanced. Stress at retrieval impaired memory for the word list and resulted in a higher rate of false memory. CPS did not affect memory and false recall for neutral conditions, suggesting that cortisol plus sympathetic activity are unrelated to the recall of neutral information. The findings demonstrate how stress-induced cortisol levels and heightened sympathetic activity are important for enhancing memory consolidation. Memory can be impaired, though, if stress is present at retrieval (Smeets, Otgaar, Candel, & Wolf, 2008).

Increases in cortisol can enhance cognitive functioning up to a certain point. Activating the autonomic nervous system, the CPS leads to heightened cortisol levels and mild activation of the HPA axis. Duncko, Johnson, Merikangas, & Grillon (2010) found an association between CPS and increased working memory capacity. Better working memory led to improved learning for the Sternberg recognition task. Enhanced working memory also resulted in better executive functioning which is important for filtering out irrelevant information. Being able to focus solely on relevant information is necessary in stressful situations (Duncko, Johnson, Merikangas, & Grillon, 2010). Not all research supports the claim that arousal improves working memory. De Quervain, Roozendaal, Nitsch, McGaugh, & Hock (2000) found that treatment with cortisone with acute-stress levels led to impaired recall of long-term declarative memory for a word list. No enhancement effects were found for cortisone administration before or after learning. The

dose of cortisone may have been too low for any significant effects to be found (De Quervain, Roozendaal, Nitsch, McGaugh, & Hock, 2000). Acute stress may impair or not affect memory at all (Kuhlman et al., 2005; Vedhara et al., 2000).

Anomalous Effects of Arousal

Tunnel memory occurs when peripheral details are diminished and central details are facilitated, usually occurring in stressful situations (Mackworth, 1965; Williams, 1988). For example, when an officer shoots a suspect, the officer can only remember the contour of the suspect's face (Stratton, 1986).

The cue-utilization hypothesis by Easterbrook suggests that attentional narrowing accompanies emotional events. That is, attention is only focused on the emotional stimuli as arousal increases. In the presence of arousal, performance on tasks that involve many cues is hindered compared to tasks with minimal cues (Easterbrook, 1959). For neutral events, both central and peripheral details are expected to be remembered. After controlling for exposure duration and eye fixation, central details are still increasingly remembered for arousing stimuli (Christianson, Loftus, Hoffman, & Loftus, 1991). Taylor (1991) found that negative features appear to be more salient than positive aspects of a situation. In response to Taylor's claim, Lang (1994) concluded that a pronounced startle response occurs in response to negative affect. As a result, rapid narrowing of attention for focusing on central details occurs. Christianson (1992) theorized that tunnel memories occur because of increased attention, more pre-attentive processing, and increased post-event elaboration for central details of an upsetting scene.

Supporting the theory of attentional narrowing is the weapon focusing effect. Research on this effect illustrates how the presence of an emotionally stimulating object influences memory (Steblay, 1992). At the expense of other details in memory, people better remember the weapon from a scene. Kramer, Buckhout, & Eugenio (1990) investigated the weapon focusing effect by having participants view a mock crime scene. A weapon was either visible or hidden in the viewed crime scene. Individuals in the highly visible group (weapon in plain sight) recalled significantly fewer crime scene details compared to individuals in the less visible group. Self-reported arousal ratings correlated negatively with memory accuracy scores, suggesting that increased arousal led to narrowing of attention. The researchers also assessed the weapon focus effect in a non-emotional situation where "time of exposure" for the weapon or the suspect's face was manipulated. The effect resulted even in a stark setting (Kramer, Buckhout, & Eugenio, 1990).

Another study aligning with the idea of tunnel memory was done by Loftus and Mackworth (1978). The researchers assessed eye fixations for informative and formative objects in a scene. An example of an informative object is an octopus in a farm scene. Overall, participants spent more time fixating on informative objects. Fixating on informative objects may serve as a memorization technique for differentiating between scenes. Perhaps focusing on informative objects generalizes to fixating more on central details of threatening/arousing events. Evolutionarily speaking, people need to know the difference between a dangerous and harmless situation to survive. Another explanation for increased fixation for informative objects concerns schemas. Knowing the gist of a

scene is necessary for schema activation. Concentrating more on informative items (i.e. items that do not belong) allows a person to incorporate the object into the schema if it is safe to do so (Loftus & Mackworth, 1978). As with tunnel memory, only the most relevant items were remembered.

Tunnel memory even holds true for autobiographical memory. Berntsen (2002) concluded that central details dominate autobiographical memories dealing with people's most shocking past events. The finding does not hold true for individuals' most positive past events. In opposition to the ideas of repression and dissociation, Berntsen's work acknowledges that negative aspects of an event are enhanced and not "put away." Both arousal and negative valence work to increase an individual's recall of past events that are negatively arousing. Central details are more likely to be included in the recollection of past negative events, whereas both central and peripheral details are included for past positive events. Tunnel memory does not seem to occur for positive events. Overall, negative events are remembered more than positive ones. For positive events, arousal is simply not enough to significantly increase recall. Negative valence has to be involved too. Talarico, Berntsen, & Ruben (2009) found an increase in peripheral details for positive events but not for negative events. According to the theory *Broaden-and-build*, paying more attention to peripheral details of an event enhances the positive experience. Increased attention to these details at time of encoding results in increased recall of the positive experience (Ellsworth & Scherer, 2003). Negative experiences do not display the phenomena of the *Broaden-and-build* theory. The narrowing of attention for salient central details inhibits encoding for peripheral details (Welch, 2001). Increased recall for

central details of a negative event could be a consequence of rehearsal and reconstruction. Relying more on their general knowledge and intuition, people are more likely to describe their positive experiences with peripheral details. Information for negative experiences is scrutinized more, and central details are what a person focuses on (Bless et al., 1996).

As with negative autobiographical events, the theme and essence of traumatic events are remembered better than the peripheral details are. Christianson & Loftus (1987) had participants view slides while focusing on rehearsing the central details. The researchers tested the participants' recall twenty minutes later and after two weeks. Central details that had been rehearsed were better recalled for the traumatic event slides. The complete traumatic slide was less recognizable compared to the non-traumatic slides, suggesting that peripheral details were not encoded for the traumatic slides. Peripheral details were focused on for the non-traumatic slides, making overall slide recognition easier. In another study, victims and onlookers of a bank robbery were asked to recall the robbery. Compared to the onlookers, the victims significantly recalled more of the robbery's details. Anxiety for the event enhanced the memory for it, and the effect even lasted fifteen months after the event had occurred. Arousal in response to visually distressing information affects memory, but what about physical stressors?

Pain as an Agonistic Effect to Arousal

Pain leads to enhancements in both physiological and cognitive mechanisms of arousal. When a person is mentally aware of the body's physiological arousal, an emotion occurs. Stanley Schachter hypothesized that individuals induced with anxiety would display altered affiliation tendencies. Female college students were separated into two

groups—high anxiety and low anxiety. The researchers convinced participants in the high anxiety group that they would be receiving a painful shock. Whereas individuals in the low anxiety group were told the shock would be painless. The women were asked to rate their anxiety levels and decide whether they preferred waiting alone or with others before receiving the shock test. Sixty-three percent of participants in the high anxiety group wanted to remain together compared to only 33% of the participants in the low anxiety group (Schachter, 1959). Due to increased levels of physiological arousal, alterations in cognition occurred, suggesting the existence of a link between the two. The changes made to cognitions in response to changes in one's physiological state parallels cognitive dissonance.

Cognitive dissonance occurs when an individual's attitudes do not align with a behavior. If an individual is experiencing cognitive distress, but not physical distress, then consistency is not present. To create a sense of consistency, a person will attempt to synchronize the differences. For example, a person expects a dinner to go extremely well, but it does not. As a result, dissonance is present and the person experiences physiological distress (Cooper, 2007). Eisenberger et al., 2003 suggested that the neural systems involved in stressful situations overlap. Participants who are harshly rejected remember more details about the event compared to participants politely rejected (Pajkos et al., 2011). Like Eisenberger found, there appears to be synchrony amongst the neural circuitry associated with distressing experiences. If this is the case, then a picture of chopped fingers should elicit arousal just like a CPS would.

Would a Combo of Arousing Pictures and CPS Enhance Memory?

It is unclear how stressors interact to affect memory. Common phenomena where a rape victim cannot remember the rapist's face, even though the rapist had no mask on, often occur (Bryne, Hyman, & Scott, 2001). The Yerkes-Dodson Law may explain the discrepancies. The intensity of a stimulus is a significant determinant of arousal, and different tasks require different amounts of arousal for optimal performance. High glucocorticoid levels may enhance memory for emotionally arousing information, but impair memory for information unrelated to the stressor. The effects of arousal may vary with memory type. Mildly elevated glucocorticoid levels are ideal for long-term memory formation, whereas low levels hinder long-term memory formation (Anderson, Revelle, & Lynch, 1989). Gold (1987) also found support for the inverted-U curve proposed by the Yerkes-Dodson Law. After training, rats were immediately injected with glucose and showed memory improvements the following day. Moderate levels of arousal led to the best results, indicating the superiority of the dose-response curve.

The source of arousal may also serve as a determinant of memory enhancement or inhibition. In a study by Libkuman et al. (1999), arousal was induced via an exercise bike or emotional slides. Physiological arousal resulting from the bike led to deficits in memory for the gist, central, and background details, but the emotional arousal resulted in an enhancement for background and central details. In this case, arousal was viewed as multi-dimensional. Perhaps, emotional slides and a CPS result in different cognitive outcomes due to differences in arousal. It is also unclear whether central or peripheral details of stressful events are remembered better. How memory is affected under stressful

conditions has been a topic of interest for many years. Why does it appear that under some emotional situations, memory suffers?

Current Study

The purpose of the current study was to assess the interaction of a physical stressor (CPS) and a visual stressor (emotional slide) on memory. Although previous work has looked at the impact of emotional stimuli and physical stressors individually, little research has combined both. There are also many inconsistencies in the literature concerning both tunnel memory and CPS. Increased levels of stress should enhance memory, specifically for events preceding the critical period. The combination of CPS and emotional slides could push the cognitive/memory system past the inverted-U curve and show memory inhibition (Gold, 1989). In contrast, the memory effect may be dependent on how the individual participants handle the combination. Those participants who rate their emotion and pain as severe may show memory degradation, whereas those in the same high arousal/CPS condition who rate their arousal as less extreme may retain the retrograde memory advantage (Yerkes-Dodson Law, 1908). The arousing conditions should also affect centrality. Tunnel memory should occur when the physical and visual stressors are combined and when they are presented separately. Our hypotheses were as follows:

1. If the Cold Pressor stress test and emotional slides increase arousal, then information that occurred before and during the stressors should be better remembered.

2. If participants experience an increase in arousal, then cognitive efficiency should increase post-slideshow.
3. If participants experience a physical stressor, visual stressor, or both then tunnel memory should occur.

METHOD

Participants

Participants ($N = 141$) were undergraduates from Butler University. Because Butler University is predominately female, there were more females ($N = 105$) compared to males ($N = 36$). The average age of participants was 20.05 years. Students enrolled in psychology classes received extra credit for their participation. Students not enrolled in psychology courses received no incentive. Participants with a history of heart problems, vascular disease, high blood pressure, a history of fainting or seizures, Reynaud's phenomenon, or diabetes were asked to refrain from participating in this study.

Design

The study was a 2 (condition: ice/warm water) x 2 (slide type: emotional/non-emotional) x 3 (slide order: pre-critical/critical/post-critical) mixed design. The criterion variables were cognitive efficiency and memory recall. Slide order was a within subject variable. Condition and slide type were between subject variables.

Materials

We used a mood/arousal grid test (Eich & Metcalfe, 1989) that measured valence and arousal along with a word search that served as an interpolated task. Participants also

completed a demographic survey concerning their gender, age, and year in college. We showed participants one of four slideshows (original order/critical, original order/neutral, reversed order/critical, or reversed order/neutral). The slideshow included 16 photos of various places and items around a house.

Procedure

Participants first read and signed an informed consent agreement (See Appendix A) and completed the initial mood-arousal grid (See Appendix B). Participants were allotted 8 minutes to complete the first word search (See Appendix C) and then started viewing one of the four slideshows (See Appendix D). After photos 1-5 (filler slides) and the 6th photo (pre-critical slide), participants placed their recessive arm in an ice water bath (CPS) or lukewarm water bath (control) and viewed the 7th photo (critical slide) and photos 8-10 (filler slides). Participants held their arm in the water for up to two minutes or until unbearable. The temperature of the lukewarm water was 90-100 degrees Fahrenheit, and the temperature of the CPS was 32-34 degrees Celsius. Participants removed their arm from the water and viewed the 11th slide (post-critical slide) and slides 12-16 (filler slides). After the slideshow participants completed a second mood-arousal grid and word search (See Appendix E); eight minutes was allotted for word search completion. Participants completed a free recall which consisted of three blank sheets of paper for the participants to freely recall as many items as possibly from the breakfast, lunch, and bathroom scenes (See Appendix F). Participants were debriefed and provided with contact information to the Butler University counseling center, in case any distress

beyond the experiment was experienced. Throughout the study, check-ins were provided to ensure that participants felt alright after experiencing the physical stressor.

Scoring

Memory was scored based on whether or not participants listed the correct slide items. Bathroom, lunch, and breakfast scenes had select central and peripheral items that were considered to be correct. Slide items were also broken down into correct thematic and athematic items. The scoring rules were previously used in Puga & Bohannon (2013). Amount of correctly recalled items was summed up for each participant (See Appendix G).

RESULTS

Test of Effectiveness of Manipulations

We used a series of one-way ANOVAs to perform manipulation checks for arousal and valence. We found no main effect of affect on level of arousal, $F(1, 133) = 1.848$, $p = .1767$, $d = .077$ and we found no main effect of condition on arousal, $F(1, 133) = .327$, $p = .5681$. Hypothesis one was not supported because the stressors did not cause increased arousal levels. Valence was expected to decrease with the visual and physical stressors as well, but condition had no main effect on valence either, $F(1, 133) = .064$, $p = .8001$. Affect did have a main effect on valence ratings though, $F(1, 133) = 10.615$, $p < .0014$, $d = .261$, suggesting that the emotional slides did appropriately influence valence ratings. Participants exposed to emotional slides displayed decreased valence ratings (M=.382) compared to participants exposed to non-emotional slides

(M=1.223). There was also a significant interaction between emotion type, condition, and time on Eich scores, F (1, 133) = 7.527, p <.0069, d = .215 (See Table 1). When combined with emotional slides, the CPS resulted in increased arousal post-slideshow (M =.927) compared to pre-slideshow ratings (M = .600). When combined with emotional slides, the CPS resulted in decreased valence ratings post-slideshow (M = .382) compared to pre-slideshow ratings (M = 1.545). For emotional slides put with warm water, arousal was higher post-slideshow (M = .817) compared to pre-slideshow ratings (M = .622). Valence ratings decreased (M = .927) post-slideshow compared to pre-slideshow ratings (M = 1.171) when emotional slides were combined with warm water. These results indicate that our hypothesis about arousal's effects on memory and cognitive efficiency will not be supported. Although CPS appears to have increased arousal, it only did so in the presence of emotional slides.

Test of Affect and Condition on Memory and Cognitive Efficiency

Further analysis using one-way ANOVAs for condition and affect on the dependent variables of memory recall and cognitive efficiency were done. As expected, condition did not have a main effect on memory recall of central/peripheral details, F (1, 133) = .827, p = .3649 or memory recall of thematic/athematic items, F (1, 134) = .852, p = .3576. Affect also did not have a significant effect on memory recall for central/peripheral details, F (1, 134) = .878, p = .3504, nor did it have a significant effect on memory recall of thematic/athematic items, F (1, 134) = .972, p = .3260. As stated earlier, a lack of enhancement for memory recall and cognitive efficiency were most likely due to the failed arousal manipulation.

Affect did have a main effect on cognitive efficiency, $F(1, 134) = 11.224$, $p < .0010$, $d = .269$. As displayed by figure 1, cognitive efficiency increased after viewing emotional slides ($M = 17.603$) compared to non-emotional slides ($M = 14.447$). Compared to the initial level of cognitive functioning ($M = 13.804$), post-slideshow functioning increased as indicated by the number of words found in the word search ($M = 16.645$). Counter to hypotheses, CPS did not increase cognitive efficiency, $F(1, 134) = 1.084$, $p = .2998$, $d = .024$. Only part of our hypothesis two was supported—emotional slides resulted in increased cognitive efficiency post-slideshow.

Test of Tunnel Memory

Alone, affect had no main effect on recall, but there was a significant interaction between affect and perceptual centrality, $F(1, 134) = 4.282$, $p < .0404$, $d = .153$ (*See Figure 2*). For emotional slides, central items were better recalled ($M= 1.863$) compared to the amount of peripheral items recalled ($M = 1.076$). This suggested tunnel memory. For non-emotional slides, central items were still remembered more ($M = 1.756$) compared to peripheral items ($M = 1.215$) but the difference was larger with the emotional slides. Even with variations in slide order, central items were remembered more, but to what extent varied. Overall more central items were remembered from the post-critical slides ($M = 1.935$) compared to the pre-critical ($M = 1.536$) and critical slides ($M = 1.877$). The differences were not very large, indicating a lack of arousal. Peripheral items were also remembered better for the post-critical slides ($M = 1.659$) compared to the pre-critical ($M = 1.197$) and critical slides ($M = .384$). In opposition to hypothesis one, more post-critical items were remembered compared to pre-critical and

critical slide items. The widest gap between number of recalled peripheral and central items occurred for the critical slides, an indication of tunnel memory. Again, only part of hypothesis three was supported because CPS did not result in tunnel memory but the emotional slides (i.e. critical slides) did.

Although the emotional slides resulted in enhanced recall of central details, the CPS did not significantly interact with perceptual centrality in such a way, $F(1, 134) = .275$, $p = .6006$. No significant interaction between perceptual centrality, condition, and affect resulted, $F(2, 268) = 1.744$, $p = .1768$, $d = 103$.

Effect of Context on Memory

The effect of context on free recall was assessed using ANOVAs and had a significant effect, $F(1, 134) = 302.143$, $p < .0001$, $d = 1.461$. A significant interaction between context and affect also occurred, $F(1, 134) = 8.731$, $p < .0037$, $d = .234$. Thematic items were recalled more from non-emotional slides ($M = 2.683$) compared to emotional slides ($M = 2.216$). Athematic items were recalled more from emotional slides ($M = .549$) compared to non-emotional slides ($M = .301$). As expected, thematic items were remembered better ($M = 2.568$) compared to athematic items ($M = .362$) overall. '

DISCUSSION

The purpose of this study was to investigate the interaction of a CPS and a visual stressor on memory and cognitive efficiency. Numerous studies have addressed the effects of physical stressors and visual stressors on memory (Andreano & Cahill, 2008; Puga & Bohannon, 2013), but few have studied their interaction, specifically on

perceptual centrality. Increased arousal tends to result in heightened memory for information preceding the stressor (Puga & Bohannon, 2013). In order to observe this effect, the arousal manipulation needs to work. To test for arousal, we used the Eich-Metcalfe mood/arousal grid and had participants complete it before and after viewing the slideshow. We checked arousal levels to see if the CPS exaggerated the arousal response like we hoped for. Unfortunately, the manipulation check failed and was most likely due to a limited amount of arousing information. Only one emotional slide was used in the slideshow and most likely was not enough to increase arousal ratings. Our manipulation check for valence only worked for emotional slides. Unlike we expected, CPS by itself, did not result in decreased valence ratings. Emotional slides did result in decreased valence ratings, suggesting that the emotional slides exaggerated the decrease in feelings of pleasantness. The failed arousal manipulation checks suggests that our study did not turn out like we had expected.

We did not find support that items from pre-critical and critical slides were better remembered than items from post-critical slides. There are a couple of possible reasons for why our hypothesis one was not supported. Emotionally induced memory can lead to enhanced or impaired recall for pre-critical information depending on whether this information was prioritized to begin with (Sakiki, Fryer, & Mather, 2013). Perhaps participants were too focused on what condition (i.e. ice or warm water) they were going to receive and could not focus on the pre-critical slides. After getting the ice or warm water bath out of the way, participants may have been able to better focus and prioritize the post-critical information. Differences in level of surprise have been found to affect

memory in previous studies as well. Brown and Kulik (1977) asked participants to recall their accounts of John F. Kennedy's assassination. The higher the level of surprise, the more vivid and detailed the recollections were. Surprise appeared to correlate with the quality of participants' responses. With this said, other studies have shown otherwise. Vaclavik (2011) assessed participants' memories for first sexual encounters. Participants who planned their sexual encounters showed enhanced memories compared to those who had not planned their sexual encounters. A person may encode a surprising personal event differently than a non-personal event. Instead of encoding all details of a personally relevant event, an individual may encode the most relevant details. As mentioned earlier, doing so serves as a survival strategy. A non-personal event that's surprising carries less threat with it, and thus more details are retained.

Another reason for the lack of support may be that only one emotional slide was included in the slideshow, and the emotional slide was probably not viewed as a threat. As a result, information preceding the critical slide did not need to serve as mnemonic device for avoiding threat. However, Puga & Bohannon (2013) used emotional slides and found that participants remembered more of the information preceding the critical slides. In our slideshow, we only used one emotional slide, but Puga & Bohannon (2013) used four emotional slides. Maybe one emotional slide was not enough to increase arousal. Arousal interacts with stress hormones, and differences in level of arousal could produce different outcomes in terms of memory (Andreano, Gorski, & Le, 2003).The difference in the number of emotional slides used, most likely accounted for our hypothesis not being supported.

Hypothesis two regarding cognitive efficiency and stressors was partially supported. CPS did not have a main effect on cognitive efficiency, but affect did. Participants who saw emotional slides performed better on word search two. It is important to note that participants in the emotional affect group started higher on their level of cognitive efficiency. Perhaps seeing what condition they were going to receive, affected attention. Individuals who knew they were in the CPS group may have become more alert and thus performed better on word search one. Still, participants in the emotional affect group displayed a higher increase in cognitive efficiency level compared to participants in the non-emotional affect group.

Lastly, we did find support for hypothesis three concerning the phenomena of tunnel memory. Participants who viewed emotional slides recalled more central items overall compared to peripheral items. This finding is in line with many other findings and suggests that people remember only the most important items in stressful situations. Still, there is much disagreement as to how tunnel memory occurs. Some researchers favor the attentional-narrowing theory (Mackworth, 1965; Williams, 1988), while others attribute tunnel memory to heightened arousal levels (Loftus, 1991). Our study overlaps more with the theories that favor attentional-narrowing. Participants displayed increased memory for post-critical central items but did not display significantly increased arousal ratings, suggesting that attention was being more focused on certain items. Caution should be taken though when analyzing these findings because of the limited number of emotional slides used.

Limitations

Like most studies, our study has limitations that need to be addressed. Participants knew ahead of time which condition they were going to be in, potentially influencing level of alertness. Care should be taken to cover up the CPS or warm water bath to prevent the unwanted effect of another variable in future studies.

Another limitation was the number of emotional slides used in the slideshow. Unlike Puga & Bohannon (2013), we only implemented one emotional slide. In future studies more emotional slides need to be used to determine whether a lack of arousing stimuli influenced what was remembered. This could also help determine whether it is attentional-narrowing, arousal, or both that result in tunnel memory.

Effects of gender should also be assessed more. Cahill and Stegeren (2003) gave men and women a B-adrenergic receptor antagonist (propranolol) to assess its impact on long-term memory for an emotionally salient story. Memory for central details were enhanced for women and peripheral details for men. Propranolol improves memory for the peripheral details by activating the right amygdala/hemisphere function in men. For women, propranolol activates the left amygdala/hemisphere function (Cahill & Stegeren, 2003). The results show how stress and arousal may affect memory for men and women differently. Looking at men and women separately could provide insight into differences that a CPS and a visual stressor has on memory. Going off of that, the effects of a CPS and a visual stressor might affect different populations in a variety of ways. It would be interesting to compare the effects of the visual stressor on college students' and older individuals' memories.

It is important to also keep in mind the variety of memory issues surrounding health issues such as insomnia. Although our study asked individuals with diabetes and other related health concerns to refrain from participating, we had no way of ensuring that that participants did not display other medical conditions. Medical literature supports the notion that college students with insomnia display deficits in learning and memory, most likely a result of alterations in neurocognitive functioning and synaptic plasticity. (Curcio, Ferrara, & Gennaro, 2006). Differences in memory could be interacting with subject variables like personal health issues. It would be helpful to better control for such variables.

Finally, some of the items on the slideshow may have been difficult to recognize, limiting the number of items that could be recalled. Future studies should address this concern by including items that are universally recognized.

Ideas for Future Studies

Robinson (1980) gave participants a series of words and asked them to recall a personal experience that came to mind. The speed at which a participant recalled an event depended on the emotional intensity of the word. That is, the emotion itself did not matter. In our study, we looked at pre and post slideshow valence ratings but did not assess other emotions such as anger. Although our arousal manipulation did not work this time around, the emotional slide affected valence. The critical slide was limited in what emotion it conveyed. In the future, it would be interesting to incorporate slides that elicit a variety of emotions such as anger, sadness, and joy. Perhaps results would change when

a slideshow with joyful images was combined with the CPS, keeping in mind the Yerkes-Dodson Law.

Another idea for future research centers on shared experiences. Boothby (2014) found an amplification of pleasant and unpleasant experiences when shared with another individual. Participants who tasted bitter chocolate rated it lower when another individual was present and tasted the chocolate as well. The same result held for when flavorful chocolate was tasted. Future work could include participants watching a slideshow together while immersing their arms in a CPS or lukewarm water bath. It would be beneficial to see if shared experiences enhance memory in addition to valence ratings. Recalling the events together could also affect what items are better remembered and would provide even more insight about perceptual centrality.

Lastly, previous work has shown the effects that amygdaloid damage has on memory. Rats with amygdaloid damage did not respond to fear like healthy rats did. The amygdala plays a crucial role in emotion and memory (Ledoux, 1996). Cahill & McGaugh (1998) concluded that individuals with damage to their amygdala do not differ from healthy individuals in terms of emotional reactions. Rather, they differ in terms of the translation process. That is, individual with amygdala damage struggle with translating an emotional reaction into an improved long-term recall. Knowing these results, responses to a CPS might be similar but still lead to differences in memory for a set of slides, especially in terms of perceptual centrality.

Even with its limitations, our study contributes to research concerning memory and stressors. This study is a step forward in the direction of addressing the interaction of

visual and physical stressors. Additionally, our study provides even more evidence for tunnel memory. When asking people what they recall from stressful situations, one should be aware of the tunnel memory phenomena. This is important in legal proceedings where individuals are asked to testify. Both visual and physical stressors may limit what a person recalls which can save lives in the moment, but lead to less detailed memory in the future.

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Table 1. Eich scores for the interaction of emotion type, condition, and time

Emotion Type, Condition, Time	Count	Mean	Standard Deviation
Arousal, Warm, Immediate	82	**.622**	1.645
Arousal, Warm, Later	82	**.817**	1.664
Valence, Warm, Immediate	82	**1.171**	1.570
Valence, Warm, Later	82	**.927**	1.412
Arousal, Ice, Immediate	55	**.600**	1.832
Arousal, Ice, Later	55	**.927**	1.783
Valence, Ice, Immediate	55	**1.545**	1.501
Valence, Ice, Later	55	**.382**	1.748

Figures

Figure 1: Interaction of time and slide type on cognitive efficiency, indicated by word search score

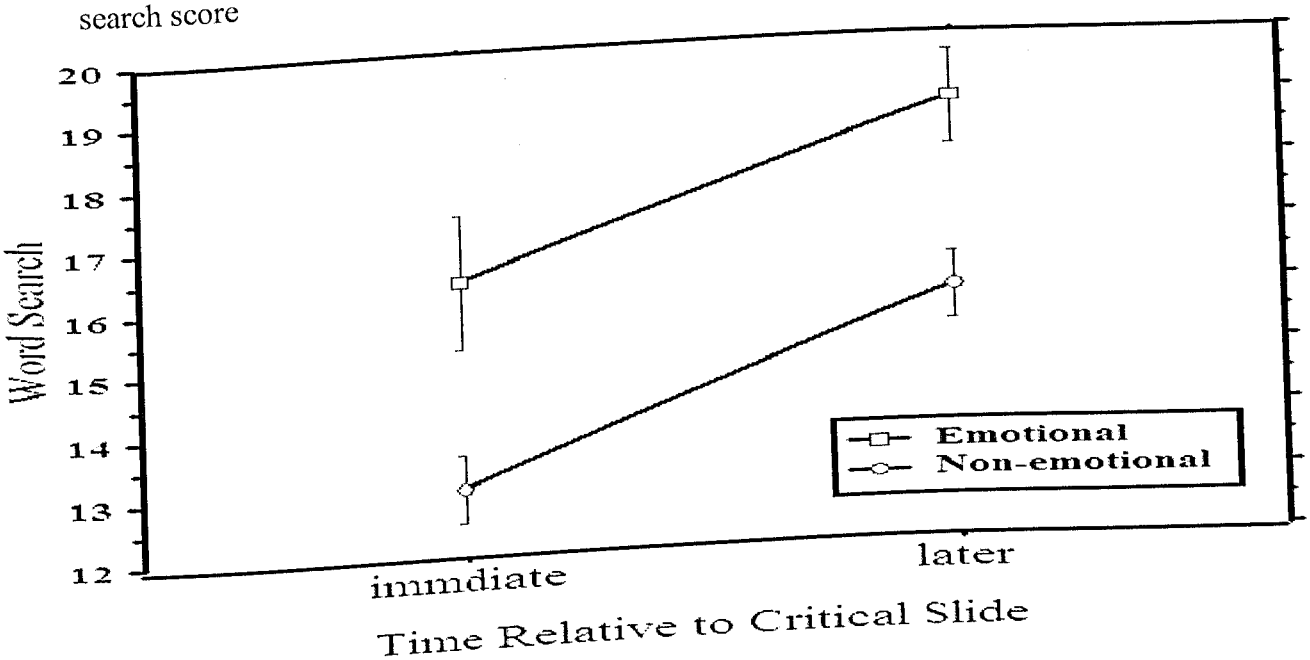
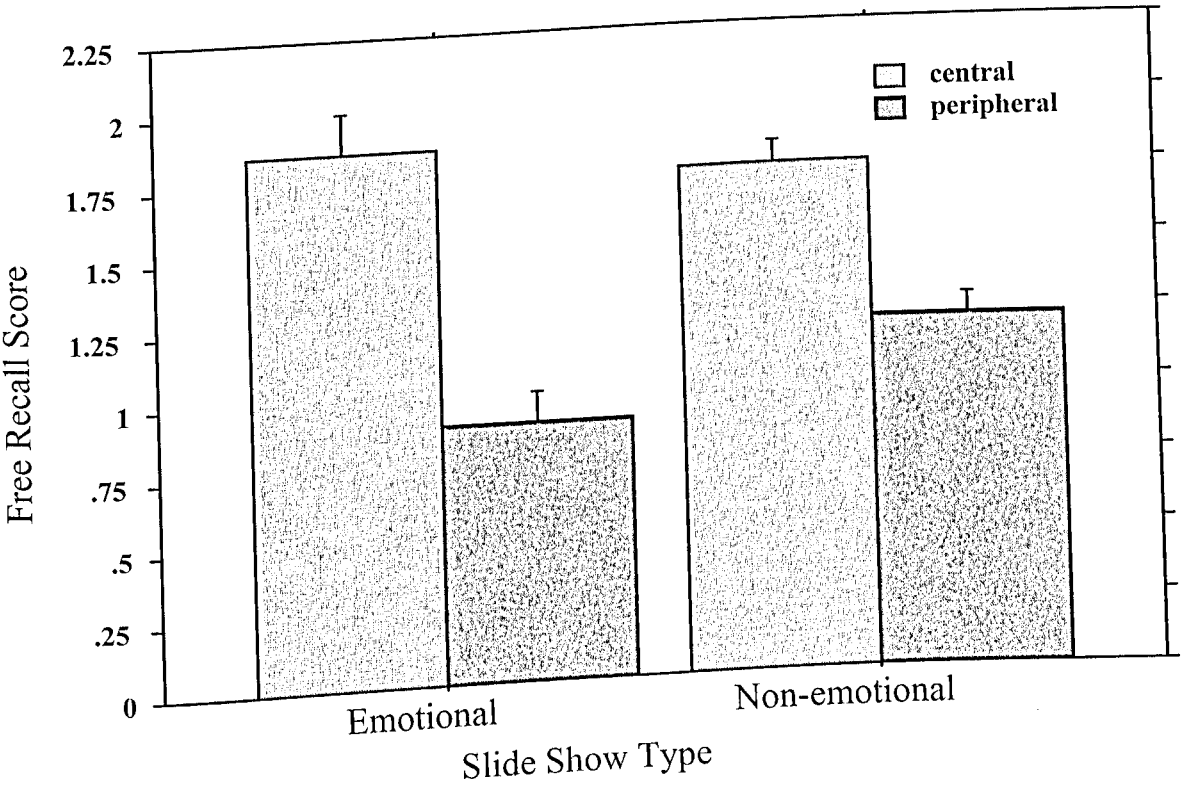


Figure 2: The significant interaction of slide show type and perceptual centrality on free recall score



APPENDIX A. Statement of Informed Consent

CONSENT BY SUBJECT FOR PARTICIPATION IN RESEARCH PROTOCOL

Research Project: "Memory on Ice: Retrograde Enhancement of Thematic Information"

Student Investigators: Alexandra Robinson-Norris & Anna Sutter
Principal Investigator: Dr. John Neil Bohannon III

I_____, herby consent to participation as a subject in the above named research project, conducted under the direction of the named person at Butler University. My consent is given of my own free choice without undue coercion and the following things have been explained to me.

1. Nature and Duration of Procedures.

This psychological experiment examines memory for items from a set of slides. During this study, you will work on a word search and mood/ arousal grid. You will then immerse your recessive arm into either a bucket of warm water or into an ice bath for two minutes while you're viewing either gory or neutral slides. If needed you can withdraw your arm at any time without consequence. Immediately after two minutes are up you will remove your arm, if you have not done so yet, and finish viewing slides. Right after the slides are done, you will fill out another questionnaire. The study will take roughly an hour.

2. Potential Risks and Benefits.

There are some perceived risks involved in participating in this study. All participants will be asked to immerse their recessive arm into either an ice bath or lukewarm water. Therefore, if you are sensitive to temperature changes or feel lasting pain from ice or warm water, you may not want to complete this study. We also request that you do NOT participate in this study if you have a history of heart problems, vascular disease, high blood pressure, history of fainting or seizures, Reynaud's phenomenon, or diabetes. Additionally, the gory slides could cause some discomfort. If you do experience undue stress, you may contact the Butler University counseling center at (317)-940-9385.

We do not anticipate that either you or your classmates will directly benefit from your participation in this research. With that said, your participation may help contribute to our knowledge of how visual and physical stressors affect the brain, ultimately helping us to better understand how the brain's wired.

Participating in this study may offer you one way to earn extra credit in your psychology classes. The amount of extra credit received may vary depending on your professor. If you are unable to complete this study, your professor may give you an alternative way to earn the same amount of extra credit.

You participation in this study is entirely voluntary. You are free to choose whether or not you participate in this study. If you decide to withdraw from the study, your relationship with faculty at Butler University will not be negatively affected. Your decision will not result in any loss of benefits in which you are entitled to. If you choose to participate, you may withdraw at any time by notifying the person administering the research session. Upon your request to withdraw, all information you have provided us will be destroyed. Any information you do provide will not affect your academic standing.

I have had the opportunity to ask questions and obtain answers to any concerns I might have. I understand that participation in this study is voluntary, and at any time I am free to withdraw without consequence or discrimination. In the case of withdrawing, I understand that any information I have provided to the researcher will be destroyed.

Data collected through this experiment will be presented at various conferences and used for scientific papers. However, raw data will be stored using random numbers and personal information will not be revealed. Any personal information supplied to the experimenters will only be used to notify professors of participation. When required by law, the records of this research may be reviewed by applicable government agencies. All information will be stored in a locked storage container in the psychology department to ensure participant's confidentiality.

_____ _____

Signature of Subject Date

_____ _____

Signature of Investigator Date

If you have any questions or concerns, please feel free to contact:

Alexandra Robinson-Norris
anrobin1@butler.edu
219-309-6725

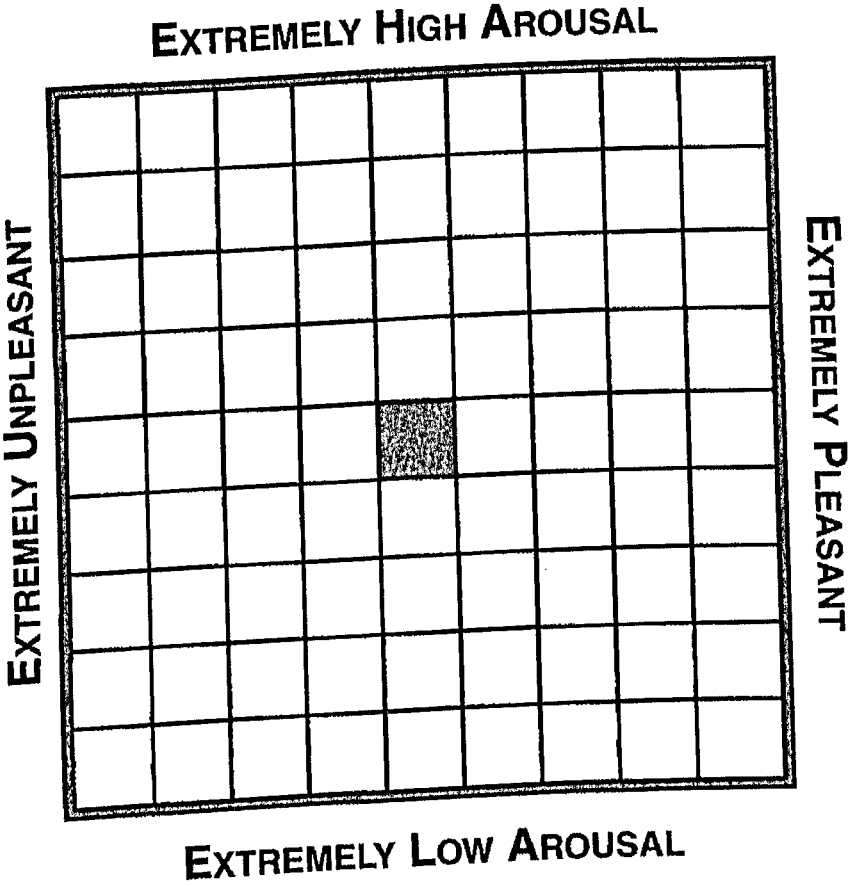
Anna Sutter
asutter@butler.edu
812-599-7734

Dr. John Neil Bohannon III
nbohanno@butler.edu
317-940-9240

Butler University Counseling Services (Located at the HRC on campus): 317-940-9385

APPENDIX B. Mood Arousal Grid Used Pre and Post Slideshow

Please fill in the box that best describes your current state of arousal and pleasantness.



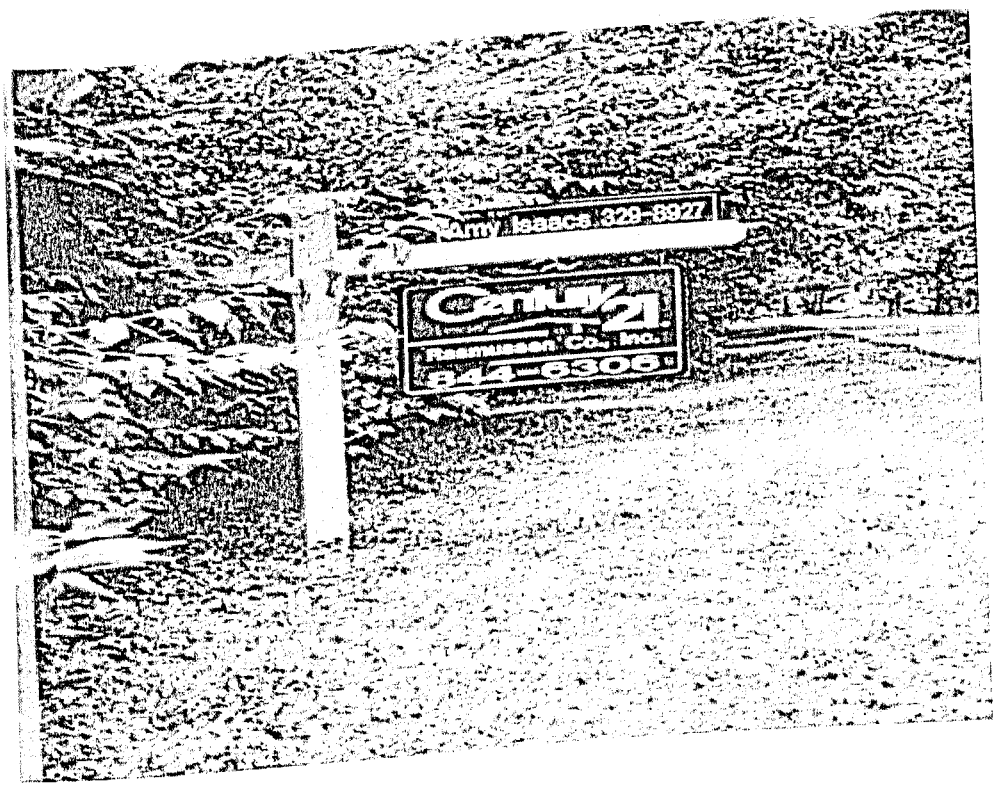
APPENDIX C. Word Search Pre-Slideshow

Please work on the word search puzzle until the researcher asks you to stop.

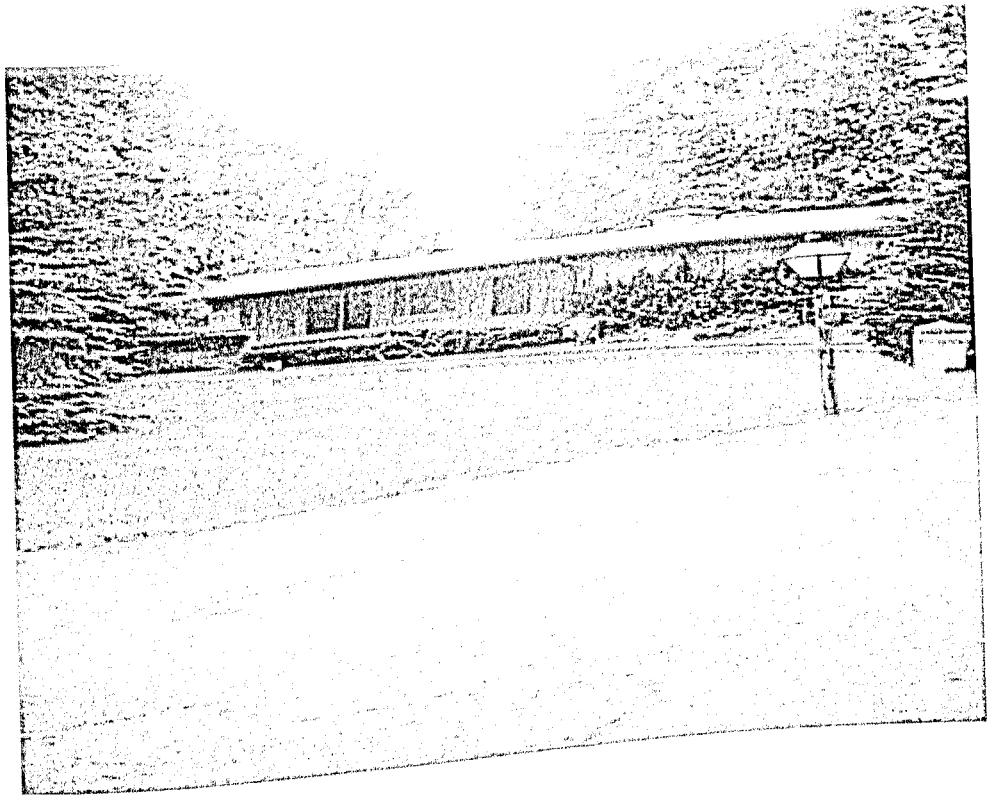
ALTER
ARRANGE
ATTUNE
AUGMENT
AVERT
CONTORT
CROOKED
DENY
DETOUR
DIET
EDIT
EVOLVE
FLEE
GROW
INFLUENCE
INNOVATE
MATURE
MODIFY
MODULATE
OVERRULE
REACT
REDUCE
REFORM
REMODEL
REVERS

APPENDIX D. Slideshows

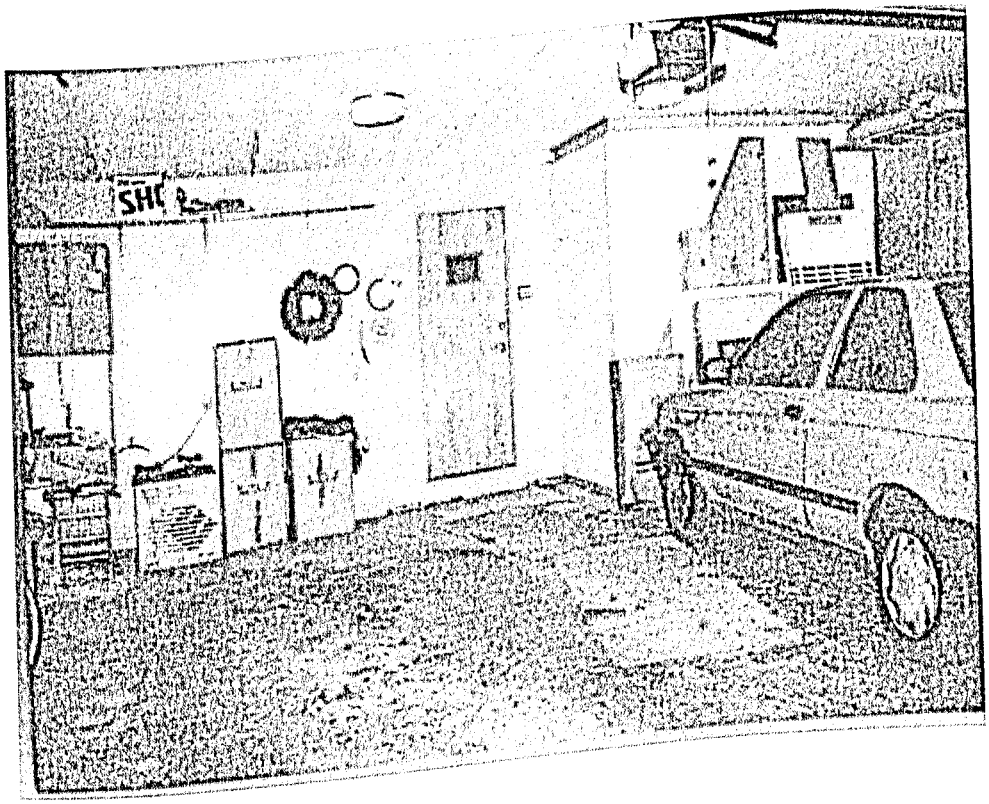
Sale Sign



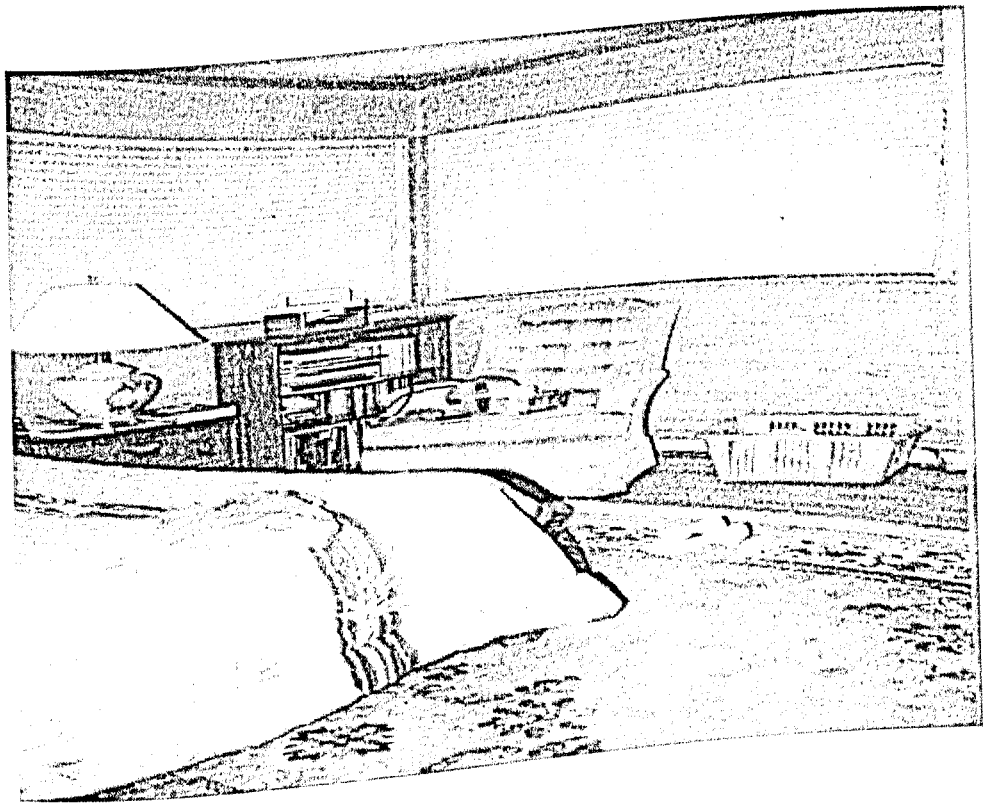
Front Yard



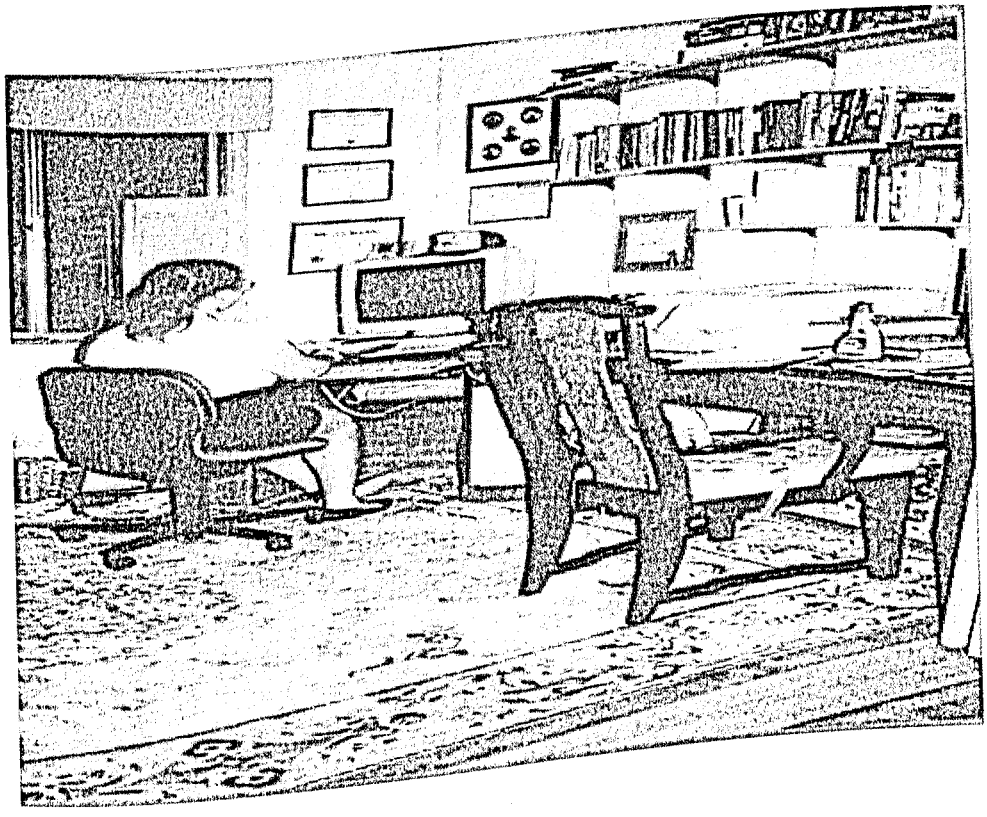
Garage



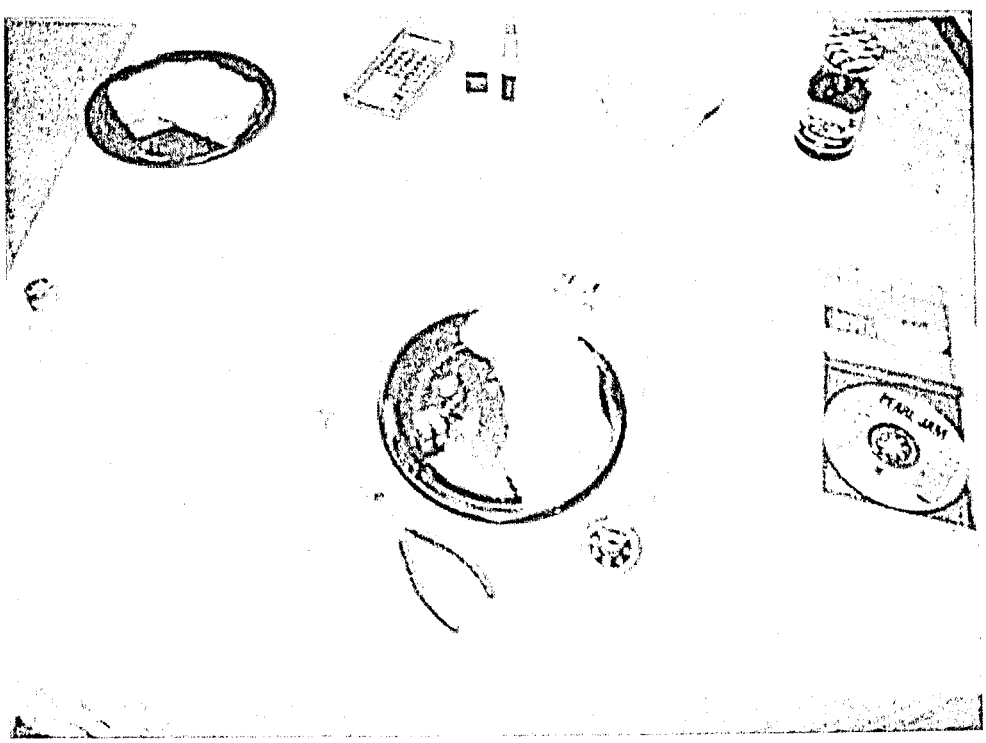
Bedroom



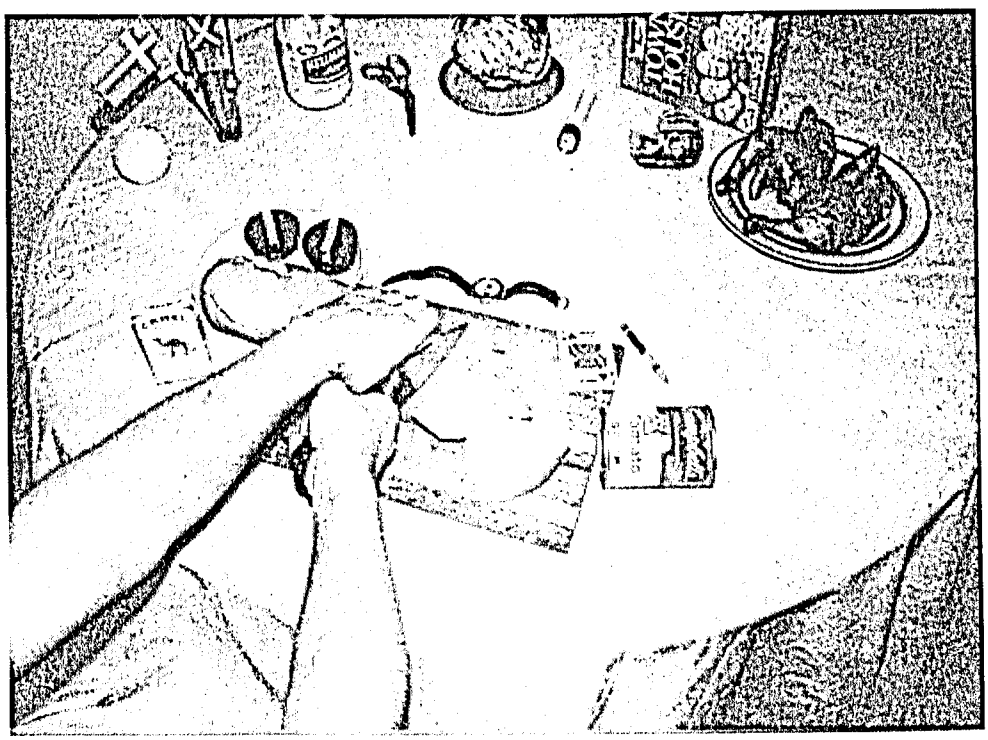
Den



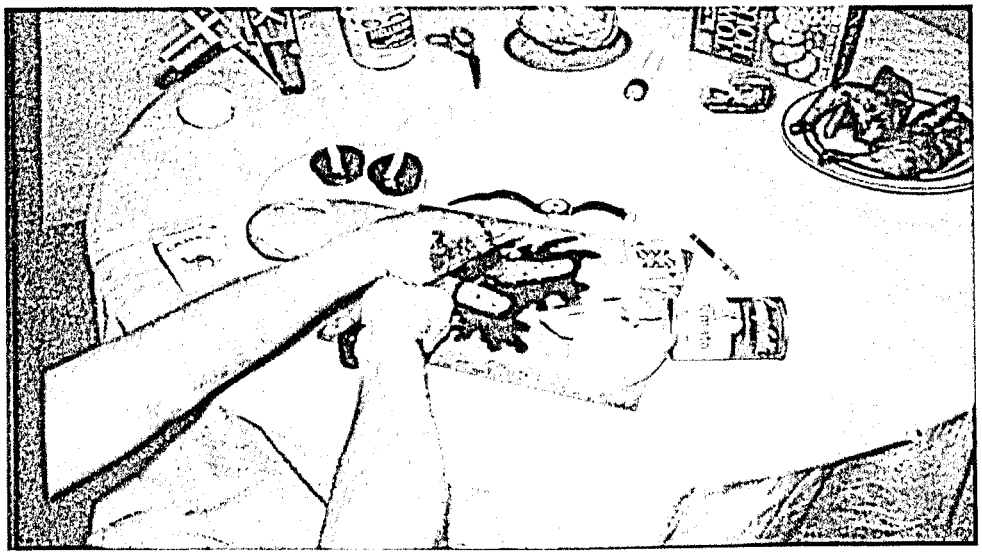
Breakfast



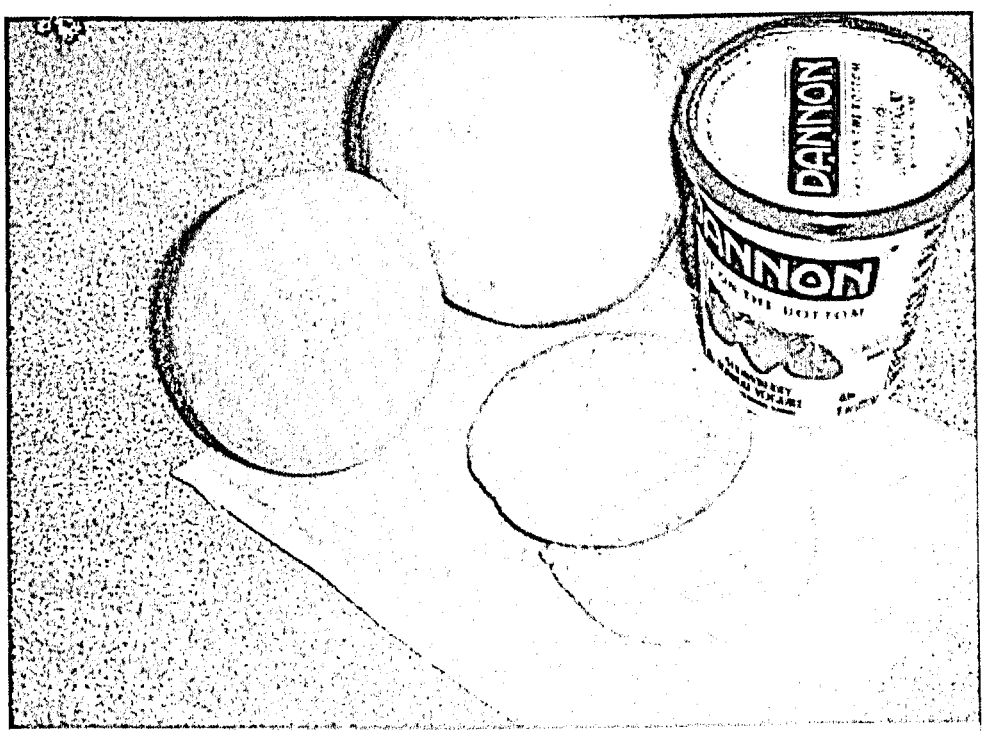
Lunch Preparation

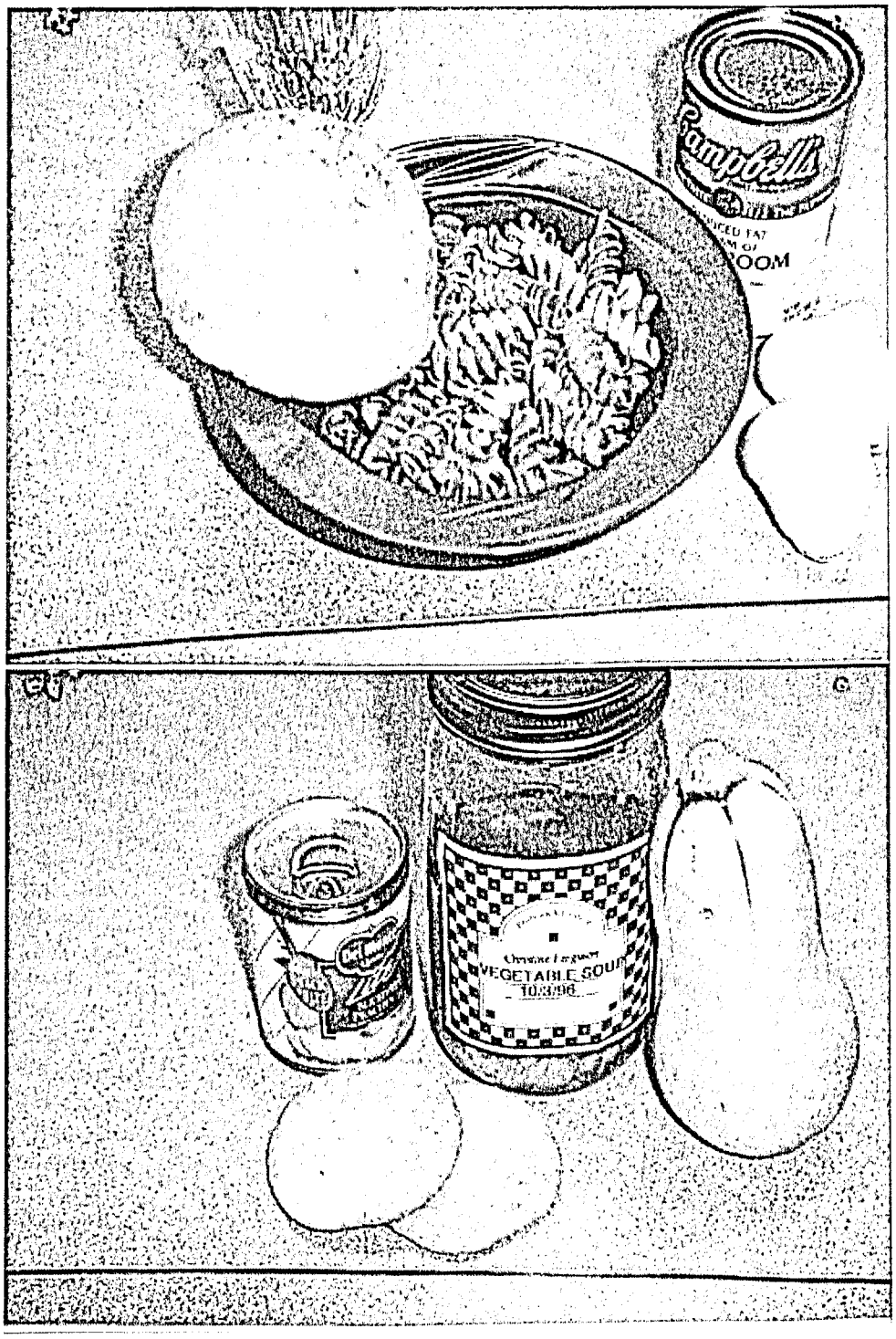


Non-Emotional Critical Slide

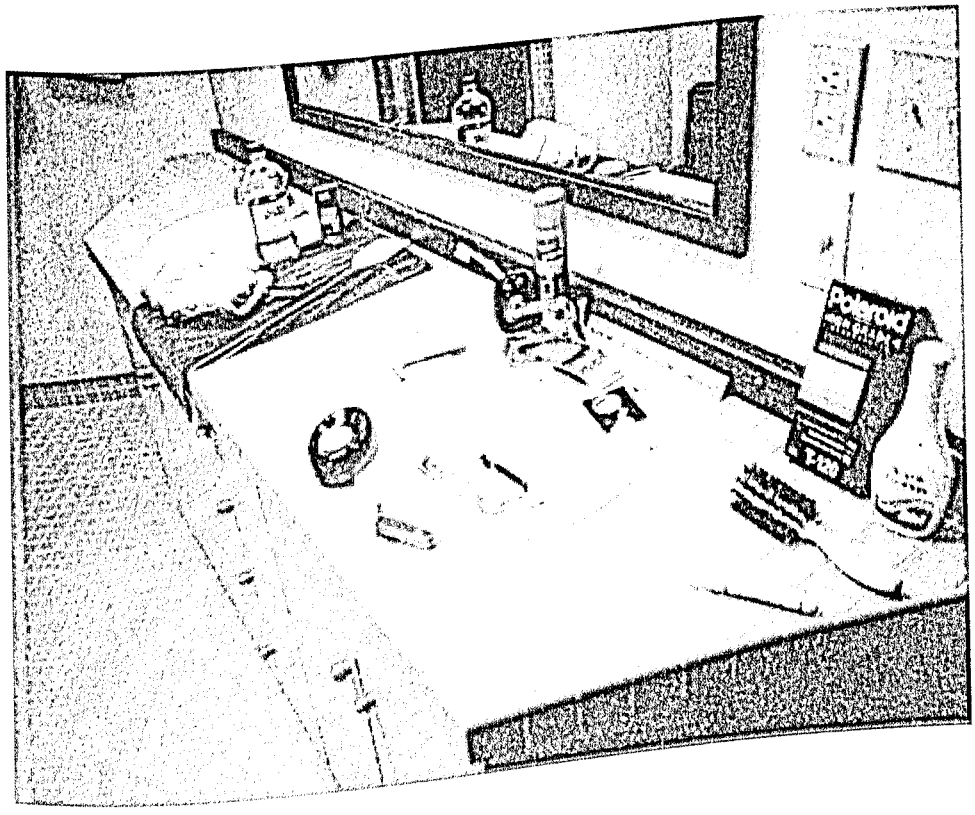


Emotional Critical Slide

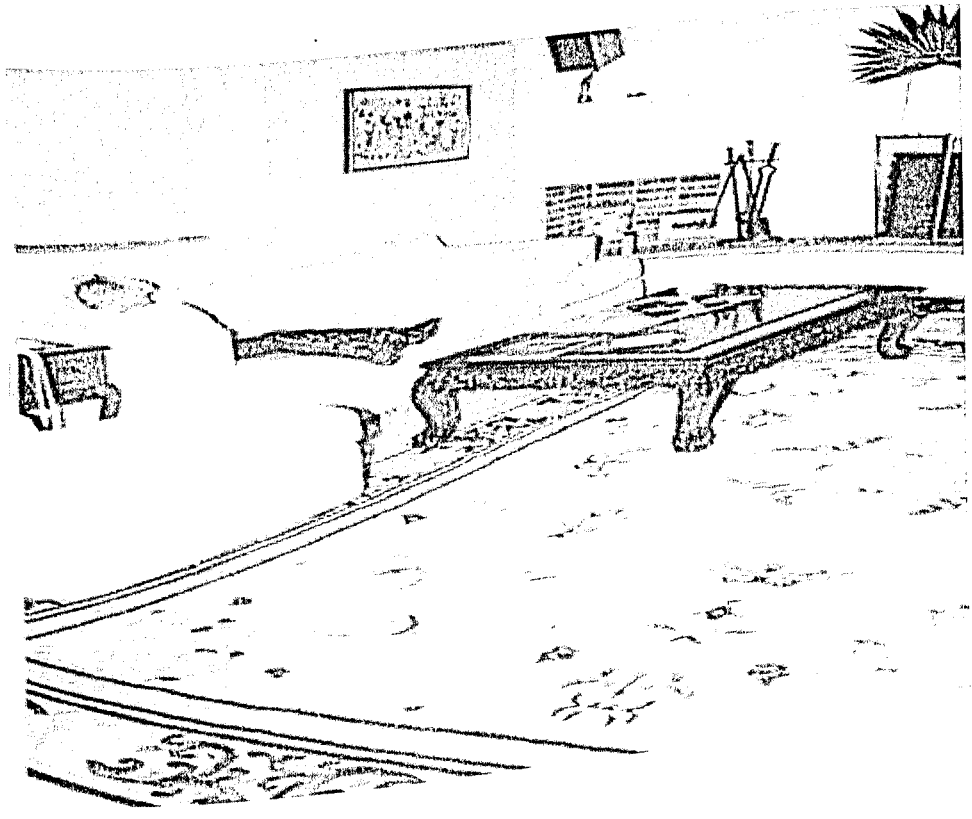



Campbell's
VEGETABLE SOUP
10/3/96

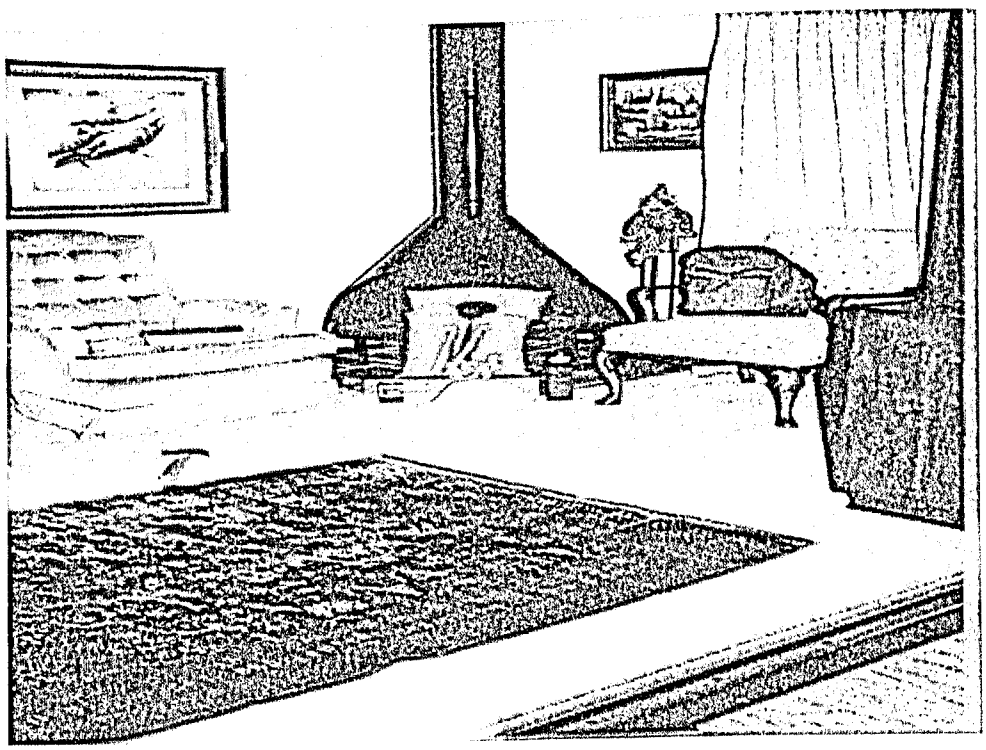
Bathroom



Family Room

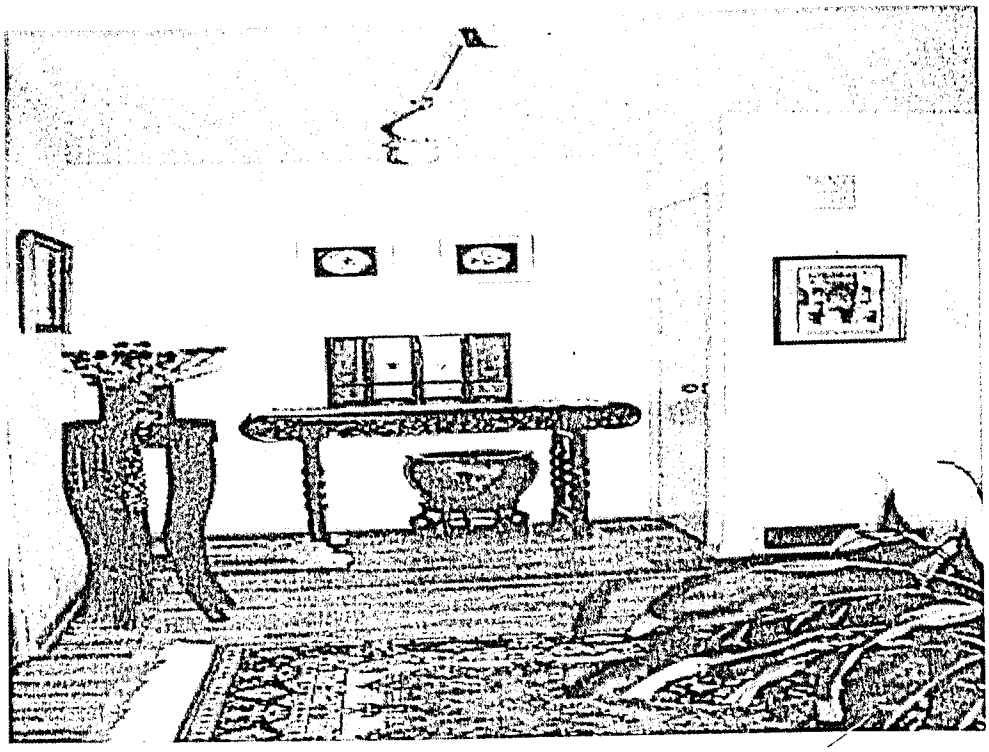


Sunroom

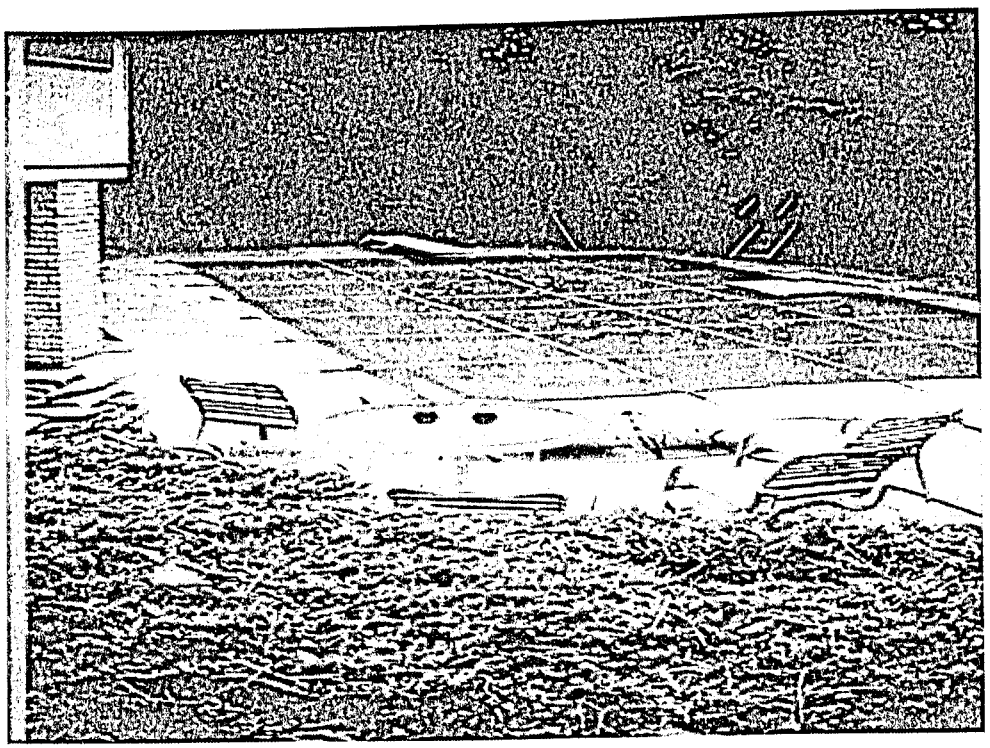


Kitchen

Foyer

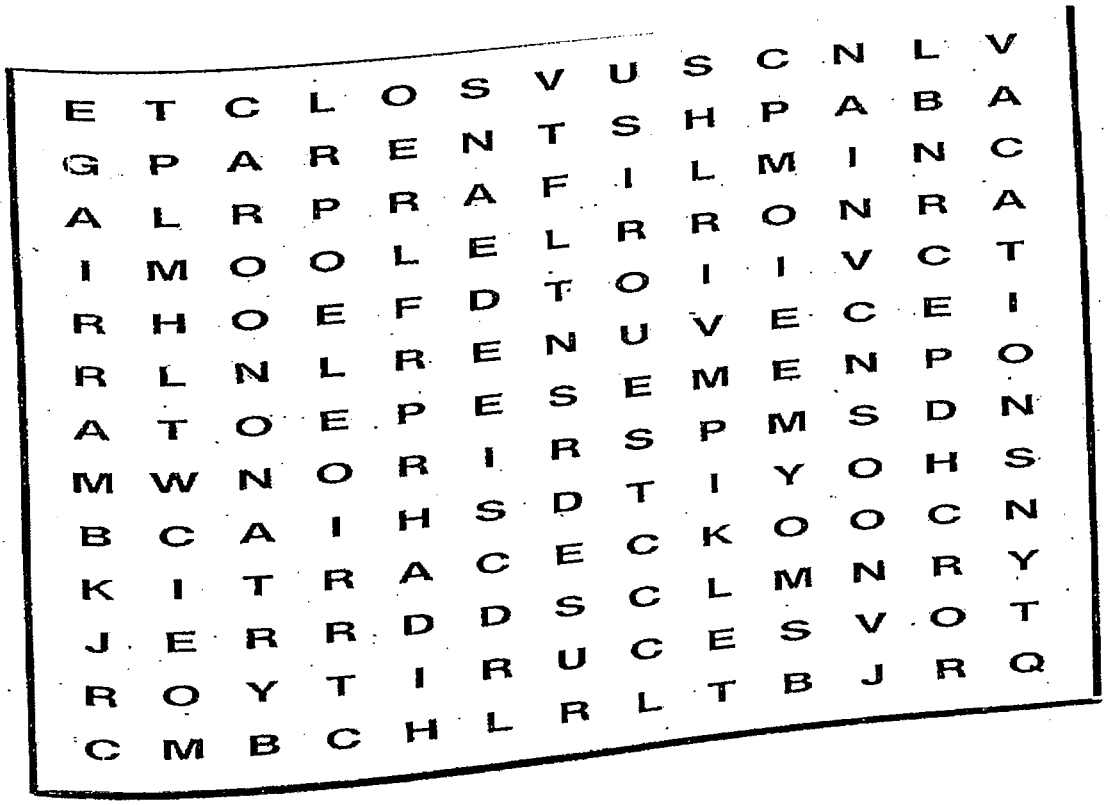


Pool



APPENDIX E. Word Search Post-Slideshow

Please work on the word search puzzle until the researcher asks you to stop.



E	T	C	L	O	S	V	U	S	C	N	L	V
G	P	A	R	E	N	T	S	H	P	A	B	A
A	L	R	P	R	A	F	I	L	M	I	N	C
I	M	O	O	L	E	L	R	R	O	N	R	A
R	H	O	E	F	D	T	O	I	I	V	C	T
R	L	N	L	R	E	N	U	V	E	C	E	I
A	T	O	E	P	E	S	E	M	E	N	P	O
M	W	N	O	R	I	R	S	P	M	S	D	N
B	C	A	I	H	S	D	T	I	Y	O	H	S
K	I	T	R	A	C	E	C	K	O	O	C	N
J	E	R	R	D	D	S	C	L	M	N	R	Y
R	O	Y	T	I	R	U	C	E	S	V	O	T
C	M	B	C	H	L	R	L	T	B	J	R	Q

ACCEPTED
ANNIVERSARY
AWARD
BIRTH
CHILDREN
COMMUTER
DIPLOMA
FRIENDS
HOME
HOPES
JOB
JOY
LOVE
LUCKY
MARRIAGE
NORMAL
PARENTS
PROFESSION
RETIRE
SCHOOL
SECURITY
TALENT
TRIPS
VACATIONS

APPENDIX F. Free Recall Test

Please Circle: Female/Male

Please try to recall as many items from the selected scenes as accurately and as detailed as you can remember. You do not have to provide an answer for every line.

Breakfast Scene

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____

19. _____

20. _____

Lunch Preparation Scene

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____

20. _____

Bathroom Scene

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____

APPENDIX G: Scoring Rules

Bathroom Scene

Correct	Incorrect
Mirror, Tile, Sink(s), flyswatter, towel, baseball glove, mouthwash, deodorant, toothbrush, toothbrush holder, shaving cream, ruler, toothpaste, razor, screwdriver, Swiss army knife, highlighter, Polaroid, VHS, head & shoulders, hairbrush, light switch, counter, soap, soap holder, faucet,	Toilet, Shower, Blue,

Central	Peripheral
Soap, soap holder, Swiss army knife, Colgate, toothpaste, screwdriver, faucet, sink, shaving cream, tooth brush, toothbrush holder, ruler, razor	Mirror, counter, sinks, highlighter, hair brush, Polaroid, VHS, head & shoulders, light switches, baseball glove, flyswatter, floor, mouth wash, deodorant

Thematic	A-Thematic
Mouthwash, deodorant, towel, sink(s), light switches, counter, mirror, toothpaste, soap, soap holder, hairbrush, head and shoulders, shampoo, razor, shaving cream, faucet	Baseball glove, flyswatter, screwdrivers , Swiss army knife, highlighter, Polaroid, VHS, ruler,

Lunch Preparation Scene

Correct	Incorrect
Cutting Board, Table, Table Cloth, Bread, Knife, Playing Card, King Card, Crayon, Watch, Hostess Cakes, Plate(s), Camel Cigarettes, Soup, Campbell's, Tomato Soup, Chicken, Tape, Crackers, Flashlight, Lettuce, Scissors, Mayo, Soldier, Tennis Ball,	Fruit, Orange, Cookie, Yogurt, Pasta, Garlic, Severed Hand, Bloody Hand, Blood (Anything from the filler slides)

Central	Peripheral
Camel Cigarettes, Soup, Campbell's, Watch, Hostess Cakes, Plate, Crayon, Playing Card, King of Spades, Bread, Knife, Cutting Board,	Tennis Ball, Soldier, Mayo, Scissors, Lettuce, Plates, Flashlight, Crackers, Tape, Chicken, Table Cloth

Thematic	A-Thematic
Bread, cutting board, knife, hostess cupcakes, soup, tomato soup, Campbell's chicken, crackers, mayo, lettuce, plate(s)	Playing card, crayon, watch, cigarettes, soldier, tennis ball, flashlight scissors, tape,

Breakfast Scene

Correct	Incorrect
Salt & Pepper Shakers, Dollar Bill, Toast, Plates, Calculator, Lipstick, Orange, Bowl, Jelly, CD, Pearl Jam CD, Padlock, Pliers, Silverware, Knife, Fort, Milk, Glass, Toy Car, Dice, Eggs, Tablecloth	Yellow,

Central	Peripheral
Milk, Glass, Pliers, Fork, Knife, Silverware, Dice, Eggs, Toy Car, Plate, Padlock	Plates (note if plural, they would have had to look to periphery), Dollar, Money, Salt & Pepper Shakers, Toast, Calculator, Lipstick, Orange, Bowl, Fruit, Jelly, Pearl Jam, CD, Table Cloth

Thematic	A-Thematic
Salt & Pepper Shakers, Table Cloth, Toast, Plates, Orange, Fruit, Bowl, Jelly, Eggs, Milk, Silverware, Fork, Knife	Money, Dollar Bill, Calculator, lipstick, Pearl Jam CD, CD, Pliers, Tool, Padlock, Dice, Toy Car