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Chronic, Lethal Versus Acute, Non-lethal Threats: A Look inside the Memories of Cancer Patients at the Time of Their Diagnosis

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ABSTRACT

Consequentiality, affect, and rehearsal are also important components that help contribute to the recall of autobiographical memories. Traditionally, these features have been assessed in public dramatic events in the past such as the Challenger explosion and the 9/11 terrorist attack. In opposition to these traditionally studied events, the present study examined the effects of these features on five different private events. An analysis of these different experiences was assessed to determine the role of consequentiality, affect, and rehearsal play on memory recall. These three components were assessed in five different events during different points of the lifetime. Adults diagnosed with a cancer diagnosis (N = 44) were examined and compared to adults who heard about their child's injury (N = 63, Hillman et al., 2010), adults who viewed their child's injury (N = 37 Hillman et al., 2010), adults who experienced a car accident (N = 74, Shaneyfelt, Minor, & Bohannon, 2008), and adults who experienced an injury during their childhood (N = 109, Hillman et al., 2010). All of these events were measures with a two part survey that consisted of a free recall narrative of the event and a detailed series of proved questions which included ratings of vividness, affect, and an estimate of rehearsals. Cancer diagnosis memories yielded the highest memory detail and recounts, but the lowest vividness ratings. This finding sheds light on how the method of information input plays different roles in both memory quality and quantity.

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Daily life is routine to people; a passive process that they live through without much thought. That is, unless, something unexpected and arousing takes place. An event like this, such as the assassination of JFK, may cause a special type of memory to be formed; this type of memory is called a flashbulb memory, which is more comprehensive and vivid than memories from daily life (Brown & Kulik, 1977). Arousal can be any elevated state of emotion such as anger, sorrow, surprise, etc. Due to the arousing circumstances that surround these types of memories, it allows the memory to be encoded more comprehensively, and is therefore easier to recall (Christianson, 1989). These emotions enable these memories to be more impressive than neutral events (Julian, Bohannon, & Aue, 2009). Memories for stimuli and events which can be considered emotional have been found to be both more vivid and more accurate than those of neutral stimuli (Todd, Talmi, Schmitz, Susskind, & Anderson, 2012; Labar & Cabeza, 2006). Since an arousing state is one of the main focuses of flashbulb memories, there is much research in this area which deals with traumatic public events such as The Challenger Explosion, and the JFK assassination as mentioned above (Brown & Kulik, 1977; Neisser & Harsch, 1992; Neisser et. al 1996). Although, it should be noted that emotionally private events have also shown similar characteristics of flashbulb memories due to arousal, and therefore these memories are more vividly remembered as well (Rubin & Kozin, 1984). Alternatively, other researchers have debated that even though these memories are formed in a different set of circumstances, they are no different than the memories that are formed every day (Talarico & Rubin, 2003). However, the majority of research has shown evidence that these flashbulb memories are distinct from memories formed on a day to day basis.

There has been limited research on memories of cancer patients at the time of their diagnosis. Furthermore, there has been no fixed research that has analyzed the flashbulb-like qualities of discovering one's own cancer diagnosis. With a cancer diagnosis being potentially life threatening, these memories can be considered private, traumatic events. Autobiographical memories can be pertinent to one's survival, therefore causing the memory to be enhanced. Nairne and Pandeirada (2008) proposed that since memory has evolved over time in order to better reproductive fitness, memory systems have paralleled this evolution by focusing on retaining information that is fitness related. The large majority of women who were part of a study which focused on the medical treatment and satisfaction from their diagnostic consultation throughout their cancer care, stated that their diagnostic consultation was a highly memorable event, with none of them indicating poor recollection of the memory (Mager & Andrykowski, 2002). This event can also have the element of surprise if the individual had no preceding medical conditions or indications that they might have a critical illness. With the diagnosis of cancer, there are also the long-term effects of treatment such as medications, chemotherapy, radiation, and/or surgery. Depending on the severity of the disease, this makes the diagnosis both acutely and chronically life changing.

Two studies that attempted to study the flashbulb memory aspect of private, traumatic events were used to compare to the obtained data from the current study. These studies have different arousal and consequentiality components than cancer diagnoses, and consisted of childhood injuries that resulted in a hospital visit and car accident memories where the driver had no anticipation of the event. Memories regarding childhood injury were an important comparison because it addressed an acute, non-life-threatening event. These events were extremely emotional for the individuals as a child so the arousal aspect of these memories is present. Due to this high emotionality at the time of encoding, the needed parallel for comparison of these memories to cancer diagnosis memories is present. The parent's memory of their child's injury was also taken into account, with the parent having to have been present at the time of the injury or told verbally about the injury. Most childhood injuries result from falling, and often only produce scrapes or broken bones, which do not have serious, chronic consequences (Hillard, 2008). Memories from car accidents also have the high arousal component, and have the potential to be acutely lethal or non-lethal. Again, this high arousal component at the time of encoding is crucial for the overall comparison that the current study intends to make with cancer diagnoses.

Encoding Factors

Episodic memory is currently defined as an autobiographical memory according to Tulving (1972). It has also been referred to in other ways such as later collective memory (Brewer, 1996) and personal memory (Brewer, 1986). Tulving (1985) defined remembering as the awareness or consciousness of a particular event that is integrated into an individual's past experiences. Flashbulb memories are indeed an instance of remembering; however, there are two views of these special memories that are controversial to one another. The first view states that the emotions at the time of encoding are of the utmost importance; on the other hand, the second view insists that perceptual vividness is reconstructed at the time of recall, which can undermine accuracy (Neisser & Harsch, 1992; Talarico & Rubin, 2003). Numerous studies have designated certain features that are necessary for the appropriate encoding to take place at the time of the event (Conway, 1995; Gold, 1992). Rehearsal, consequentiality, and affect have been shown to be other crucial components of a flashbulb memory. Contextual features can also act as powerful retrieval cues for the target information (Godden & Baddeley, 1975). The current study focuses not only on the absence and presence of these features, but also the short-term versus long-term aspect of the event's consequentiality.

Rehearsal

Rehearsal is defined as the number of times that an individual repeats the story of the memory to either another individual or an audience. Conway & Pleydell-Pearce (2000) proposed a retrieval model that is based around the idea that the retrieval of certain information from an individual's memory is strongly influenced by the desire to reconstruct those memories in a way that fits into one's future goals, expectations, and ideal self-image. In other words, autobiographical memories are needed for an individual to justify his or her future goals, based upon pre-existing memories (Conway & Tacchi, 1996).

Another retrieval based model proposed by Atkinson and Shiffrin (1968) is the dual-storage model, which indicates that when a memory is retrieved, it could emerge from either long-term or short-term memory storage. While long-term memory was found to be a more enduring option for memories, short-term memory was only temporary but also more readily available. A "U-shaped" serial position curve demonstrates memory, with a strong positive correlation between the number of rehearsals and the probability of later recall (Atkinson & Shiffrin, 1968). Similarly, Rundus (1970) found that as the number of rehearsals increased so did the strength of the memory in the long-term memory storage.

In support of Rundus' findings in 1970, Brown & Kulik (1977) also found a positive correlation between the number of rehearsals and memory elaboration. This study looked at nine different events that were likely to cause the formation of flashbulb memories due to the pivotal aspects that these events contained. Also, previous research has demonstrated that as the number of rehearsals of a memory increases, the vivid reminiscence of these memories will also increase as time passes (Julian, et al., 2009). In addition, Fels (2011) found that regardless of the affect level at the time of encoding, individuals who rehearsed events numerous times were better able to retain their memories and were also better able to reiterate facts from the time of the event. Likewise, an increase in the number of attempts to recall was found to aid memory when it was recalled at a later time, which demonstrates how rehearsal can act as a practiced instance of remembering (Tulving, 1969).

Overall, this evidence supports the hypothesis that the more an individual rehearses his or her cancer diagnosis memory, the more easily and more vivid the memory should be with each additional retrieval. Similarly, the same is expected for childhood injury events and car accidents.

Consequentiality

How much an event will impact an individual's life, otherwise known as the consequentiality of the event, has a strong influence on how flashbulb memories are formed and maintained over a long period of time. There have been examples of this in previous research, such as that done by Brown and Kulik (1977), where the assassination of Martin Luther King was found to be more consequential for African Americans living in the United States than Caucasian Americans. Also, Conway (1995) found that British citizens remembered the resignation of the former Prime Minister Margaret Thatcher better than citizens of other European countries. In response to these findings, Conway (1995) developed a theory that events that were deemed as more consequential would be better remembered. Talmi (2013) demonstrated that stimulus priority may encourage deployment of cognitive factors, which could also drive priority assignment. This explanation was derived from the combination of the mediation and arousal-biased competitive theories. Lower consequentiality events have shown a tendency towards higher rates of forgetting with recall. In contrast, events that are considered highly consequential go on to be formed into flashbulb memories (Conway, 1995).

In opposition to the theories that indicate that higher consequentiality results in better recall, research done by Schmolk, Buffalo, and Squire (2000) that examined the role of consequentiality in memories for the OJ Simpson verdict found that consequentiality had a minimal effect on memory encoding and recall. In agreement with this study's findings, Neisser and Harsch (1992) found the same minimal effect of consequentiality on memory regarding the explosion of the Challenger. Rice (2012) also found no difference between whites and non-whites in consequentiality in regards to the 2008 President Obama election. However, the majority of the research that has been done with consequentiality, and how it relates to encoding and recall, is supportive of the theories that assume positive correlation.

A threat to survival is one of the critical aspects of consequentiality that is relevant to memory. These threats can come in many different forms such as a head-on vehicle collision or falling from a tree as a child. In respect to a cancer diagnosis, the idea of consequentiality can be easily related to a threat towards an individual's survival. Information that is processed as relevant to survival is remembered far better than information that is processed in different contexts (Nairne, 2010; Otgaar, Smeets, & van Bergen, 2010). Within the medial temporal lobe of the brain are "concept cells," which are responsive to personally relevant items, or those that are salient enough to be memorized (Quiroga, 2012). Therefore, there may in fact be both a specific part of the brain and specific type of cell that has played a role in the survival of the human species.

A major consequence that is highly relevant to the current study is that of death. Studies done by Mineka and O'hman (2002) and Flykt (2005) showed that the shift in focus from thoughtful decision making to one of highly focused attention with rapid processing has clear adaptive value, which enables the individual to devote attentional resources to life threatening stimuli in times of danger. The thought of death can be perceived as a threatening stimuli because it is not compatible with evolutionary processes. As age increases, health tends to decline and those surrounding an individual will begin to become deceased. An example of the repercussions of these types of events was demonstrated by Carstensen & Turk Charles (1994) who found that older adults have a large bias towards processing material that is considered personally emotional. Another study done a few years later concluded that this bias is because as age increases, the adult realizes that the end of life is near (Carstensen & Turk Charles, 1998). Adults who are at this elder stage of life realize the importance of the emotional quality of interactions with others, and they begin to take precedence over all other functions (Carstensen & Turk Charles, 1998).

Behind the behavioral and emotional changes that accompany coping with evolutionary threats are chemical mechanisms occurring within the brain. Woodson (2003) found that corticosterone levels were significantly elevated in cat-exposed rats in comparison with the group that was place in the neutral environment. As discussed later on in this paper, high levels of corticosterone shut down the hippocampus, which is responsible for working memory, and shift the memory formation process to the amygdala, which is responsible for long-term memory.

In regards to childhood injury, it was found that these events were both more uniformly arousing and had superior recall of the event when compared to other traumatic childhood events such as parental divorce or a learning disorder diagnosis (Hillard, Gillott, & Bohannon, 2008). The survival mechanism that was mentioned above by Flyt (2005) has also been found to occur within children as well (Bjorklund & Pelligrini, 2000; Volk & Atkinson, 2008). Long-term memory is a critical component to the survival mechanisms that play a role is our overall fitness. Due to a life threatening situation having the highest possible consequentiality, it makes sense that memories formed in these situations contain high levels of detail and remain easy to recall.

Affect

Another contributing characteristic of flashbulb memories that has been found to better encoding and enhance maintenance of the memory over time is the extent of the affect that the particular event has. Affect can be described as the level of arousal or emotion experienced by the individual at the time of the event. Different types of arousal can include shock, anger, distress, and etc. James (1890) wrote that "An experience may be so exciting emotionally as almost to leave a scar on the cerebral tissues" (670). Previous research on flashbulb memories has found that the higher the affect at the time of the event, the better the recall of the long-lasting memory of the arousing event (Colgrove, 1899; Winograd & Killenger, 1983; Bohannon, 1998; Julian et al., 2009). The Mediation Theory proposed by Talmi, Schimmack, Paterson, & Moscovitch (2007) suggests that emotional events recruit other cognitive resources such as attention, distinctive processing, and organization in comparison to neutral events, which results in a memory advantage. According to Tekcan and Peynircioglu (2003), and Bernsten and Thomsen (2005), the accuracy and durability of emotional memories can span decades. In other words, the more emotionally aroused the individual is at the time of encoding, the more easily the memory will be recalled.

Unlike emotionally arousing events, emotionally neutral events have been found to demonstrate lower levels of the amount of recall. Events that have been deemed as emotionally neutral do not show the same level of detail that those of emotional memories do. Extensive research has shown that strong emotionality can enhance memory (Cahill, Gorski, & Le, 2003; McGaugh, 2004; Sharot, Delgado, & Phelps, 2004; Nielson, Yee, & Erickson, 2005). Kensinger et al. (2002) showed that adults of two different age ranges showed better recall for highly arousing pictures than for the low arousing pictures. These same results also demonstrated a similar trend when concerning valence of the memories, showing a greater amount of recall for the negative and positive stimuli when compared to the neutral stimuli. Talmi and McGarry (2012) found that the participants in their study allotted more attention to emotional pictures which in turn accounted for greater emotional memory. Graves et al. (2007) compared both younger and older adults' responses to neutral and arousing stimuli, and the results showed that the mean ratings from their analysis were significantly higher for the arousing story than for the neutral story for both emotionality and personal reactions; these findings allowed them to conclude that emotional arousal enhanced memory for central detail.

In comparison to the previous findings regarding age gap and consequentiality, Graves et al. (2007) demonstrated that the younger and older adult age groups did not differ in regards to emotionality, but did in fact significantly differ for personal reactions with the older adults having a higher mean rating. However, older adults showed an overall stronger personal reaction than younger adults for both neutral and arousing stories (Graves et al, 2007). With most samples having a large age range, it is important to acknowledge the age differences in participants and that age's effect on how incoming information is perceived.

In relation to positive versus negative arousal, events that were deemed as positive showed more detail than those that were deemed negative (Lindsay, Wade, Hunter, & Read, 2004). Dissociation models propose that impaired retrieval of personal memories is a defensive response that reduces awareness of aversive memories (van der Kolk & van der Hart, 1989). However, other models suggest that individuals may adopt an avoidant coping style in response to a traumatic event that results in impaired access or reporting of trauma memories (Fivush, Sales, Goldberg, Bahrick, & Parker, 2004).

There is current debate about the fine line between the level of hormone that produces highly detailed encoding versus levels that can cause obstructed encoding and repressed recall. Talmi (2013) summarizes from previous work that the arousal caused by an emotional event induces the release of the stress hormones adrenaline and cortisol, which trigger the activation of the amygdala which is important for memory consolidation of information during emotional events. Duffy (1957) indicates that "the optimal degree of activation appears to be a moderate one which expresses the relationship between activation and quality of performance taking the form of an inverted U" (268). Andreano & Cahill (2006) also found an inverted-U-shaped relationship between cortisol levels and memory consolidation in human subjects. It was concluded from further analysis that an intermediate level of cortisol correlated with peak memory performance (Andreano & Cahill, 2006). In summary, it has been found across multiple studies that an intermediate level of arousal creates the optimal level of hormones for memory consolidation that will result in superb recall.

With memory being capable of being broken down into sub-types such as working and long-term episodic, stress has the capability of inducing different effects depending on the memory type being utilized. Working memory has been found to be more susceptible to impairment by stress than long term memory in a novel environment (Woodson et al., 2003). Any stress induced memory impairment found by Woodson et al. (2003) was selective for recently acquired spatial working memory. These findings were supportive of findings from Diamond et al. (1996) found that stress produced retrograde amnesia by interfering with recently acquired, but not long-term spatial memory. On the other hand, it has been found that long-term episodic recognition memory was significantly enhanced for pleasant, aversive, and interesting pictures that were relevant to neutral pictures (Hamann, Ely, & Clinton, 1999). In a study done by Kangas, Henry, and Bryant (2005), participants who were suffering from acute stress disorder generated significantly fewer specific memories than participants without the disorder. Along with their findings, Harvey et al. (1998) found that deficits in autobiographical memory recall in acute stress disorder are not simply a function of depression.

Deficits in autobiographical memory could be related to many other factors, with one possibility being age. A study done by Turk et al. (2003) revealed that both recall and recognition tests show a tendency for younger adults to have better recall for negatively valenced stimuli than older adults. Turk et al. (2003) explained these results by way of the socioemotional selectivity theory, which states that older adults are better able to regulate their emotions in a way, that they are able to maintain positive affect and decrease negative affect. It is important to note that Turk et al. (2003) strongly believed that these memory differences were not secondary to age related cognitive declines, but were in fact due to enhancement of emotional regulation over time.

There have been several mechanisms proposed for the explanation of deficits in autobiographical memories following traumatic events. One of these mechanisms proposes that the dissociative symptoms in acute stress disorder will result in the impaired retrieval of trauma-related memories because these memories are associated with a strong negative affect (van der Kolk & van der Hart, 1989). Foa & Hearst-Ikeda (1996) recommended a mechanism involving cognitive avoidance which results in the inability to recall traumatic memories. In relation to this study, patients with acute stress disorder may be unwilling to access and/or report a specific traumatic memory, which is consistent with recent developmental studies of impaired retrieval in stressed children (Fivush et al., 2004).

The last of these mechanisms allocate that autobiographical memory deficit following trauma may occur because the intrusive symptoms deplete cognitive capacity that would otherwise be devoted to meaningful memory search (McNally et al., 1994; Wilhelm et al., 1997; Williams, 1996). Joseph (1998; 1999) found that under conditions of overwhelming terror, what was experienced may be forgotten or stored abnormally. It is important to note that in a study done by Stratton (1919) female rats as well has human females appeared to respond differently to acute stress than did males of each species. It is a possibility that cancer patients may lack the additional essential resources to allot to memory retrieval depending on how negatively arousing they perceived their diagnostic consultation (Kangas, Henry, and Bryant, 2005).

The fact that children's memory skills improve over the age span from four to 17 makes it hard to determine whether the increase in elaboration of autobiographical memories is due to the increase in affect, or is due to an increase in general memory skills (Agypt, 2007). In similarity to divorce memories of children, childhood injury is also high in affect. In support of that these memories are due to affect and not an improvement in general memory skills as age increases during adolescence, Thornberry and Bohannon (2009) found that childhood injury memories showed little developmental change from the range of six years old into teens. Both relational processing (integrated structure) and item-specific processing (discriminability) have shown effects that enhance the storage and retrieval of information in both adults and children (Burns, 2006; Howe, 2006). Since survival tasks elicit self-referential processing, these findings make sense. This evidence shows that these mechanisms that form the evolutionary adaptions in human memory are present early in life, and are deemed developmentally invariant according to Howe & Otgaar (2013).

Neuroscience Behind Encoding and Recall

Due to the physiological changes that occur within the brain over time, it is important to understand how these physical changes effect memory mechanisms. The medial temporal lobe consists of an interconnected hierarchy of areas in the brain which include the amygdala, hippocampus, entorhinal cortex, parahippocampal cortex, and perirhinal cortex (Quiroga et al., 2008). The hippocampus is at the top of this hierarchal structure, with the amygdala having connections to the other MTL areas and sensory cortex (Quiroga, 2012). Neurons that are present in the human MTL have been found in previous research to be selectively activated according to the level of novelty and familiarity with an image, with the amygdala being concerned with relevant emotional processing in regards to fear (Quiroga et al., 2008).

According to Suthana & Fried (2012), the ability to form new episodic memories is dependent on an intact hippocampus and surrounding MTL. However, for the MTL to encode properly, the event must be perceived and processed in the upstream cortices (Suthana & Fried, 2012). In disagreement with the consolidation model, the recall of episodic memories is always dependent on the hippocampus (Quiroga, 2012). According to the multiple trace theory, the hippocampus is always necessary for binding different neocortical representations of an event to recall the episodic memory at a later time (Quiroga, 2012).

Responses that take place in the MTL, hippocampus, and entorhinal cortex are extremely particular because these responses are crucial in the transformation of novel stimuli to depictions that can be consciously retrieved later on as episodic memories (Suthana & Fried, 2012). In fact, several functional neuroimaging studies in humans have shown that the same brain areas activate during the encoding of new distinct information and the recall of this encoded information (Suthana & Fried, 2012). Previous research has found that patients with MTL damage lose the ability to form new episodic memories (Suthana & Fried, 2012). In agreement with this, Quiroga (2012) found previous evidence that demonstrated MTL lesions cause anterograde amnesia.

Work done by Cahill et al. (1995) and Adolphs et al. (1997) suggested that the results of damage to the amygdala in human patients indicate that the amygdala plays a role in enhancing episodic memory. Hamann, Ely, & Clinton (1999) found that for aversive pictures, recognition-memory enhancement was directly correlated with bilateral amygdala activity during the aversive picture scans. However, there was a slight preference for an inferior and right-lateralized activation for positive pictures (Hamann, Ely, & Clinton, 1999). A follow up correlation analysis of these imaging findings demonstrated a specific relationship between the enhancement of episodic memory for both pleasant and unpleasant emotional stimuli and the level of activity in the amygdala. Subjects who showed greater episodic-memory enhancement that was associated with emotional stimuli also tended to have higher levels of activity in the amygdala when compared to the subjects who showed the least enhancement (Hamann, Ely, Clinton, 1999). The amygdala activity that Kensinger, Kensinger, & Addis (2011) found supports encoding of item-specific details and leads to the retention of a vivid memories with episodic details. Dolcos, Denkova, & Dolcos (2012) reported a correlation between activation in the amygdala and medial temporal lobes with successful encoding of emotional stimuli in contrast to neutral stimuli.

Hamann, Ely, & Clinton (1999) also demonstrated that recognition-memory enhancement for both pleasant and aversive pictures were correlated with bilateral activity in the hippocampal region. Diamond et al. (2007) found that the initiation of a stressful experience produces an intense, brief, initiation of memory-encoding malleability within the hippocampus. This process involves a shift in the hippocampus from its cognitive mapping mode to flashbulb memory mode (Diamond et al., 2007). However, Kolk (1996) found that extreme arousal demonstrates an inhibitory effect on the hippocampus' memory functions. In rebuttal to this, multiple studies have found that acute stress can interfere with cognitive and electrophysiological measures of hippocampal functioning (Lupien & McEwen, 1997; de Kloet, Oitzl, & Joels, 1999; Kim & Diamond, 2002).

Joseph (1998; 1999) found that that hippocampus cannot coordinate its functioning when an individual is experiencing overpowering fear; under these conditions, whatever the individual experiences may be distorted when it is encoded or completely forgotten. Due to this failure of the hippocampus under these conditions, the amygdala steps in to encode these emotional memories and assist with their recall. Another study performed by Metcalfe and Jacobs (1998) supplies further evidence for these previous findings and calls the amygdala a component of the "hot" memory system because it functions optimally under emotionally intense conditions. It has also been found by numerous studies that fear conditioning produces long-lasting increases in excitability in the amygdala (Adamec, Blundell, & Collins, 2001; Schroeder & Shinnick-

Gallagher, 2005; Adamec et al., 1998; Rosen, Adamec, & Thompson, 2005). Woodson et al. (2003) found that hippocampal-dependent working memory was more susceptible to impairments by stress than hippocampal-independent long-term memory, which further supports previous research done by Diamond et al. (1996) which showed that the memory impairments secondary to increased corticosterone levels was selective for hippocampal-dependent memory over hippocampal-independent memory.

In relation to previously discussed cortisol levels in relation to affect, Mico, McEwen, & Shein (1979) demonstrated that subsequent glucocorticoid-related behavioral work has led to the conclusion that long periods of stress can suppress optimal hippocampal functioning. However, amygdala activation is necessary for the modulation of memory by glucocorticoids, as well as for the induced suppression of hippocampal LTP (Roozendaal & McGaugh, 1997; Kim et al., 2001; Roozendaal et al., 2001; Akirav & Richter-Levin, 1999; Richter-Levin & Akirav, 2000). Cahill et al. (1996) found a significant positive correlation between the level of brain glucose metabolic rate in the right amygdala during encoding and the number of emotional, but not neutral, films recalled three weeks later. These results demonstrate a relationship between amygdala activity and episodic memory for aversive stimuli (Cahill et al., 1996). Under conditions of acute stress or the administration of corticosterone, it was found that hippocampal LTP was blocked (Shors et al., 1990; Shors & Thompson, 1992; Pavlides et al., 1995; Pavlides et al., 1995; Pavlides et al., 1996; Garcia et al., 1997; Pavlides & McEwen, 1999; Akirav & Richter-Levin, 1999; Zhou, Zhang, & Zhang, 2000; Wang, Akirav, & Richter-Levin, 2000; Kim et al., 2001; Alfarez et al., 2002; Xiong, Wei, & Xiang, 2004; Kim et al., 2005; Krugers et al., 2005; Weiegert et al., 2005; de Quervain, Roozendaal, & McGaugh, 1998; Conrad, Lupien, & McEwen, 1999; Roosendaal et al., 2004; Kirschbaum et al., 1996; de Quervain et al., 2000; Wolf et al., 2001; Payne et al., 2002;

Buss et al., 2004; Wolf et al., 2004; Kuhlmann, Kirschbaum, & Wolf, 2005; Kuhlmann, Piel, & Wolf, 2005; Payne et al., 2006; Buchanan, Tranel, & Adolphs, 2006; Elzinga, Bakker, & Bremner, 2005; Jay et al., 2004; Garcia, 2001). However, Diamond et al. (1996) found evidence that corticosterone levels alone are insufficient to block LTP and impair memory. LeDoux (1996) found that there is an adrenal steroid threshold in the hippocampus; when this threshold is surpassed due to extreme and sustained levels of stress, the hippocampus can no longer optimally function. When this shut down of the hippocampus occurs, it has been proposed that amygdala functioning is enhanced (LeDoux, 1996).

Diamond et al. (2007) also investigated the extent that the prefrontal cortex is involved with task performance, and was able to conclude that the extent to which the pre frontal cortex is involved in a task, and the degree to which the pre frontal cortex is suppressed by emotionality, are the primary determinants of whether a task's arousal performance curve will be linear or curvilinear. Therefore, if a task involves focused attention to an isolated cue with minimal cognitive demands, then the performance on that task may be enhanced under conditions of high arousal (Diamond et al., 2007).

Since age varies among all participants within the cancer diagnosis group, it is important to examine how age might affect recall. Cohen et. al (1994) examined older adults' abilities to form flashbulb memories for emotionally arousing events; the results from this study demonstrated that older adults were able to form less flashbulb memories than younger adults were. Cohen et al. (1994) speculated that the difference in abilities to form flashbulb memories could be secondary to the lowered responsiveness of the endocrine system in older adults.

Turk et al. (2003) was mentioned earlier regarding the memory differences in older and younger adults in relation to the emotionality of the stimuli. This study turned to the socioemotional selectivity theory as mentioned above, for the explanation of these results, which were also supported by the research done by Mather et al. (2004). Mather measured the activation of the amygdala in both younger and older adults in response to positively arousing, negatively arousing, and neutral visual stimulation. This study revealed that older adults had a higher level of activation change when the visual stimuli altered from neutral to positive, whereas younger adults showed an equal level of activation change when visual stimuli altered from neutral to negative and from neutral to positive (Mather et al., 2004). These results support the same idea that Turk et al. (2003) put forth, in that older adults are less responsive to negative emotional stimuli than younger adults. Overall, receiving a cancer diagnosis is an acutely stressful event which has the capability to enhance or inhibit encoding of the information. The current study will provide insight to which side of this pole is true for cancer patients.

Cancer Treatment Consequences

Chemotherapy has been found to impair both cognitive function and memory, with ranges from 75-95%; however, over a period of two years, these statistics drop to 17-35% impairment after the patient's last chemotherapy treatment (Ahles & Saykin, 2001). Previous research has also shown that the fatigue and depression experienced by cancer patients are both associated with decreased cognitive function (Bender et al., 2006; Castellon et al., 2004). Therefore, after a patient has successfully completed a round of chemotherapy and feels a sense of triumph, it should be predicted that their cognitive abilities should start to increase, not only because their severity of depression would decrease, but also because of the adverse physical effects of the chemotherapy itself such as fatigue.

However, recent research has revealed that active treatment may not negatively impact memory functions. In a study performed by Myers, Sousa, and Donovan (2010), no significant correlations were seen between active disease and memory problems, inferring that active chemotherapy treatment does not have as devastating of an effect on memory. Myers et al. (2010) was also able to identify fatigue as a significant predictor of memory problems, which agrees with the previous research done by Bender et al. (2006) and Castellon et al. (2004). It was also reported by Myers et al. (2010) that no significant difference in the severity of memory problems was seen between participants who had received chemotherapy as part of their treatment at some period, and those participants who were actively receiving chemotherapy. A slightly negative correlation between time since chemotherapy and the report of memory problems was also found in Myers et al. (2010), which further supports the earlier findings of Ahles and Saykin (2001).

Another form of treatment which is most common for solid tumors is radiation. Cognitive deficits associated with cancer radiation therapy of brain tumors include prominent dysfunction of episodic memory (Roman & Sperduto, 1995; Anderson et al., 2000; Moore et al., 1992; Crossen et al., 1994; Abayomi, 1996; Lee et al., 1989; Surma-aho et al., 2001; Kramer et al., 1997; Wefel et al., 2010; Dietrich et al., 2008). It should also be noted that a study done by Armstrong et al. (1993), showed that patients who underwent radiation therapy treatment for brain tumors showed an initial deterioration in long-term memory, regardless of the location of the tumor, on an average of about 1.5 months status post the completion of the treatment. However, patients also consistently demonstrated the rebound phenomenon between 4.7 and 7.6 months after the treatment (Armstrong et al., 1993).

The concept of rebound is important in regards to the improved functioning of memory for specific tasks. Hippocampal neurogenesis (growth of the nerve cells within the hippocampus) appears critical for at least some hippocampal-dependent memory tasks (Monje & Dietrich, 2012). In a study done with rodents, increased hippocampal neurogenesis results in improved performance in certain hippocampal-dependent memory tasks (van Praag et al., 1999). According to Monje and Dietrich (2012), impairment of hippocampal neurogenesis may explain the profound difficulties patients experience encoding new episodic memories following treatment for cancers requiring radiation. Chemotherapeutic agents have also been found to impair hippocampal neurogenesis in experimental models (Seigers et al., 2008; Winocur et al., 2006; Mignone & Weber, 2006). Depending on the delay between diagnosis and the completion of the protocol, the current study will be better able to clarify the inhibition and rebound aspects of memory after treatment.

The Current Study

The current quasi-experiment examined how the acute or chronic consequentiality of a childhood injury memory and car accident memory versus cancer diagnosis memory affected the recall of the memory overall. These events were of natural cause, and therefore provided the experimenter with a view to the inside mechanisms that are likely to enhance memory. We examined how the affect and consequentiality of a patient at the time of their cancer diagnosis affected the vividness of the individual’s memory. Childhood injury is an event that has a high emotional response during encoding but without long-term threat, and therefore this should create the parallel for comparison (Hillman et al., 2010). Car accidents are also experiences that involve high levels of arousal, and have the potential to involve possible chronic pain or disability after the fact.

Similar to two previous studies that looked at childhood injury memories and car accident memories (Hillman et al., 2010; Shaneyfelt, Minor, & Bohannon, 2008), three experimental predictions were made. First, if an evolutionary memory pathway exists to determine threat over and above arousal, then a cancer diagnosis should be more threatening, and also be a better remembered event, regardless of the effects of rehearsal and arousal at the time of encoding. Second, if the arousal mechanism is the proximal cause of flashbulb characteristics in cancer diagnoses memories, then the three different kinds of consequentiality being studied should be equally remembered once the arousal levels of each event are equated. These types of consequentiality include: acute non-lethal threats, cute potentially lethal threats, and the chronic-lethal threats (Appendix 3), should be equally remembered once the arousal levels of each event are equated. Another way of looking at the issue is once delay, rehearsal, and arousal at the discovery/event are equated, do the memories across events differ in quantity or resistance to decay? Lastly, if the evolutionary age of the mechanisms alone determines memory, then the actual injuries with imagery and real immediate pain should be best recalled regardless of delay, rehearsal or rated arousal. Both painful and visual inputs are considered evolutionarily old and should carry weight over and above the evolutionary late achievement of language. Hence, there should be memorial consequences of language, with the self in the case of cancer diagnoses, and with the other in the case of childhood injury where the parent heard about the injury. Also, a hierarchy should be seen between the self and other, where the self is more important even if the other is of biological issue such as in the case of the parent in childhood injury.

METHOD

Participants

The current study assessed 44 individuals who had a confirmed cancer diagnosis. Participants could have a current or previous cancer diagnosis, and were not excluded based on any kind of treatment or medication that they may have received. Participants had to be 18 years or older to participate. The patients ranged from 22-75 years of age (M = 52.43 years, SD = 13.76) with 37 of participants being female and seven being male. The average age of diagnosis was 47 years old (SD = 12.80). Due to the confidential subject matter of medical information, participants involved in this study emailed and/or called the researcher if they wished to participate. The participants were recruited through different mediums: flyers that were sent out on a national level to cancer support groups, personal recruiting in psychology classes, and use of the Butler University SONA system.

The participants signed a statement of informed consent before beginning the study that was included in the US mail packet, or the electronic version for the e-mail version of the protocol (See Appendix 2). Participants were informed that they could discontinue the study at any time without any repercussions. All protocols were kept completely confidential, and participant lists were safely stored in a location only accessible to the researcher. Participants were given a $5 Starbucks gift card based on their completed protocol return, and were also entered in a drawing to win a $50 Visa gift card as additional compensation for participating in the research project.

Hillman et al. (2010) assessed 110 freshmen undergraduates at Butler University who suffered an injury as a child that required a trip to the hospital. Out of these participants, 77 of were female and 20 were male. The remaining 13 participants did not indicate their gender. The average age of injury was 10.92 years old (*SD* = 4.49), with all of the participants being 18 years old at the time of recall. Participants were offered extra credit in one of their psychology classes for participation. In addition to the participants filling out a survey, they were also asked to provide their parents information so that they could be sent a protocol inquiring about their view of the injury.

Out of the 109 participants who took the childhood injury survey and provided parental information, 101 parents sent in a completed protocol. The age and the gender of the parent were not asked. Of the 101 parents who responded, 37 of them had actually seen their child's injury, while the remaining 63 were not present and heard about their child's injury through word of mouth.

Shaneyfelt, Minor, & Bohannon (2008) assessed 75 undergraduate students at Butler University who had experienced a car accident. For inclusion of this data in the current study, the participant had to not have seen the accident coming. Of this sample, 21 of the participants were male and the remaining 54 participants were female. The average current age of these participants was 19.62 years old (*SD* = 1.05), with the average delay between the accident and the time of recall being 4.51 years (*SD* = 6.04). For their participation, students were given extra credit in one of their psychology classes.

Materials and Procedure

The current study took approximately 20-30 minutes to complete. The study consisted of a single protocol which tested the participant's memories for discovering their cancer diagnosis (Appendix 2). The diagnosis protocol was compromised of two main parts. The first part consisted of a free recall narrative which asked the participants to describe the memory for the discovery of the diagnosis. The second part of the protocol consisted of discovery probed questions about the participant's discovery memory, such as the age of the participant at the time of the diagnosis, number of times the participant's discovery was told to others, as well as the expectedness of the diagnosis, vividness of the diagnosis, and arousal level of the announcement of the diagnosis. The probed questions resembled the following: "What were you wearing at the time you learned of your diagnosis?"; "What did you do right after discovering your diagnosis?" and "Where were you when you learned of your diagnosis?" After each discovery probe question the participant's confidence level was assessed using a scale ranging from 1-5, where 1 indicated no confidence and 5 indicated extreme confidence. In addition to the discovery probed questions, other questions concerning the diagnosis were also asked. Such questions included "After your diagnosis, did you receive extra support?" and "After the diagnosis took place, how did you feel?"

After the completed protocol was received either by e-mail or US mail, the participant was mailed a $5 Starbucks gift card and entered into a drawing to win a $50 Visa gift card for participation. The address of the participant was provided by the participant after they indicated in the beginning of the study that they were interested in the $5 Starbucks gift card.

The seven canonical features used in scoring the narratives as well as the ten probe questions used in the probe response section were scored and assessed across all three event conditions. The canonical features for the free recall section was ranked on a scale of 0-3, with 3 indicating more elaboration (Appendix 4). The canonical features for the probed response section were ranked on a scale of 0-2, with 2 indicating more elaboration (Appendix 6). Participants were also asked to rate their confidence in their probed responses on a 1-5 scale, with 5 indicating the most confidence that their answer is accurate.

Each free recall portion of the protocol was scored in accordance with Brown and Kulik's (1977) characteristics for emotional and personal memories. Seven different canonical features were used when scoring the free recall portion of the protocols: others present (those present during the event), author's affect (the emotional reaction of the individual) activity (any behavior that occurred prior to the event), location (where the participant was during the event), time (when the event occurred), other's affect (the emotion reaction of individuals other than the participant that were present for the event), and aftermath (any behavior that occurred after the event). The scoring system was a 0-3 scale, where 0 elicits no response and 3 elicits an elaborate response (Appendix 4).

The probed questions further investigated the canonical features that were of interested, as well as other details surrounding the diagnosis event and the aftermath. Questions such as these assessed the weather that day, any indication of previous knowledge about their diagnosis, support received from family and friends, and any medications they received besides chemotherapy agents. The scoring system was on a 0-2 scale, where 0 elicits no response and 2 elicits an elaborate response (Appendix 6).

Only one other researcher and I scored all of the protocols to avoid inter-rater reliability inconsistencies, which resulted in a reliability estimate of 91% for the scoring rules of the free responses and 96% for the scoring rules of the probed responses. Scores were entered into Microsoft-Excel and later uploaded to a statistical analysis program called Stat-View 5 for further analysis. Data from the current study on discovering a person's diagnosis was then compared to previously collected data from childhood injury memories for both the child and parents and car accident memories (See Appendix 3).

In the study performed by Hillman et al. (2010), participants completed the similarly formatted two part protocol that the cancer patients had, with the exception of the question content which was focused on their injury versus a cancer diagnosis. This protocol consisted of the free recall narrative and probed recall responses, which also included a confidence in answers component. Hillman et al. (2010) used the same scoring mechanisms based on canonical features as mentioned above. This allowed us to use this data for comparison analysis.

Shaneyfelt, Minor, & Bohannon (2008) also used the same protocol format as the current study and Hillman et al. (2010), with the content focused on the car accident memory. This similar protocol format allowed the researcher of the current study to make comparisons across all 5 sets of data due to this data being scored on the same scales. As a set standard within the research lab where all of these studies have been performed, it can be assumed that both the car accident and childhood injury scoring rules resulted in inter rater reliability results that were at least or over 90%.

RESULTS

Multiple ANOVAs were run with differing independent and dependent variables. After initial ANOVAs were ran looking at how the different flashbulb characteristics differed by event type, further ANOVAs were performed to pursue different aspects of significant results. If the F-value was significant, Fischer's LSD post-hoc analysis was run to differentiate which groups significantly differed from each other. ANOVA results for comparison of flashbulb characteristics between events, as well as means and Cohen's f^2 can be found below in Table 1.

Table 1. Means and measures of the five events

	Cancer Diagnosis (N = 44)	Car Accident*** (N = 74)	Childhood Injury**** (N = 109)	Parent View (N = 37)	Parent Hear (N = 63)		
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	*F (4, 326)*	*Cohen's f^2*
Test Delay	5.21 (5.57)	4.51 (6.04)	6.41 (4.28)	6.80 (4.54)	6.44 (4.05)	2.4**	0.13
Affect	4.09 (1.31)	4.03 (.93)	3.19 (.99)	3.41 (.90)	3.28 (.75)	12.9*	0.38
Recounts	54.95 (43.69)	16.11 (21.50)	20.22 (20.64)	10.82 (10.44)	12.12 (14.14)	23*	0.56
Vividness	2.30 (1.67)	4.08 (.82)	3.72 (.87)	3.65 (.86)	3.56 (.96)	23*	0.51
Free Recall	.59 (.18)	.48 (.17)	.52 (.14)	.52 (.19)	.41 (.21)	7.5*	0.28
Probed	.78 (.17)	.77 (.22)	.68 (.13)	.66 (.15)	.58 (.18)	13.2*	0.39
Confidence	.83 (.14)	.70 (.16)	.86 (.12)	.84 (.18)	.83 (.17)	15.2*	0.42

*$p < .0001$
**$p < .0518$
***Car accident data was collected from Shaneyfelt, Minor, & Bohannon, 2008
****Childhood injury memory was collected from Hillman et al., 2010

Delay

When the events were compared to one another, delay was marginally significant, F (4, 315) = 2.38, p < .0518. Car accidents had the shortest delay, and significantly differed from all of the other memories besides cancer diagnoses. None of the other events significantly differed from each other.

Affect

The emotional status of the participant at the time of encoding significantly differed between the six different events, F (4, 321) = 12.90, p < .0001. Cancer diagnosis memories had the highest affect ratings, which were significantly higher when compared to all of the other events besides car accidents. The same was true for car accident memories in that they were significantly different from all of the other events besides cancer diagnoses. None of the events relating to childhood injury significantly differed from each other.

Recounts

Recounts, or the number of times that the participant retold the story to another, statistically significantly differed between events, $F (4, 306) = 25.03$, $p < .0001$. Car accidents and cancer diagnoses did not differ from each other as events that threatened the rememberer, and both had high affect ratings. All the affect ratings related to the three childhood injury-related events were low, and did not differ from each other.

Another analysis was performed where information type replaced event type as the independent variable. How the participant received the information (via pain, vision, or language) had a significant effect on the number of times that the event was retold to others, $F (2, 308) = 8.12$, $p < .0004$ (See Figure 5). Those who received information through language, which include parents who were told about their child's injury and cancer diagnosis patients, had the highest number of recounts ($M = 28.80$, $SD = 35.96$). In addition, language input participants ($M = 28.80$, $SD = 35.96$) had significantly higher numbers of recounts than both pain input participants ($M = 18.58$, $p < .0019$) and vision input participants ($M = 10.82$, $p < .0003$). However, pain and vision input participants did not significantly differ from each other. Again this lack of significant difference may be due to the fact that both pain and vision are more evolutionarily old than language, and they produce strong enough memories where the individual does not need to recount them as often to retain their quality.

Figure 5 here

Vividness

The vividness of the memories significantly differed between event types, F (4, 318) = 21.97, p < .0001. Car accident memories had the highest vividness ratings, whereas cancer diagnosis memories had the lowest vividness ratings. Further analysis of these means revealed that car accident vividness ratings were significantly higher than all of the other events used for comparison. In addition, cancer diagnosis memories had significantly lower vividness ratings than childhood injury memories, parents who viewed their child being injured, and parents who heard about their child's injury. From these results, it seems that the method of information input could play a role in vividness, in addition to whom the threat is directed at.

Another ANOVA was performed to see if there was an interaction effect between victim roles and affect group on the vividness of memory. Victim status had no significant main effect on vividness of memory, but if it was combined with affect group in an interaction, a significant impact on memory vividness occurred, F (2, 31) = 3.08, p < .0475 (See Figure 3). Affect group alone had a marginal main effect on vividness ratings, F (2, 315) = 2.56, p < .0787. The means for the affect group vividness ratings demonstrated an inverted "U" shape (See Figure. 4). Parents who had an injured child and were categorized into the upset affect group had the highest vividness rating (*M* = 4.33, *SD* = .52), whereas parents who fell into the calm category had the lowest vividness ratings (*M* = 3.36, *SD* = 1.00). These results demonstrate that when the threat is directed towards another, specifically another who is of genetic similarity to oneself, affect plays an important role. In addition, these outcomes lead to the assumption that vividness and confidence have a different set of mechanisms than memory quantity does.

Figure 3 here

Figure 4 here

Another ANOVA was run where event type was replaced by information input type as the independent variable. Vividness ratings significantly differed between information type groups, F (2, 320) = 19.34, p < .0001 (See Figure 6). Those who experienced pain (car accident and childhood injury participants) had higher vividness ratings of their memories (*M* = 3.86, *SD* = .87) than those who heard about the event (parents who weren't present when their child was injured and cancer patients diagnosis conversation) (*M* = 3.04, p < .0001). In addition, those who saw the event happen (*M* = 3.65, *SD* = .86) (car accidents and parents viewing their child become injured) also had higher vividness ratings that those who heard the event (*M* = 3.04, p < .0034). However, pain and visual input participants did not significantly differ in their vividness ratings.

Figure 6 here

Free Recall Narrative

Events differed in the amount of detail contained, F (4, 315) = 7.49, p < .0001. Cancer diagnosis memory narratives had the largest amount of detail, whereas narratives of parents who had heard about their child's injury had the least (See Table 1). Also, cancer diagnosis narrative memories were significantly more detailed than car accident memories, childhood injury memories, and parents who heard about their child's injury. In addition, cancer diagnosis memories were marginally more detailed than parents who viewed their child's injury. This marginal effect could be due to the evolutionary survival threat to the parent, since their child is their genetic offspring.

Car accident memories had significantly greater detail than parent's memory of hearing about their child's injury. This particular result demonstrated the effect that victim status has, in whether it is directed at the self or another who is genetically related to the self. Within the three childhood injury related events, childhood injury memories had significantly more detail in the free recall narratives than parents who heard about their child's injury, and these memories were also significantly less detailed than memories of parents who viewed their child's injury. These results again demonstrate that the information input type has an effect on a memory's quality, with pain being remembered the best and a verbal recount of threat to another being the worst.

Another ANOVA was performed, but the independent variable was changed from event type to the information input method. The different information types did not significantly differ from each other. Next, information input type was replaced with victim status (self versus other) as the independent variable. Whether the victim was the self, or a parent's offspring, made a significant difference on the amount of detail in the free recall narrative, $F (1, 318) = 9.81$, $p < .0019$. When the event happened to the individual present in the experience (*M* = .52, *SD* = .17), the free recall contained significantly more detail than when the event happened to another (*M* = .45, $p < .0019$).

An additional ANOVA was performed in order to see if there was an interaction effect between victim roles (self versus other) and affect group (calm, moderate, or upset) on free recall detail. Victim roles did not significantly differ from each other in regards to the level of detail contained in the free recall responses, whereas affect groups did, $F (2, 310) = 3.91$, $p < .0210$ (See Figure 1). Upset participants had the highest detail in their free recall narratives (*M* = .55, *SD* = .17). Instead of the moderate affect group (*M* = .48, *SD* = .16) having the next highest mean for detail, the calm group was next in line for the level of detail (*M* = .50, *SD* = .19). The interaction between victim role and affect group categorization was significant, F (2, 310) = 6.11, p < .0025. Both the calm (*M* = .50, p < .0499) and moderate (*M* = .48, p < .0097) affect groups had significantly lower levels of detail in their narratives than the upset affect group (*M* = .55, *SD* = .17). When the victim was another person, in this case a parent's child, and that parent was upset at the time of encoding, they had the highest amount of detail in the free recall narrative (*M* = .66, *SD* = .32). However, if the parent was calm at the time of encoding, they had the least amount of detail in their narratives (*M* = .42, *SD* = .21).

A new ANOVA was run to analyze how the free recall narrative detail level was affected by event type, affect group, and recount group. As mentioned above, free recall significantly differed by event type. However in this new comparison, the results differed for the effects on the free recall detail, F (4, 268) = 4.24, p < .0024. Recount groups also significantly differed in the amounts of detail in their narratives F (1, 268) = 5.55, p < .0192. In this analysis, affect groups did not significantly differ in the amount of detail that their free recall narratives contained.

The interaction between event type and affect group had a significant impact on the free recall narrative detail content, F (8, 268) = 2.38, p < .0173. In addition, the event by recount group interaction also had a significant influence the level of detail in the narratives, F (4, 268) = 4.36, p < .0020. However, the affect group by recount group interaction was not significant. Yet, when event type was added to this interaction it marginally impacted free recall narratives, F (8, 268) = 1.8, p < .0762.

Probed Question Responses

The probed responses of participants significantly differed between events, F (4, 324) = 13.22, $p < .0001$. Cancer diagnosis participants' probed responses were scored the highest, whereas memories of parents who heard about their child's injury scored the lowest (See Table 1). Cancer diagnosis memory responses were scored significantly higher than all of the other events besides car accidents. Both of these memories produced high levels of detail in their responses, but it appears that something is lost when the threat is directed towards another and is conveyed through language. Childhood injury memories had significantly higher scores on the probed responses than parents who heard about their child's injury. In addition, parents who were present at the time of their child's incident had higher scored responses than parents who only heard about their child's injury.

An ANOVA was performed in order to see if there was an interaction effect between victim roles and affect group categorization for probed response detail scores. The victim role significantly influenced the detail of the probed responses, F (1, 319) = 13.07, $p < .0003$. When the event happened to the individual, the probed responses contained significantly more detail than when the event happened to another. However, both affect group alone and the interaction between victim and affect group was not significant.

A new ANOVA was run to see if there were any significant interactions that affected the detailed responses of the probed question of the protocol. Again as mentioned earlier, probed responses of the different events significantly differed, but in this comparison the results were the following, F (4, 276) = 5.59, $p < .0002$. In addition, recount groups significantly differed in how they responded, F (1, 276) = 5.47, $p < .0201$. However, the interaction between event type and recount group was not significant. The affect groupings did not differ in how they responded to the probed questions.

Probed Response Confidence

Probed memory confidence statistically significantly differed between events, $F(4, 323) = 15.23$, $p < .0001$. Childhood injury memories had the highest confidence ratings, whereas car accident memories had the lowest. In fact, car accident memories were significantly lower in confidence than all of the other events.

Another ANOVA was run to see how victim role (self or other) and affect group (calm, moderate, upset) influenced the confidence in the probed recall answers. Which affect group the participant was split into had no effect on confidence, whereas there was a significant effect of victim status (self vs. other) on confidence, $F(1, 319) = 13.07$, $p < .0003$ (See Figure 2). However, the interaction between affect group and victim was not significant.

Figure 2 here

DISCUSSION

Prediction One

Hypothesis one stated that if an evolutionary memory pathway exists to determine threat over and above arousal, then a cancer diagnosis should be more threatening, and also be a better remembered event, regardless of the effects of rehearsal and arousal at the time of encoding. Evolution should give an advantage to those individuals with better memories. This evolutionary advantage should be displayed in easily remembered experiences related to: resource gathering, sexual selection, and avoiding threats. The current study only focused on the threat avoidance.

Howe & Otgaar (2013) came to the conclusion that evolution is a distal cause, and works through proximal mechanisms. Two of these proximal mechanisms are arousal and rehearsal. In relation to the current study, car accident and cancer diagnosis memories were found to not significantly differ for arousal, but cancer patients were likely to recount their diagnosis conversation twice as often. Perhaps the increased recounts of cancer diagnosis memories are due to the language input of the threatening information. Since language is newer evolutionarily, these memories would be expected to be the weakest; this may be why the memory must be rehearsed more often. If a memory involves painful and visual input, as well as high arousal, the memory will not necessarily require high rehearsal to have extensive detail and other flashbulb characteristics (Julian, Bohannon, & Aue, 2009). However if the memory has a low arousal rating, all is not lost.

Both car accident and cancer patients had the event directly happen to the participant. Threats that are directed towards the self were better remembered than threats related to others, even if that other is your own child and is a product of your genetics. However, because a child is genetically related to each parent, one would expect parents who viewed their child's injury to have better memories than parents who only heard about their child's injury. This is exactly what this study found; parents who viewed their child's injury had both more detailed free recall narratives and probed questions responses.

Hypothesis was confirmed in that cancer diagnosis memories were remembered the best. However, it cannot be determined whether this superiority is due to the extremely high number of recounts, or because they had the highest level of threat/consequentiality. Cancer diagnosis memories displayed significantly higher detail in the free recall narratives when compared to all of the other events. However, in the probed recall responses, car accident memories and cancer diagnosis memories were not found to significantly differ in the level of detail that they contained. This demonstrates that the input mechanism may play a role that helps equate the car accident probed responses with the cancer diagnoses. As discussed previously, the evolutionarily oldest input is pain, which is experienced by car accident participants. In addition to pain, car accident participants also had the visual input at the same time. However, participants who indicated that they "saw the accident coming" were removed before analysis so that the element of surprise was involved. This may explain why there was no difference in the level of detail in the probed recall responses.

Prediction Two

The second hypothesis that if the arousal mechanism is the proximal cause of flashbulb characteristics in cancer diagnoses memories, then the three different kinds of consequentiality (cancer diagnosis, versus car accident, versus childhood injury) being studied should be equally remembered once the arousal levels of each event are equated. The division of threat, information input, and victim status by event type is broken down in Appendix 3. affect significantly differed between event types, with cancer diagnosis memories having the highest affect ratings and childhood injury memories having the lowest.

The free recall narratives and probed recall responses were used to assess the detail of the memory. The free recall narrative detail significantly differed between event groups, which infer that the different types of consequentiality play a role in how well a memory is remembered. However, what affect group the scores were filtered into did not significantly differ. This demonstrates that arousal does not play a role in how detailed the free recall narrative of the memory is at the time of retrieval.

The number of times that a memory was recounted had a significant influence on the amount of detail in the free recall narrative. This positive correlation was discussed previously in regards to the proximal mechanisms that contribute to memory. However, the interaction between affect group and recount group was not found to be significant, which demonstrated how strong of pull affect has on this relationship. Overall, affect does not seem to be a determining factor in how free recall narratives are rated on level of detail.

However, affect alone does not cover the entire story of the factors that lead to better memory. Both the type of event and number of recounts appear to be a crucial part of what determines the quality of the memory. The problem with this relationship is that it is unable to be determined whether event type, number of recalls, or the relationship between these two variables is responsible for the increased quality.

The probed recall responses were also used to assess memory quality in order to get a more comprehensive picture. As with the free recall narratives, the amount of detail in the probed responses significantly differed between event types, which lets us conclude that the level of consequentiality and/or level of threat plays a role in the encoding of the memory. In addition, the recount group classification also had a significant influence on the level of detail in the probed responses which mirrors the findings for the free recall narratives.

In contrast to the free recall responses, the probed responses were influenced less by the level of affect at the time of encoding. However, since both of these measures demonstrated that affect group does not influence the quality if memories in this study, we can be confident that affect is not a determining factor of a memory's quality. As with the free recall portion, any interaction effect that included affect group classification nullified the results.

In conclusion, the original prediction of hypothesis two was not supported. Nonetheless, the event type is not the only component that influences a memory's quality. The number of recounts was also found to significantly influence both free recall narratives' and probed responses' level of detail. Therefore, these relationships should be further analyzed in the future to better understand the memory mechanism at play. In addition, it is of interest to note that the means for the affect group vividness ratings demonstrated an inverted "U" shape (See Figure. 4). This is relevant to the findings that Rubin & Kozin (1984) displayed, which is that the quantity, not the quality, of affect predicts memory vividness.

Prediction Three

The last hypothesis states that if the evolutionary age of the mechanisms alone determines memory, then the actual injuries with imagery and real immediate pain should be best recalled regardless of delay, rehearsal, or rated arousal. Therefore, childhood injury and car accident memories should be better remembered than the parents' memory of their child's injury and cancer diagnosis memories.

Additionally, the amount of evolutionary time that systems have to integrate information should also show differences in memory. For example, pain would be the oldest form of environmental information that organisms have to deal with. Fifty to one hundred millions years later, primitive forms of vision would inform organisms about their environment, and if those visual signals were related to survival or sex, they should have privilege in the memorial system. Vision allows nearly no delay between detecting elements in the environment and our ability to process their location, type, advantage/disadvantage to approach, etc.

Among the most efficient storage and retrieval codes, language is the newest input and processing medium for humans following vision by as much as 300 million years or more. We transfer images that we see into verbal codes which is what we remember; in other words, a form of compression (Sternberg, 2003). Language is also a way to allow items to exit our memory by attaching the meaning one word to other words through association.

The development of information input evolutionarily also mimics the human fetus development through life. The fetus is able to hear sounds in utero, and slowly begins to develop its vision once it is exposed to the outside world. Language, however, is a late accomplishment developmentally. Humans do not develop language skills until around the age of 18 months.

Due to these developmental and evolutionary processes, one would expect to see language as being the newest way to process information. Therefore this information should be more difficult to recall, even if that threat is more severe. However, there is the possibility that severity of threat trumps every other factor, and therefore the memories that are of the highest threat should be better remembered.

One would expect to see the equal prevalence of pain and visual input, or maybe pain over visual, to overpower verbal input. The parallel to this idea in the current study is demonstrated by the car accident participants. These participants had the pain and visual input mechanisms that allowed them to reach the same level of arousal and narrative detail as cancer diagnosis patients who utilized their language input mechanism. However, pain and visual input participants did not significantly differ in their vividness ratings. Again, this lack of difference reverts back to the fact that both pain and vision and older evolutionarily, whereas language is fairly new. In conclusion, this hypothesis was shown to be false.

Threat to Self versus Other

Memory is used to remember the past, anticipate future events and interpret them accordingly (Otgaar & Howe, 2014). Although memory may not be perfectly accurate, it helped us navigate the world with better proficiency (Otgarr & Howe, 2014). Just like any other biological system, memory evolved to enhance survival and reproduction (Nairne et al., 2009). Natural selection has also affected memory evolution because it enhanced fitness in specific environments (Bowlby, 1969; Tooby & Cosmides, 1992). Processing information with regard to survival has been shown to enhance long-term memory (Nairne, Thompson, & Pandeirada, 2007; Kang & McDermott, 2008). Nairne, et al. (2007) assumed that memory has become adapted to help humans resolve reproduction and survival problems.

Prior work in adaptive memory used imagined threats to the rememberer to stimulate putative adaptive memory circuits (Howe & Otgaar, 2014). Subjects were asked imagine being on a savannah without food water or weapons and rate words for their survival value. This approach showed reliable, albeit small, enhancements to recall of the word lists. What the experimental approach lacked was a parallel to real world experience and survival processing not related to the participants themselves. Threats to one's children are certainly fitness critical and when parents see their child injured, their event recall is almost as detailed as the recollection of the injured children themselves (Atkinson & Bohannon, 2013). Henry, et al. (2000) found children recalled more details about the death of their parent than the death of their best friend's parent. Clearly, the passing of a parent in an altricial species like humans has huge survival (fitness) consequences for the deceased parent's offspring and is well recalled despite not being a direct threat to the self. The current study offers supporting evidence for this idea. Affect ratings were higher for both parents who heard about and saw their child's injury when compared to the children's affect. In addition, parents who viewed their child's injury had more vivid memories than cancer diagnoses.

Parents who viewed their child's injury had the same level of free recall detail as the child victim. In addition, these parents also had more extensive free recall narratives than car accident participants. Only in the probed responses, did child injury victims exceed their parents in memory quantity (See Table 1). All parents, child victims and cancer diagnosis patients were equally confident in their probed memory. The interaction between threat (self versus other) and affect group (calm, moderate, upset) demonstrated that parents had a significant increase in free recall detail ratings, probed response confidence, and vividness ratings (See Figure 1, Figure 2, and Figure 3).

Not only were parents evolutionarily tuned into threats towards their off spring, but children are also programmed early on to recognize survival threats. Otgaar & Smeets (2010), found both younger (4-8) and older (9-11) children have been shown to display fitness-relevant memory processing. Otgaar & Howe (2014) concluded that natural selection exerts a significant pressure during childhood, and these pressures should be apparent in memory related to survival cues. In the current study, the injury acted as a survival cue because it involved a hospital trip and medical intervention.

Childhood injury memories were found to have more recounts than car accident memories, and were more vivid than cancer diagnosis memories. In addition, these memories were slightly more detailed than car accident memories in the free recall narratives. Among other events, childhood injury memories had the highest confidence in the probed recall responses. Even though this is only one type of survival threat during childhood, it provides further evidence that memory evolutionary mechanisms exist early on.

Vividness and Confidence

A flashbulb event reliably enhances measures of memory quality like vividness and confidence (Talarico & Rubin, 2003). In fact, the association of vividness with belief in memory accuracy is fairly common (Neisser, 1982; Neisser & Harsch, 1992; Weaver, 1993; Schmolck et al., 2000). Vividness and confidence may correlate within each event within SS whereas the means across events do not show a correlation. In contrast to these findings, the current results found no link between vividness and confidence. Childhood injury memories which were found to have the highest confidence ratings, yet only had a moderate vividness rating when compared to the other four events. Cancer diagnosis memories and parent's memories had the same confidence ratings, yet cancer diagnosis patient's had the lowest vividness ratings. Finally, whereas cancer diagnosis memories had the highest vividness ratings, they had the lowest confidence ratings. These results point to vividness and confidence being two separate characteristics of flashbulb memories, instead of symptoms of the same memory quality mechanism.

Another memory modulator is affect. Measures of initial affective arousal have been correlated with the belief that the memory is accurate (Talarico & Rubin, 2003). Habermas and Diel (2013) also demonstrated that emotionality was an excellent predictor of memory vividness. Interestingly, recent research found specific genetic polymorphisms that may positively influence both cognition and affective processes that allow greater emotional memory capacity (Todd et al., 2011). Using the modulation hypothesis as a foundation, the Endophenotypic Model of Emotional Memory (EMEM) proposed that humans who have increased perceptual vividness at encoding are more likely to have more extensive and vivid memory. Todd et al. (2011) suggested that this enhancement at encoding interacts with the effects of arousal enhancing consolidation. The EMEM model holds that salient events elicit enhanced attention as well as arousal-enhanced memory consolidation processes (Todd et al., 2011). This enhanced perceptual experience may be linked to the amygdala's enhancing effect on the visual cortex for emotional images (Bradley et al., 2003; Padmala & Pessoa, 2008), and also modulates memory (Cahill & Anderson, 2009).

In contrast to these findings, the current results found no link between vividness and confidence. Whereas cancer diagnosis memories had the highest affect, they had the lowest vividness and moderate confidence when compared to the other four events. In addition to these findings, childhood injury memories had the lowest affect, yet they had the second highest vividness ratings and the highest confidence. Overall, these conflicting findings need to be pursued further in order to determine the actual underlying mechanisms of how affect influences vividness and confidence. However, the idea of actual physiological changes is intriguing evolutionary; perhaps our brains have come to evolve to better accommodate emotional memories so that cues to survival can be better encoded and more easily recalled.

Yerkes Dodson Law

The brief improvement of memory processing in the hippocampus during times of stress or arousal enhances the declarative component of FBMs (Diamond et al., 2007). This stress activation of the hippocampus causes a rapid and intense elevation of intracellular calcium, which leads to a quick enhancement (phase 1) (Diamond et al., 2007). However after this brief time of hippocampal plasticity, a refractory period occurs; stimulation delivered during this time is less effective at inducing long-term processing (phase 2) (Diamond et al., 2007; Leider, Bohannon, & Sauer, 2012). This change in charge within the cell creates an inverted "U" shape which was initially found by Duffy (1957), who demonstrated that the relationship between activation and quality of performance was a moderate one. Andreano & Cahill (2006) also found an inverted U pattern between cortisol levels and memory consolidation.

The question then becomes, if this relationship is true, should FBM even exist due to these memories being high in emotionality? The answer is yes; extensive research shows that under certain conditions, high levels of emotionality can enhance memory (Ni, 1934; Cahill, Gorski, & Le, 2003; McGaugh, 2004; Sharot, Delgado, & Phelps, 2004; Nielson, Yee, & Erickson, 2005). Almost all FBMs are brief in nature, and therefore do no trigger the full shut down of the hippocampus. The amygdala appears to remain in phase 1 longer than the hippocampus, which may be why the amygdala has such a crucial role in the consolidation of the emotional memory (Izquierdo & Medina, 1997; Pelletier & Pare, 2004; McGaugh, 2004). In contrast, Kavushansky et al. (2006) found that emotional learning resulted in suppression of long-term processing in the amygdala. These results are suggestive that just as the hippocampus, the amygdala as an initial activation phase which is followed by a slowly developing inhibitory phase.

In the current study when participants were broken down by affect group and vividness, the inverted "U" shape was demonstrated (See Figure 4). This finding supports the concept that a moderate level of arousal helps participants enhance certain characteristics of memory. In addition, cancer diagnosis memories were found to have the highest affect rating and the lowest vividness rating. However, a conflicting finding was found with car accident memories. These memories were second overall for affect, but were found to have the highest vividness. Due to their affect rating being in the upper range, they should have had a moderate or lower vividness rating. It is a possibility that the method of information input could be playing a role in this relationship and should be further investigated.

Further, parents who viewed their child's injury were considered the "moderate" group with how they compared to the other events. Therefore, one should assume that these memories had the most detail in the free recall narratives and probed recall responses because they should have been consolidated the best at encoding. However, this was not the case. Parents who viewed their child's injury had the same amount of detail as childhood injury memories, and were also less detailed than cancer diagnosis memories. This does not correspond with the Yerkes Dodson law, especially since cancer diagnosis memories had the highest affect whereas childhood injury memories had the lowest affect.

In comparing the detail in the probed responses, one should assume that memories of parents who viewed their child's injury had the most detail due to their "moderate" affect. Again, as with the free recall narratives, this was not found to be the case. These memories were only found to be more detailed in the probed responses than parents who heard about their child's injury. In addition, these memories did not significantly differ in probed response detail when compared to childhood injury memories (See Table 1).

Limitations and Weaknesses

The sample size of cancer patients collected (N = 44) was smaller than had been originally desired, yet large enough to provide statistically significant results that demonstrated mostly large effects. In future studies or for replication, a larger sample size is recommended in order to increase power. In addition, comparison between different types of cancers would be interesting to see how the severity and the anticipation of the duration of treatment would affect the encoding characteristics. One limitation with only being able to obtain participants from cancer support groups is that they were in a setting where they are encouraged to share their story with others and possibly a therapist. In future studies, participants should be asked how many times they: recounted their diagnosis story outside of any type of therapy or support group and how many times they have recounted their diagnosis conversation in total.

The patients who contacted the researcher were majority female, with only seven males composing part of the sample. If there were any kind of gender effects within the cancer diagnosis sample, it is safe to say that they were not detected in part due to this female biased. Efforts were made to contact cancer support groups for prostate cancer patients with little response in return. In future studies, efforts should be made to achieve a more gender balanced sample.

The current study recruited participants through three main methods which included: Butler SONA systems, in class advertisements, and dispersing posters to cancer support group meeting places on a national level. However, due to the sensitive topic, this recruitment process needed to be approached with confidentiality and empathy in mind. Financial compensation was used to increase participation which originally increased numbers in the beginning of the study, but the number of participants who contacted the researcher eventually dwindled out.

Conclusions

The analysis of the five event conditions demonstrated that the information input method, affect at the time of encoding, number of recounts, and perceived consequentiality/threat of the situation significantly affect memory quantity. The low vividness demonstrated by cancer diagnosis memories in comparison to the other event's vividness ratings demonstrates the importance of whether the threat is directed at the self or another, and how the information is actively delivered during the event. These results show how these factors have the potential to impact memory quality. Memory quality consists of the confidence in and vividness of the memory at the time of recall, while memory quantity consists of the level of detail in the free recall narratives and probed responses (Talarico, LeBar, & Rubin, 2004). Even though the threats of a car accident and childhood injury are delivered through the oldest evolutionary mechanisms of pain and vision, the threat of a cancer diagnosis through language was shown to trump both of these events in memory quantity. From these findings, we can assume that the perceived consequentiality of the event is more important than the input mechanism when it comes to the quantity of the memory as assessed by the level of detail in free recall narratives. However, it is also important to note that cancer diagnosis and car accident memories did not differ in the level of detail that was contained in the probed recall responses. Even though cancer diagnosis and car accident memories did not significantly differ from each other in their affect ratings, cancer diagnosis memories still came out on top with memory quantity.

In closing, this study is important because it demonstrates how different factors affect memory recall across varying event conditions. It provides insight into how the presence and absence or degrees of certain features like vividness, affect, consequentiality, and rehearsals can have on memory recall. For instance, knowing that the method of information input and perceived threat affect the quality of memory can benefit us as humans to better understand what is going on with memory on an evolutionary level.

References

Abayomi, O.K. (1996). Pathogenesis of irradiation-induced cognitive dysfunction. *Acta Oncol, 35,* 659–63.

Adamec, R. E., Blundell, J., & Collins, A. (2001). Neural plasticity and stress induced changes in defense in the rat. *Neuroscience and Biobehavioral Reviews, 25* (7-8), 721–744.

Adamec, R. E., Burton, P., Shallow, T., & Budgell, J. (1998). NMDA receptors mediate lasting increases in anxiety-like behavior produced by the stress of predator exposure — implications for anxiety associated with posttraumatic stress disorder. *Physiology and Behavior, 65* (4-5), 723–737.

Adolphs, R., Cahill, L., Shul, R., & Babinsky, R. (1997). Impaired declarative memory for emotional memory material following bilateral amygdala damage in humans. *Learning Memory, 4*, 291-300.

Agypt, B. (2007). *Children's memory for the announcement of their parents' divorce*. Butler University Hono's Thesis.

Ahles, T.A., & Saykin, A.J. (2001). Cognitive effects of standard-dose chemotherapy in patients with cancer. *Cancer Investigation, 19,* 812–820. doi: 10.1081/CNV-100107743

Akirav, I. & Richter-Levin, G. (1999). Biphasic modulation of hippocampal plasticity by behavioral stress and basolateral amygdala stimulation in the rat. *Journal of Neuroscience, 19,* 10530–10535.

Alfarez, D., Wiegert, O., Joels, M., & Krugers, H. (2002). Corticosterone and stress reduce synaptic potentiation in mouse hippocampal slices with mild stimulation. *Neuroscience, 115* (4), 1119–1126.

Anderson, V.A., Godber, T., Smibert, E.,Weiskop, S., & Ekert, H. (2000). Cognitive and academic outcome following cranial irradiation and chemotherapy in children: A longitudinal study. *British Journal of Cancer*, *82*, 255–62.

Andreano, J. M. & Cahill, L. (2006). Glucocorticoid release and memory consolidation in men and women. *Psychological Science, 17* (6), 466-470.

Armstrong, C., Mollman, J. J., Corn, B. W., & Alavi, J. J. (1993). Effects of radiation therapy on adult brain behavior: Evidence for a rebound phenomenon in a phase 1 trial. *Neurology*, *43*(10), 1961-1965.

Atkinson, D., Hillman, J. & Bohannon, J. (2013). *Flashbulb memory microcosms: Recollections of childhood injuries by victims and parents*. Paper presented at SARMAC, Rotterdam, NL.

Atkinson, R. C., & Shiffrin, R. M. (1968) Human memory: A proposed system and its control processes. In. K. W. Spence and J. T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and Theory, 2* New York: Academic Press.

Berntsen, D. & Thomsen, D. K. (2005). Personal memories for remote historical events: Accuracy and clarity of flashbulb memories related to World War II. *Journal of Experimental Psychology, General, 134* (2), 242-257.

Bjorklund, D. F., & Pelligrini, A. D. (2000). Child development and evolutionary psychology. *Child Development, 71,* 1687-1708.

Bohannon, J. N. (1988). Flashbulb memories for the Space Shuttle Disaster: A tale of two theories. *Cognition 29*, 179-196.

Bowlby, J. (1969). *Attachment and loss.* New York: Basic Books

Bradley, M.M., Sabatinelli, D., Lang, P.J., Fitzsimmons, J.R., King, W., & Desai, P. (2003).

Activation of the visual cortex in motivated attention. *Behavioral Neuroscience, 117* (2), 369-380.

Brown, R. & Kulik, J. (1977). Flashbulb memories. *Cognition*, *5*, 73-99.

Buchanan, T. W., Tranel, D., & Adolphs, R. (2006). Impaired memory retrieval correlates with individual differences in cortisol response but not autonomic response. *Learning and Memory,13* (3), 382–387.

Burns, D. J. (2006). Assessing distinctiveness: Measures of item-specific and relational processing. In R. R. Hunt & J. B. Worthen (Eds.), *Distinctiveness and memory* (pp. 109-130). New York, NY: Oxford University Press.

Buss, C., Wolf, O. T., Witt, J., & Hellhammer, D. H. (2004). Autobiographic memory impairment following acute cortisol administration. *Psychoneuroendocrinology, 29* (8), 1093–1096.

Cahill, L. & Anderson, A.K. (2009). Emotional learning in humans. In L. Squire (Eds.) *The new encyclopedia of neuroscience.* London: Elsevier.

Cahill, L., Babinsky, R., Markowitsch, H. J. & McGaugh, J. L., (1995). The amygdala and emotional memory. *Nature*, *377*, 295-296.

Cahill, L., Gorski, L., & Le, K. (1996). Amygdala activity at encoding correlated with long-term, free recall of emotional information. *Proc. Natl. Acad. Sci. USA*, *93*, 8016-8021.

Cahill, L., Gorski, L. & Le, K. (2003). Enhanced human memory consolidation with post-learning stress: Interaction with the degree of arousal at encoding. *Learning and Memory, 10* (4), 270-274.

Carstensen, L. L., & Turk-Charles, S. (1994). The salience of emotion across the adult life span. *Psychology and Aging*, *9*, 259-264.

Carstensen, L. L., & Turk Charles, S. (1998). Emotion in the second half of life. *Current Directions in Psychological Science, 7*, 144-149.

Christianson, S. A., (1989). Flashbulb memories: Special, but not so special. *Scandinavian Journal of Psychology, 27*, 55-67.

Cohen, G., Conway, M. A., & Maylor, E. A. (1994). Flashbulb memories in older adults. *Psychology and Aging, 9*, 454-463.

Colgrove, F.W. (1899). Individual memories. *American Journal of Psychology, 10*, 228-255.

Conrad, C. D., Lupien, S. J., & McEwen, B. S. (1999). Support for a bimodal role for type II adrenal steroid receptors in spatial memory. *Neurobiology of Learning and Memory, 72* (1), 39–46.

Conway, M. A. (1995). Flashbulb Memories: Essays in cognitive psychology. Hillsdale, NJ: Lawrence Erlbaum Associates Inc.

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review, 107*, 261–288.

Conway, M. A., & Tacchi, P. C. (1996). Motivated confabulation. *Neurocase, 2*, 325–339.

Crossen, J.R., Garwood, D., Glatstein, E., & Neuwelt, E.A. (1994). Neurobehavioral sequel of cranial irradiation in adults: Are view of radiation-induced encephalopathy. *Journal of Clinical Oncology, 12*, 627–42.

de Kloet, E.R., Oitzl, M.S., & Joels, M. (1999). Stress and cognition: Are corticosteroids good or bad guys? *Trends Neuroscience*, *22*, 422–426.

de Quervain, D. J., Roozendaal, B., & McGaugh, J. L. (1998). Stress and glucocorticoids impair retrieval of long-termspatial memory. *Nature, 394* (6695), 787–790.

de Quervain, D. J., Roozendaal, B., Nitsch, R. M., Mc-Gaugh, J. L., & Hock, C. (2000). Acute cortisone administration impairs retrieval of long-term declarative memory in humans. *Nature Neuroscience, 3* (4), 313–314.

Diamond, D. M., Campbell, A. M., Park, C. R., Halonen, J. & Zoladz, P. R. (2007). The temporal dynamics model of emotional memory processing: a synthesis on the neurobiological basis of stress-induced amnesia, flashbulb, and the Yerkes-Dosson Law. *Neural Plasticity, 2007*. doi: 10.1155/2007/60803

Diamond, D.M., Fleshner, M., Ingersoll, N., & Rose, G.M. (1996). Psychological stress impairs spatial working memory: Relevance to electrophysiological studies of hippocampal function. *Behavioral Neuroscience, 110,* 661–672.

Dietrich, J., Monje, M., Wefel, J., & Meyers, C. (2008). Clinical patterns and biological correlates of cognitive dysfunction associated with cancer therapy. *Oncologist*, *13*, 1285–95.

Dolcos, F., Denkova, E., & Dolcos, S. (2012). Neural correlates of emotional memories: A review of evidence from brain imaging studies. *Psychologia, 55*, 80-111.

Duffy, E. (1957). The psychological significance of the concept of "arousal" or "activation." *Psychological Review, 64* (5), 265-275.

Elzinga, B. M., Bakker, A., & Bremner, J. D. (2005). Stress-induced cortisol elevations are associated with impaired delayed, but not immediate recall. *Psychiatry Research, 134* (3), 211–223.

Fels, L. (2011). *Affect and Consequentiality Effects on Remembering Important Childhood Events*. Butler University Honor's Thesis.

Fivush, R., Sales, J. M., Goldberg, A., Bahrick, L., & Parker, J. (2004). Weathering the storm: Children's long-term recall of Hurricane Andrew. *Memory, 12,* 104–118.

Flykt, A. (2005). Visual search with biological threat stimuli: Accuracy, reaction times, and heart rate changes. *Emotion, 5* (3), 349–353.

Foa, E. B., & Hearst-Ikeda, D. (1996). Emotional dissociation in response to trauma: An information-processing approach. In L. K. Michelson & W. J. Ray (Eds.), *Handbook of dissociation: Theoretical and clinical perspectives* (pp. 207–222). New York: Plenum Press.

Garcia, R. (2001). Stress, hippocampal plasticity, and spatial learning. *Synapse, 40* (3), 180–183.

Garcia, R., Musleh, W., Tocco, G., Thompson, R. F., & Baudry, M. (1997). Time-dependent blockade of STP and LTP in hippocampal slices following acute stress in mice. *Neuroscience Letters, 233* (1), 41–44.

Godden, D., & Baddeley, A. (1975). Context-dependent memory in two natural environments: On land and underwater. *British Journal of Psychology, 66,* 325-331. doi:10.1111/j.2044-8295.1975.tb01468.x

Gold, P. E. (1992). A proposed neurobiological basis for regulating memory storage for significant events. In E. Winograd, & U. Neisser (Eds.), *Affect and accuracy in recall: Studies in "flashbulb" memories* (pp. 141-161). Cambridge, England: Cambridge University Press.

Graves, E.I., Libkuman, T.M., Otani, H., & Widner, R.L. (2007). Memory for emotionally arousing stimuli: a comparison of younger and older adults. *The Journal of General Psychology*, *134* (1), 23-42.

Habermas, T., & Diel, V. (2013). The episodicity of verbal reports of personally significant autobiographical memories: Vividness correlates with narrative text quality more than with detailedness or memory specificity. *Frontiers In Behavioral Neuroscience,7,* doi:10.3389/fnbeh.2013.00110

Hamann, S.B., Ely, T.D. & Clinton, D.K. (1999). Amygdala activity related to enhanced memory for pleasant and aversive stimuli. *Nature Neuroscience, 2*(3), 289-293.

Harvey, A. G., Bryant, R. A., & Dang, S. T. (1998). Autobiographical memory in acute stress disorder. *Journal of Consulting and Clinical Psychology, 66,* 500–506.

Henry, C., Bohannon, J. & Miller, B. (2000). *Flashbulb memories of a parent's death: Child vs. Friend differences.* Paper presented at APS, Miami, FL.

Hilliard, A. (2008). *Memories of childhood injury*. Butler University Honors Thesis.

Hilliard, A., Gillott, S. & Bohannon J. (2008) *Everybody hurts, sometimes. But how well do we remember it?* Paper presentation at APS, Chicago.

Hillman, J., Atkinson, D., Hilliard, A., & Bohannon, J. (2010). *Consistency in the memories of parents and children for traumatic childhood injuries.* Paper presented at APS, Boston.

Howe, M. L. (2006). Distinctiveness effects in children's memory. In R. R. Hunt & J. B. Worthen (Eds.), *Distinctiveness and memory* (pp. 237-257). New York, NY: Oxford University Press.

Howe, M. L. & Otgaar, H. (2013). Proximate mechanisms and the development of adaptive memory. *Current Directions in Psychological Science, 22*, 16-22. doi: 10.1177/0963721412469397

Otgaar, H., & Howe, M. L. (2014). What kind of memory has evolution wrought? Introductory article for the special issue of memory: Adaptive memory: The emergence and nature of proximate mechanisms. *Memory, 22*(1), 1-8. doi:10.1080/09658211.2013.800355

Izquierdo, I., & Medina, J.H. (1997). Memory formation: The sequence of biochemical events in the hippocampus and its connection to activity in other brain structures. *Neurobiology of Learning and Memory, 68* (3), 285-316.

James, W. (1890). *The principles of psychology*. New York: Holt.

Jay, T. M., Rocher, C., Hotte, M., Naudon, L., Gurden, H., & Spedding, M. (2004). Plasticity at hippocampal to prefrontal cortex synapses is impaired by loss of dopamine and stress: Importance for psychiatric diseases. *Neurotoxicity Research, 6* (3), 233–244.

Joseph, R. (1998). Traumatic amnesia, repression, and hippocampus injury due to emotional stress, corticosteroids and enkephalins. *Child Psychiatry and Human Development, 29* (2), 169–185.

Joseph, R. (1999). The neurology of traumatic “dissociative” amnesia: Commentary and literature review. *Child Abuse and Neglect, 23* (8), 715–727.

Julian, M., Bohannon, J.N., & Aue, W. (2009). Measures of flashbulb memory: Are elaborate memories consistently accurate? In: O. Luminet and A. Curci (Eds.), *Flashbulb memories: New issues and new perspectives* (pp. 99–122). New York: New York: Psychology Press.

Kang, S., McDermott, K.B., & Cohen, S. (2008). The mnemonic advantage of processing fitness-relevant information. *Memory & Cognition, 36*, 1151-1156.

Kangas, M., Henry, J.L., & Bryant R.A. (2005). A prospective study of autobiographical memory and posttraumatic stress disorder following cancer. *Journal of Consulting and Clinical Psychology, 73*, 293-299.

Kavushansky, A., Vouimba, R.M., Colhen, H., & Richter-Levin, G. (2006). Activity and plasticity in the CA1, the dentate gyrus, and the amygdala following controllable vs. uncontrollable water stress. *Hippocampus, 16* (1), 35-42.

Kensinger, E. A., Brierley, B., Medford, N., Growdon, J. H., & Corkin, S. (2002). Effects of normal aging and Alzheimer's disease on emotional memory. *Emotion, 2*, 118-134.

Kensinger, E A, Kensinger, D R, & Addis, R K. (2011). Amygdala activity at encoding corresponds with memory vividness and with memory for select episodic details. *Neuropsychologia, 49*(4), 663-673.

Kim, J.J. & Diamond, D.M. (2002). The stressed hippocampus, synaptic plasticity and lost memories. *Nat. Rev. Neuroscience, 3*, 453–462.

Kim, J. J., Ja, W. K., Lee, H. J., & Han, J.S. (2005). Amygdalar inactivation blocks stress-induced impairments in hippocampal long-term potentiation and spatial memory. *Journal of Neuroscience, 25* (6), 1532–1539.

Kim, J.J., Lee, H.J., Han, J.S., and Packard, M.G. (2001). Amygdala is critical for stress-induced modulation of hippocampal long- term potentiation and learning. *Journal of Neuroscience, 21*, 5222–5228.

Kirschbaum, C., Wolf, O. T., May, M., Wippich, W., & Hellhammer, D. H. (1996). Stress- and treatment-induced elevations of cortisol levels associated with impaired declarative memory in healthy adults. *Life Sciences, 58* (17), pp. 1475–1483.

Kramer, J.H., Crowe, A.B., Larson, D.A., Sneed, P.K., Gutin, P.H., McDermott, M.W., & Prados, M.D. (1997). Neuropsychological sequel of meduloblastoma in adults. *International Journal of Radiation Oncology Biology Physics, 38,* 21–6.

Krugers, H. J., Alfarez, D. N., Karst, H., Parashkouhi, K., Van Gemert, N., & Joels, M. (2005). Corticosterone shifts different forms of synaptic potentiation in opposite directions. *Hippocampus, 15* (6), 697–703.

Kuhlmann, S., Kirschbaum, C., & Wolf, O. T. (2005). Effects of oral cortisol treatment in healthy young women on memory retrieval of negative and neutral words. *Neurobiology of Learning and Memory, 83* (2), 158–162.

Kuhlmann, S., Piel, M., & Wolf, O. T. (2005). Impaired memory retrieval after psychosocial stress in healthy young men. *Journal of Neuroscience, 25* (11), 2977–2982.

Labar, K. S. & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. *Nature Reviews Neuroscience, 7*, 54-64.

LeDoux, J. E. (1996). *The emotional brain the mysterious underpinnings of emotional life*. New York, NY: Simon and Schuster.

Lee, P.W., Hung, B.K., Woo,E.K., Tai,P.T., Choi, D.T. (1989). Effects of radiation therapy on neuropsychological functioning in patients with nasopharyngeal carcinoma. *Journal of Neurology, Neurosurgery, and Psychiatry, 52,* 488–92.

Leider, M., Bohannon, J. N., Sauer, K. (2012). *Gaps in memories: Evidence of a hippocampal refractory period*. Poster presented at APS, Chicago.

Lindsay, D.S., Wade, K.A., Hunter, M.A., & Read, J.D. (2004). Adults' memories of childhood: Affect, knowing, and remembering. *Memory, 12,* 27-49.

Lupien, S.J. & McEwen, B.S. (1997). The acute effects of corticosteroids on cognition: Integration of animal and human model studies. *Brain Res. Rev., 24,* 1–27.

Mager M. W. & Andrykowkski A. M. (2002). Communication in the cancer ‘bad news’ consultation: Patient perceptions and psychological adjustment. *Psycho-Oncology, 11,* 35-46.

Mather, M., Canli, T., English, T., Whitfield, S., Wais, P., Ochsner, K., Gabriele, J.D.E., & Carstensen, L. (2004). Amygdala responses to emotionally valenced stimuli in older and younger adults. *Psychological Science, 15,* 259-263.

McGaugh, J. L. (2004). The amygdala modulates the consolidation of memories of emotionally arousing experiences. *Annual Review of Neuroscience,* 27, 1-28.

McNally, R. J., Litz, B. T., Prassas, A., Shin, L. M., & Weathers, F. W. (1994). Emotional priming of autobiographical memory in posttraumatic stress disorder. *Cognition and Emotion, 8,* 351–367.

Metcalfe, J. & Jacobs, W. J. (1998). Emotional memory: The effects of stress on “cool” and “hot” memory systems. *The Psychology of Learning and Motivation: Advances in Research and Theory, 38,* 187–222.

Micco, D. J., McEwen, B. S. & Shein, W. (1979). Modulation of behavioral inhibition in appetitive extinction following manipulation of adrenal steroids in rats: Implications for involvement of hippocampus. *Journal of Comparative and Physiological Psychology, 93* (2), 323-329.

Mignone, R.G. & Weber, E.T. (2006). Potent inhibition of cell proliferation in the hippocampal dentate gyrus of mice by the chemotherapeutic drug thioTEPA. *Brain Research, 1111,* 26–9.

Mineka, S. & O'hman, A. (2002). Phobias and preparedness: The selective, automatic, and encapsulated nature of fear. *Biological Psychiatry, 52* (10), 927–937.

Monje, M. & Dietrich, J. (2012). Cognitive side effects of cancer therapy demonstrate a functional role for adult neurogenesis. *Behavioral Brain Research, 227*, 376-379.

Moore, B.D., Copeland, D.R., Ried, H., & Levy, B. (1992). Neurophysiological basis of cognitive deficits in long-term survivors of childhood cancer. *Archives of Neurology, 49*, 809–17.

Myers, J. S., Sousa, V. D., & Donovan, H. S. (2010). Predictors of self-reported memory problems in patients with ovarian cancer who have received chemotherapy. *Oncology Nursing Forum*, *37*(5), 596-603. doi:10.1188/10.ONF.596-603

Nairne, J. S. (2010). Adaptive memory: Evolutionary constraints on remembering. In B. H. Ross (Ed.), *The psychology of leaning and motivation: Advances in research and theory* (Vol. 53, pp. 1-32). San Diego, CA: Elsevier.

Nairne, J. S. & Pandeirada, J. N. S. (2008). Adaptive memory: Remembering with a stone-age brain. C*urrent Directions in Psychological Science, 17,* 239–243.

Nairne, J.S., Pandeirada, J.N.S., Gregory, K.J., & Van Arsdall, J.E. (2009). Adaptive Memory: Fitness relevance and the hunter-gatherer mind. *Psychological Science, 20* (6), 740-746.

Nairne, J.S., Thompson, S.R., & Pandeirada, J.N.S. (2007). Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33,* 263-273.

Neisser, U. (1982). Snapshots or benchmarks? In U. Neisser & I.E. Hyman (Eds.) *Memory observed: Remembering in natural contexts,* 68-74. San Francisco: Worth Publishers

Neisser, U. & Harsch, N. (1992). Phantom Flashbulbs: False Recollections of Hearing the News About Challenger. In E. Winograd & U. Neisser (Eds.), *Affect and accuracy in recall: Studies of "flashbulb memories"* (pp. 9-31). Cambridge, England: Cambridge University Press.

Neisser, U., Winograd, E., Bergman, E., Schreiber, C., Plamer, S., & Weldon, M. (1996). Remembering the earthquake: Direct experience vs. hearing the news. *Memory, 4*, 337-357.

Ni, C.F. (1934). An experimental study of the influence of punishment for errors during learning upon retention. *Journal of Comparative Psychology, 17*, 279-301.

Nielson, K. A., Yee, D., & Erickson, K. I. (2005). Memory enhancement by a semantically unrelated emotional arousal source induced after learning. *Neurobiology of Learning and Memory, 84* (1), 49-56.

Otgaar, H., & Howe, M. L. (2014). What kind of memory has evolution wrought? Introductory article for the special issue of memory: Adaptive memory: The emergence and nature of proximate mechanisms. *Memory, 22*(1), 1-8. doi:10.1080/09658211.2013.800355

Otgaar, H., Smeets, T., & van Bergen, S. (2010). Picturing survival memories: Enhance memory for fitness-relevant processing occurs for verbal and visual stimuli. *Memory & Cognition, 38,* 23-28.

Pamdala, S. & Pessoa, L. (2008). Affective learning enhances visual detection and responses in primary visual cortex. *Journal of Neuroscience*, *28* (24), 6202-6210

Pavlides, C., Kimura, A., Magarinos, A. M., & McEwen, B.S. (1995). Hippocampal homosynaptic long-term depression/depotentiation induced by adrenal steroids. *Neuroscience, 68* (2), 379–385, 1995.

Pavlides, C. & McEwen, B. S. (1999). Effects of mineralocorticoid and glucocorticoid receptors on long-term potentiation in the CA3 hippocampal field. *Brain Research, 851* (1-2), 204–214.

Pavlides, C., Ogawa, S., Kimura, A., & McEwen, B. S. (1996). Role of adrenal steroid mineralocorticoid and glucocorticoid receptors in long-term potentiation in the CA1 field of hippocampal slices. *Brain Research, 738* (2), 229–235.

Pavlides, C., Watanabe, Y., Magarinos, A. M., & McEwen, B. S. (1995). Opposing roles of type I and type II adrenal steroid receptors in hippocampal long-term potentiation. *Neuroscience, 68* (2), 387–394.

Payne, J. D., Jackson, E. D., Ryan, L., Hoscheidt, S., Jacobs, W. J., & Nadel, L. (2006). The impact of stress on neutral and emotional aspects of episodic memory. *Memory, 14* (1), 1–16.

Payne, J. D., Nadel, L., Allen, J. J. B., Thomas, K. G. F., & Jacobs, W. J. (2002). The effects of experimentally induced stress on false recognition. *Memory, 10* (1), 1–6.

Pelletier, J.G. & Pare, D. (2004). Role of amygdala oscillations in the consolidation of emotional memories. *Biological Psychiatry, 55* (6), 559-562.

Quiroga, R. Q. (2012). Concept cells: The building blocks of declarative memory functions. *Nature Reviews Neuroscience, 13*, 587-597.

Quiroga, R. Q., Kreiman, G., Koch, C., & Fried, I. (2008). Sparse but not "Grandmother-Cell" coding in the medial temporal lobe. *Trends in Cognitive Sciences*, *12* (3), 87-91.

Rice, J., Fritz, A., & Bohannon, N. (2012). *Flashbulb memories of Obama's election to presidency*. Poster Presentation APS, Chicago.

Richter-Levin, G. & Akirav, I. (2000). Amygdala-hippocampus dynamic interaction in relation to memory. *Molecular Neurobiology, 22,* 11–20.

Roman, D.D. & Sperduto, P.W. (1995). Neuropsychological effects of cranial radiation: current knowledge and future directions. *International Journal of Radiation Oncology Biology Physics, 31,* 983–98.

Roozendaal, B., Hahn, E. L., Nathan, S. V., de Quervain, D. J., & McGaugh, J. L. (2004). Glucocorticoid effects on memory retrieval require concurrent noradrenergic activity in the hippocampus and basolateral amygdala. *Journal of Neuroscience, 24* (37), 8161–8169.

Roozendaal, B., de Quervain, D.J., Ferry, B., Setlow, B., & McGaugh, J.L. (2001). Basolateral amygdala-nucleus accumbens interactions in mediating glucocorticoid enhancement of memory consolidation. *Journal of Neuroscience, 21,* 2518–2525.

Roozendaal, B. & McGaugh, J.L. (1997). Basolateral amygdala lesions block the memory-enhancing effect of glucocorticoid administration in the dorsal hippocampus of rats. *European Journal of Neuroscience, 9,* 76–83.

Rosen, J. B., Adamec, R. E., & Thompson, B. L. (2005). Expression of egr-1 (zif268) mRNA in select fear-related brain regions following exposure to a predator. *Behavioral Brain Research, 162* (2), 279–288.

Rubin, D. C., & Kozin, M. (1984). Vivid memories. *Cognition,16*, 81-95.

Rundus, D. (1970). An Analysis of rehearsal processes in free recall. *Psychological Series, 2*, 362-370.

Schmolck, H., Buffalo, E. A., & Squire, L. R. (2000) Memory distortions develop over time: Recollections of the O.J. Simpson trial verdict after 15 and 32 months. *Psychological Science, 11*, 39-45.

Schroeder, B. W. & Shinnick-Gallagher, P. (2005). Fear learning induces persistent facilitation of amygdala synaptic transmission. *European Journal of Neuroscience, 22* (7), 1775–1783.

Seigers R, Schagen SB, Beerling W, Boogerd, W., van Tellingen, O., van Dam, F.S., Koolhaas, J.M., & Buwalda, B.(2008) Long-lasting suppression of hippocampal cell proliferation and impaired cognitive performance by methotrexate in the rat. *Behavioral Brain Ressearch*, *186,* 168–75.

Shaneyfelt, K., Minor, S. & Bohannon, J. (2008). *Flashbulb memory: Private memories for car accidents.* Paper presented at SEPA, Charlotte, NC.

Sharot, T. Delgado, M. R., & Phelps, E. A. (2004). How emotion enhances the feeling of remembering. *Nature Neuroscience, 7* (12), 1376-1380.

Shors, T. J., Foy, M. R., Levine, S., & Thompson, R. F. (1990). Unpredictable and uncontrollable stress impairs neuronal plasticity in the rat hippocampus. *Brain Research Bulletin*, *24* (5), 663–667.

Shors, T., J. & Thompson, R., F. (1992). Acute stress impairs (or induces) synaptic long-term potentiation (LTP) but does not affect paired-pulse facilitation in the stratum radiatum of rat hippocampus. *Synapse*, *11* (3), 262–265.

Sternberg, R. J. (2003). *Cognitive theory* (3rd ed.). Belmont, CA: Thomson Wadsworth.

Stratton, G. M. (1919). Retroactive hyperamnesia and other emotional effects on memory. *Psychological Review, 26* (6), 474-486.

Surma-aho, O., Niemela, M., Vilkki, J., Kouri, M., Brander, A., Salonen, O., Paetau, A., Kallio, M., Pyykkonen, J., & Jaaskelainen, J. (2001). Adverse long-term effects of brain radiotherapy in adult low-grade glioma patients. *Neurology, 56,* 1285–90.

Suthana, N. & Fried, I. (2012). Percepts to recollections: Insights from single neuron recordings in the human brain. *Trends in Cognitive Sciences, 16* (8), 427-436.

Talarico, J. M., LaBar, K. S., & Rubin, D. C. (2004). Emotional intensity predicts autobiographical memory experience. *Memory & Cognition, 32,* 1118-1132

Talarico, J. M., & Rubin, D. C. (2003). Confidence, not consistency, characterizes flashbulb memories. *Psychological Science, 14*, 455-461.

Talmi, D. (2013). Enhanced emotional memory: Cognitive and neural mechanisms. *Current Directions in Psychological Science, 22* (6), 430-336. DOI: 10.1177/0963721413498893

Talmi, D. & McGarry, L. M. (2012). Accounting for immediate emotional memory enhancement. *Journal of Memory and Language, 66*, 93-108.

Talmi, D., Schimmack, U., Paterson, T., & Moscovitch, M. (2007). The role of attention and relatedness in emotionally enhanced memory. *Emotion, 7,* 89-102.

Tekcan, A. I. & Peynircioglu, Z. F. (2002). Effects of age on flashbulb memories. *Psychology and Aging, 17* (3), 416-422.

Thornberry, D. & Bohannon, J. (2008). The impact of emotional memories on the child-amnesia barrier. Paper presentation at APS, Chicago.

Todd, R. M., Palombo, D. J., Levine, B., & Anderson, A. K. (2011). Genetic differences in emotionally enhanced memory. *Neuropsychologia, 49*(4), 734-744. doi:10.1016/j.neuropsychologia.2010.11.010.

Todd, R. M., Talmi, D., Schmitz, T. W., Sussking, J., & Anderson, A. K. (2012). Psychophysical and neural evidence for emotion-enhanced perceptual vividness. *Journal of Neuroscience, 32*, 11201-11212.

Tooby, J. & Cosmines, L. (1992). The psychological foundations of culture. In J.H. Barlow, L. Cosmines, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (19-136). New York: Oxford University Press.

Tulving, E. (1969). Retrograde amnesia in free recall. *Science*, *164*, 88-90.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory* (pp.381-403). New York: Academic Press.

Turk Charles, S., Mather, M., & Carstensen, L. L. (2003). Aging and emotional memory: The forgettable nature of negative images for older adults. *Journal of Experimental Psychology: General, 132,* 310-324.

Van der Kolk, B. A. (1996). *Trauma and memory*. New York, NY: The Gulliford Press, 279-302.

Van der Kolk, B. A. & Van der Hart, O. (1989). Pierre Janet and the breakdown of adaptation in psychological trauma. *American Journal of Psychiatry, 146*, 1530–1540.

Van Praag, H., Christie, B. R., Sejnowski, T. J., & Gage, F. H. (1999). Running enhances neurogenesis, learning, and long-term potentiation in mice. *Proceedings of the National Academy of Science USA*, *96*, 13427–31.

Volk, T., & Atkinson, J. (2008). Is child death crucible of human evolution? *Journal of Social, Evolutionary, and Cultural Psychology, 2*, 247-260.

Wang, J., Akirav, I., & Richter-Levin, G. (2000). Short-term behavioral and electrophysiological consequences of underwater trauma. *Physiology and Behavior, 70* (3-4), 327–332.

Weaver, C.A., III. (1993). Do you need a “flash” to form a flashbulb memory? *Journal of Experimental Psychology: General, 122,* 39-46.

Wefel, J.S., Saleeba, A.K., Buzdar,A.U., & Meyers, C.A. (2010). Acute and late onset cognitive dysfunction associated with chemotherapy in women with breast cancer. *Cancer, 116,* 3348–56.

Wiegert, O., Pu, Z., Shor, S., Jo¨els, M., & Krugers, H. Glucocorticoid receptor activation selectively hampers N-methyl-D-aspartate receptor dependent hippocampal synaptic plasticity in vitro. *Neuroscience, 135* (2), 403–411.

Wilhelm, S., McNally, R. J., Baer, L., & Florin, I. (1997). Autobiographical memory in obsessive– compulsive disorder. *British Journal of Clinical Psychology, 36,* 21–31.

Williams, J. M. G. (1996). Depression and the specificity of autobiographical memory. In D. C. Rubin (Ed.), *Remembering our past: Studies in autobiographical memory* (pp. 244–267). Cambridge, England: Cambridge University Press.

Winocur G., Vardy J., Binns M.A., Kerr L., & Tannock I. (2006). The effects of the anti-cancer drugs, methotrexate and 5-fluorouracil, on cognitive function in mice. *Pharmacology Biochemistry and Behavior, 85,* 66–75.

Winograd, E. & Killinger, W. A. (1983). Where were you when President Kennedy was assassinated? *Bulletin of the Psychonomic Society. 11*, 133-135.

Wolf, O.T., Kuhlmann, S., Buss, C., Hellhammer, D. H., & Kirschbaum, C. (2004). Cortisol and memory retrieval in humans: influence of emotional valence. *Annals of the New York Academy of Sciences, 1032*, 195–197.

Wolf, O. T., Schommer, N. C., Hellhammer, D. H., McEwen, B. S., & Kirschbaum, C. (2001). The relationship between stress induced cortisol levels and memory differs between men and women. *Psychoneuroendocrinology, 26* (7), 711–720.

Woodson, J. C., Macintosh, D., Flashner, M. & Diamond, D. M. (2003). Emotion-induced amnesia in rats: working memory-specific impairment, corticosterone-memory correlation, and fear versus arousal effects on memory. *Learning & Memory, 10,* 326-336.

Xiong, W., Wei, H., Xiang, X., Cao, J., Dong, Z., Wang, Y., Xu, T., & Xu, L. (2004). The effect of acute stress on LTP and LTD induction in the hippocampal CA1 region of anesthetized rats at three different ages. *Brain Research, 1005* (1-2), 187–192.

Zhou, J., Zhang, F., & Zhang, Y. (2000). Corticosterone inhibits generation of long-term potentiation in rat hippocampal slice: involvement of brain-derived neurotrophic factor. *Brain Research, 885* (2), 182–191.

Figure 1. Line graph of ANOVA for free recall results dependent on victim status and affect group

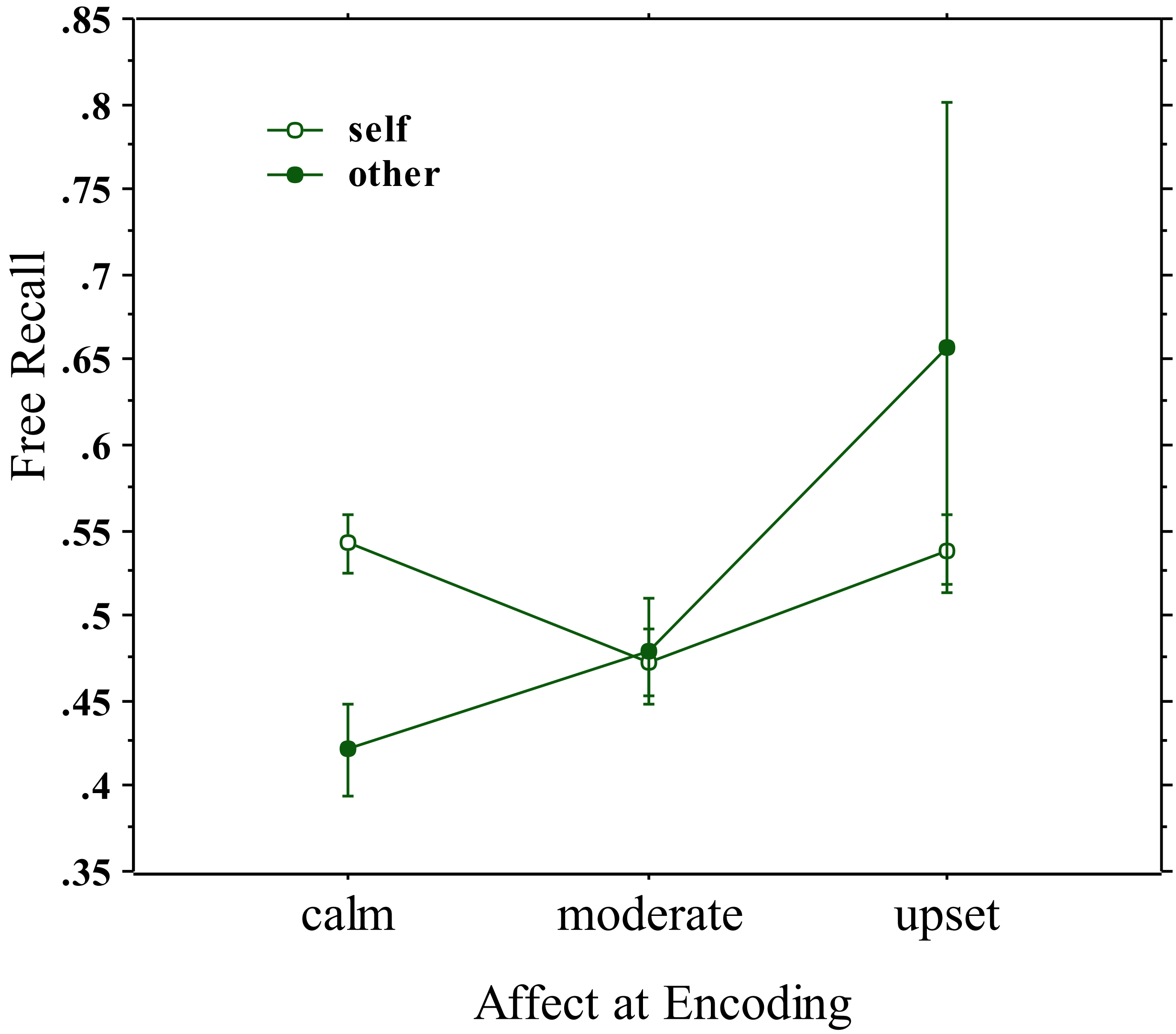


Figure 2. Line graph of ANOVA for probe response confidence dependent on victim status and affect group

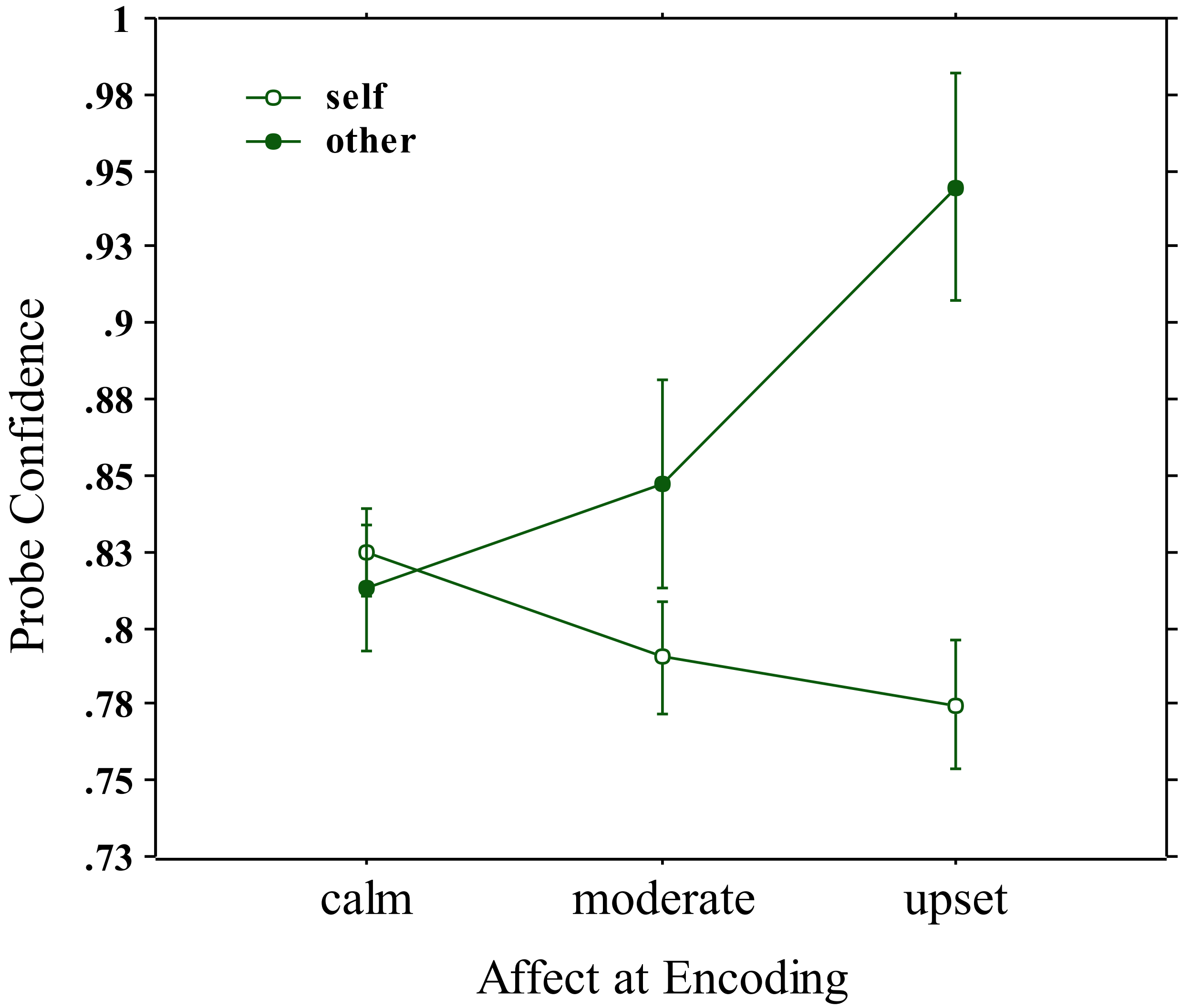


Figure 3. Line graph of ANOVA for vividness rating dependent on victim status and affect group

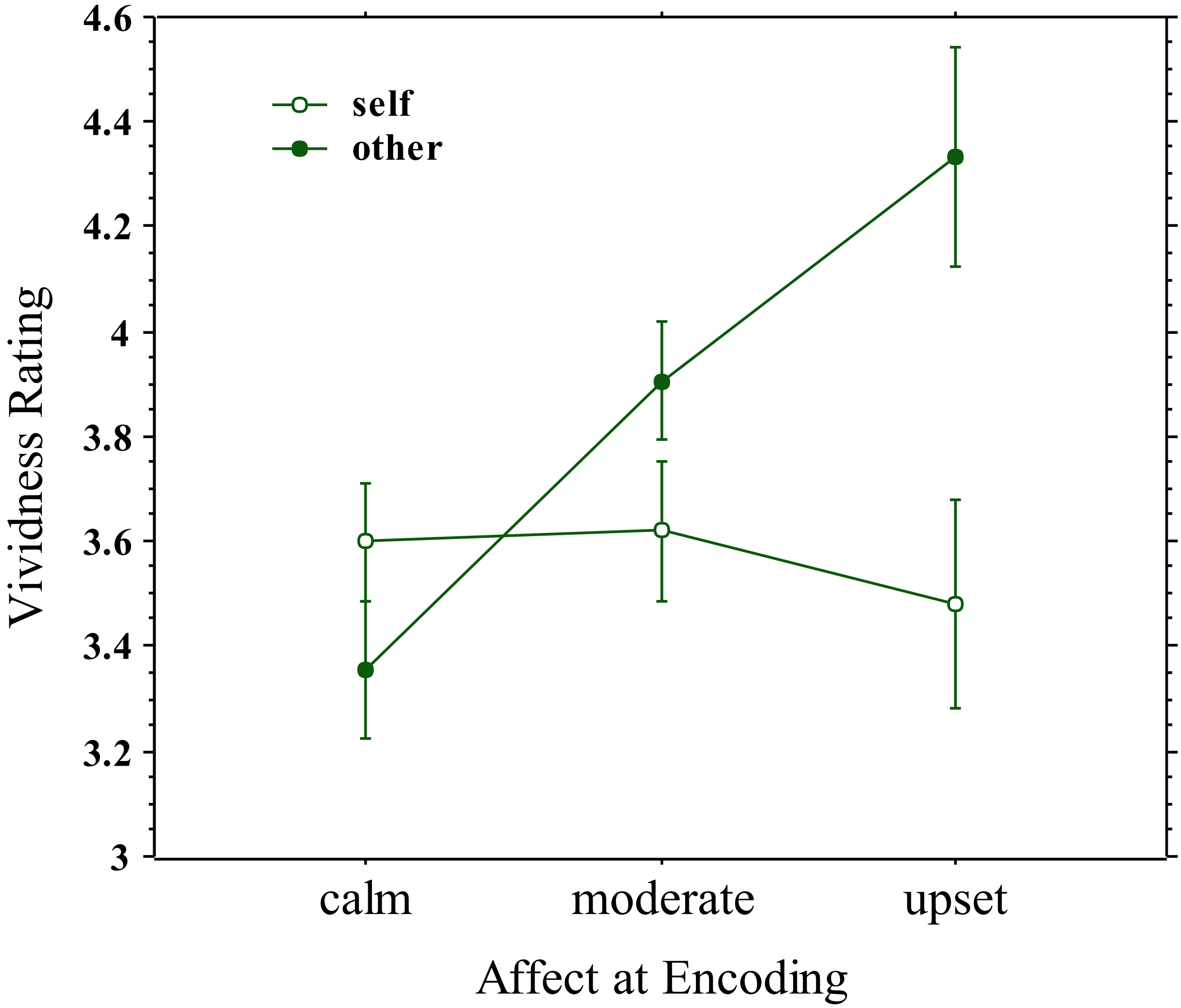


Figure 4. Means of vividness based on affect group which demonstrate an inverted "U"

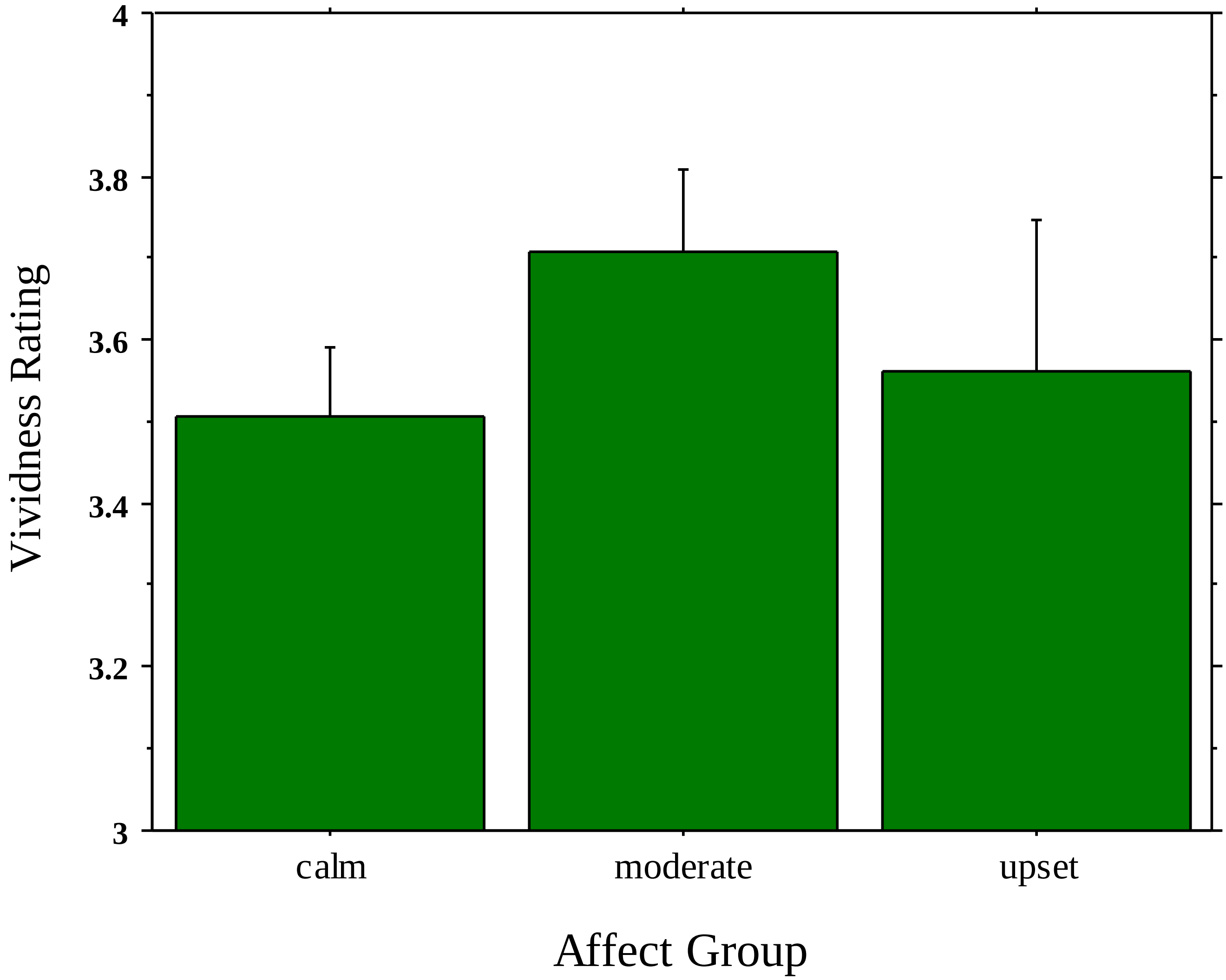


Figure 5. Bar graph of ANOVA for number of recounts dependent on information type

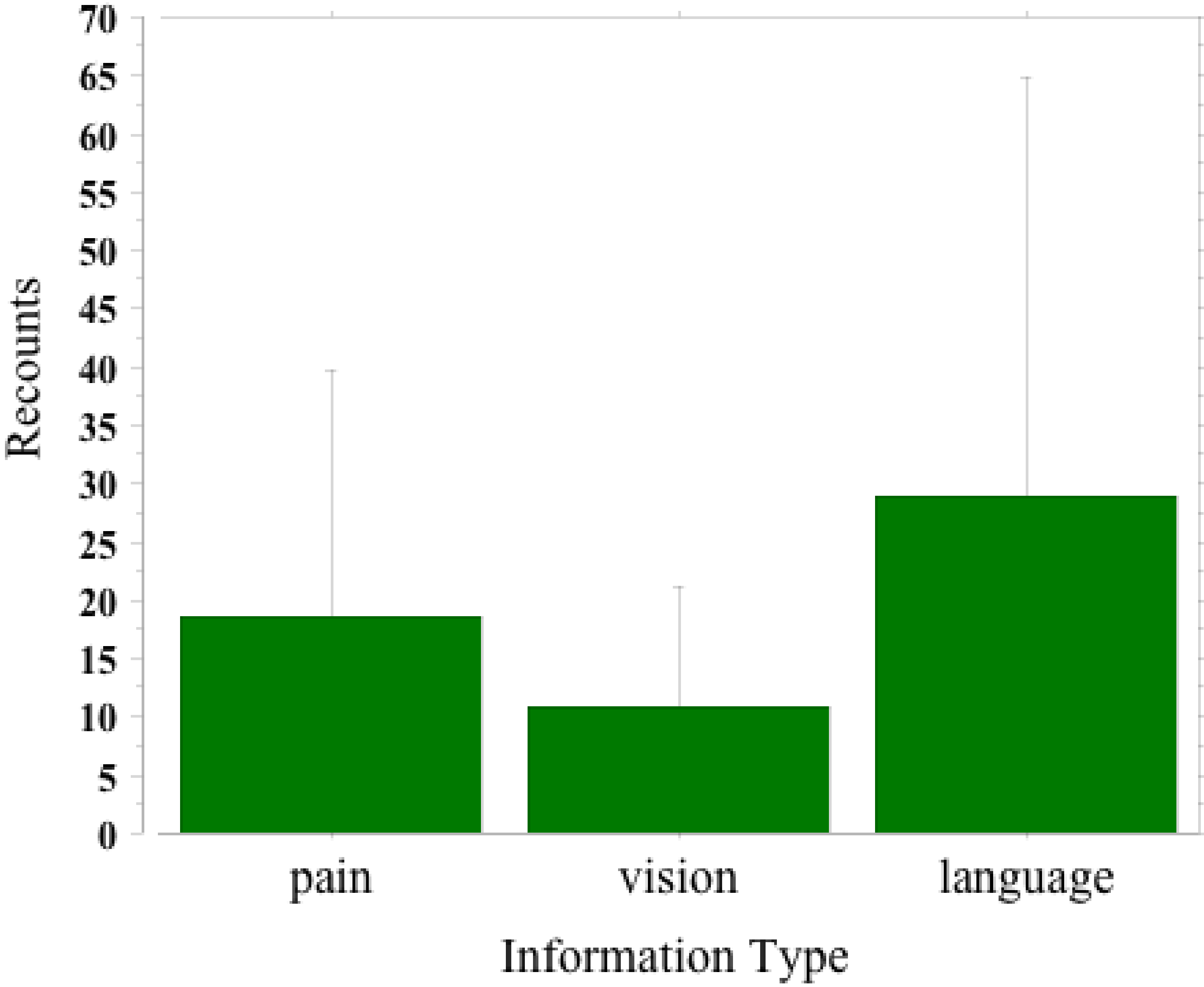
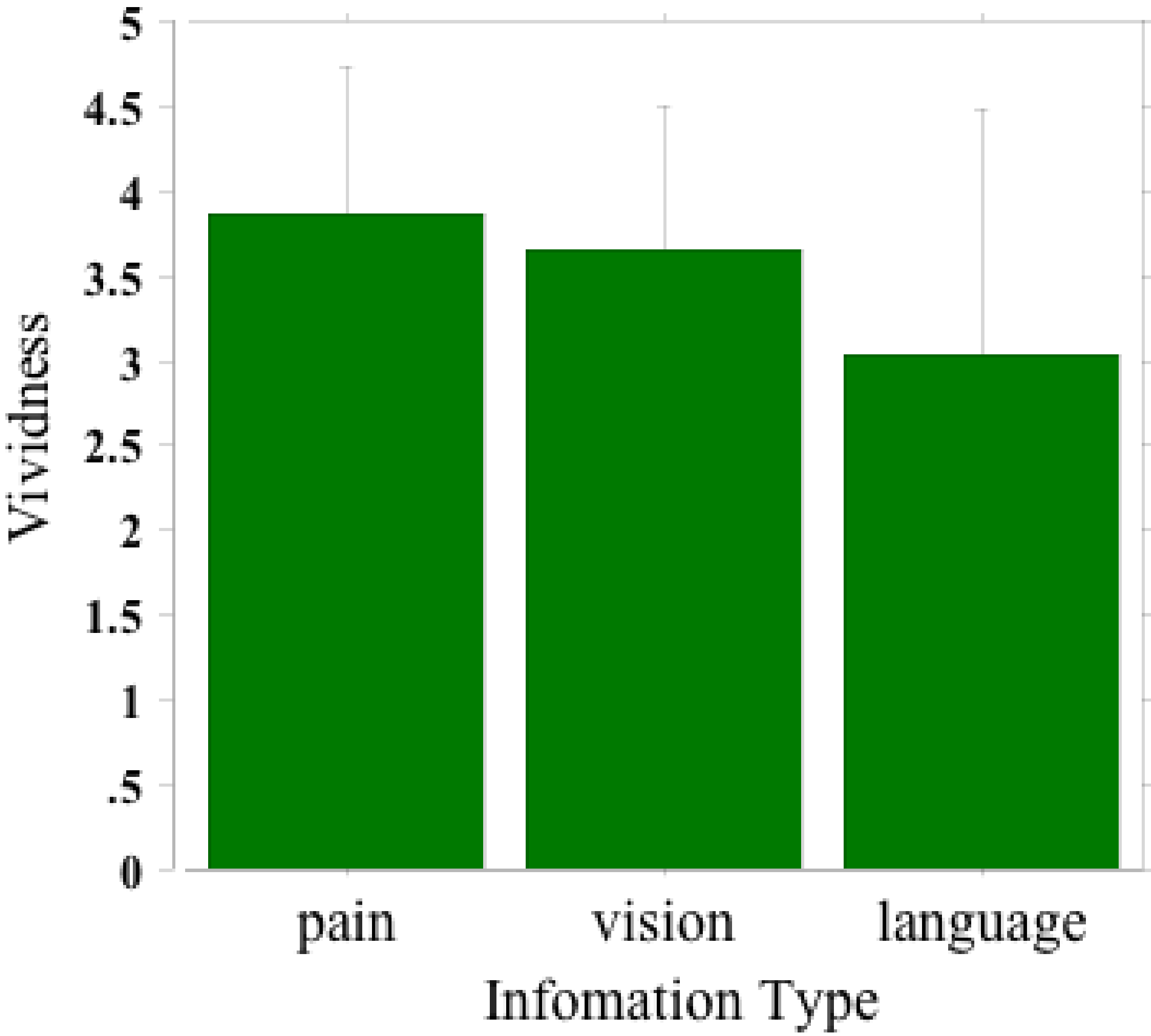


Figure 6. Bar graph of ANOVA for vividness ratings dependent on information type



Appendix 1. Statement of Informed Consent

Statement of Informed Consent

I have read the below statement, understand my rights, and agree to these conditions.

Name		Signature	
Date		Address	
City, State		Zip code	
Telephone			

Current Age: _____

Male: _____ Female: _____ (please check)

Please keep a copy of this document, or detach below the line for your personal records.

This study examines people's memories for the discovery of their cancer diagnosis. The responses will be kept confidential and will be used only for the purpose of this experiment. Once the completed document is received, this informed consent will be separated from the rest of the protocol so that your personal information and medical information will no longer be associated with one another. You're authorization to use your medical information will not expire, but the separation of the two documents is guaranteed to insure confidentiality. Not even the researchers will be able to have the ability to make a connection between the separated documents. Group averages and tendencies will be analyzed with a code for each subject maintaining the anonymity of all individual memories.

To take part in the experiment you will fill out a questionnaire that should take approximately 20-40 minutes. Participation in this study is voluntary and you will not be penalized or lose any previously entitled benefits should you choose not to participate. You may also discontinue your participation in this experiment at any time, and any information that you provided will not be used. It should be noted that e-mail communication of personal information has the possibility of breaching confidentiality. However, all access to my personal e-mail account, both via computer and smart phone, is password protected. Both my computer and phone require an unlock password to open the system, and then an additional password to access my e-mail. Within a week of the e-mail being received, it will be printed and locked in a secure drawer in a locked office, and the e-mail will be permanently deleted from my account. If you feel uncomfortable with e-mail communication, you may print and mail back the completed protocol at the following address:

Angeline Modesti
Butler University-Department of Psychology
Jordon Hall - 282
4600 Sunset Ave.
Indianapolis, IN 46208

Please do not discuss this study with anyone during or after the experiment. At your request, we will fully inform you as to the nature of this experiment no later than one month from your participation.

If you have any questions please feel free to contact:

Angeline Modesti 773.416.7497
amodesti@butler.edu

Dr. John N. Bohannon 317.940.9240
nbohanno@butler.edu

Thank you for your participation!
Participant Number (leave blank): #________

Appendix 2. Protocol

Part 1: Learning of your Cancer Diagnosis

Free Recall

PLEASE DO NOT TURN THE PAGE UNTIL THE CURRENT PAGE IS COMPLETE

Please write a detailed account of when you first heard of your cancer diagnosis as if you were witnessing the event as someone other than yourself. Please be as accurate as possible and include all of the vivid details surrounding your learning of your diagnosis. After you have completed this section, please do NOT return to edit or change any part of your narrative. Please use the area provided below for your response.

Questionnaire

Please answer the following questions about the time when you first learned that you had a cancer diagnosis.

1. How old were you at the time you learned of your cancer diagnosis? ________________

2. Please rate how expected the diagnosis was on the 5-point scale provided below. Circle the number you feel best fits.

1	2	3	4	5
Not Expected		**Average**		**Completely Expected**

3. Please rate how aroused you were upon learning of the diagnosis on the 5-point scale provided below. Circle the number you feel best fits.

1	2	3	4	5
Not Upset		**Moderately**		**Completely Upset**

4. Please rate how threatening was your diagnosis was on the 5-point scale provided below. Circle the number you feel best fits.

1	2	3	4	5
Not Threatening		**Moderately**		**Extremely Threatening**

5. Please rate how vivid you memory is of your diagnosis on the 5-point scale provided below. Highlight the number you feel best fits.

1	2	3	4	5
Not Aroused		**Moderately**		**Extremely Aroused**

6. How frequently do talk about or share this diagnosis with others? Please give a specific number.

____

7. How many times have you recalled your diagnosis? Please give a specific number. __________

Probed Responses

The following questions concern the events, people, and conditions surrounding the instant you first heard about your cancer diagnosis. In addition, please use the scale below to rate your confidence in the answer to each question. If you do not know the answer, simply leave it blank and rate your confidence as a '1'.

Not sure at all	Somewhat Confident	Moderately Confident	Very Confident	Absolutely Confident
1	**2**	**3**	**4**	**5**

7. What were you wearing at the time you learned of your diagnosis? **Confidence Rating _____**

8. What was the exact date that you learned of your diagnosis? (month/date/year- if possible)

Confidence Rating _____

9. What day of the week did you learn of your diagnosis? **Confidence Rating _____**

10. What time did you learn of your diagnosis? (to the nearest hour, AM or PM)

Confidence Rating _____

11. Who informed you of your diagnosis? **Confidence Rating _____**

12. What was the person who informed you of your diagnosis wearing when they told you?

Confidence Rating _____

13. What exactly did the person who informed you of your diagnosis say to you? (Be as specific as possible)

Confidence Rating _____

14. How did you learn of your diagnosis? (ie: over the phone, in person from another person, etc.)

Confidence Rating _____

15. Where were you when you learned of your diagnosis? (As closely as you can recall- e.g. on the couch in the living room, at the Dr.'s office etc.) **Confidence Rating _____**

16. What was the weather like at the time you learned of your diagnosis? **Confidence Rating _____**

17. Did you have prior knowledge that you might possibly have a serious medical condition? If so, what symptoms were you having? **Confidence Rating _____**

Cancer Outcome Probe

Please answer the following questions specifically and to the best of your ability. Feel free to include internal feelings at any point as well.

After your diagnosis, did you have to get extra support from your friends and family, and if so, what?

Did you receive any medication besides chemotherapy? If so, how did it affect you?

After the diagnosis took place, how did you feel?

Has your diagnosis change how you lived your daily life? If so, please explain

THE END

Thank you for your participation!

Appendix 3. Event breakdown for comparison analysis

Event	Stimulus Type	Threat Directed At	Severity
Cancer Diagnosis	Language	Self	High
Car Accident	Pain/Visual	Self	Moderate
Childhood Injury	Pain/Visual	Self	High
Childhood Injury Parent Present	Visual	Other	Moderate
Childhood Injury Parent Not Present	Language	Other	Moderate

Appendix 4. Canonical Features

Recall	Canonical Feature	Description	Quantity Score
	Activity	Subject's activity leading to the event	0-3/3
	Location	Subject's location when the event took place	0-3/3
	Time	Time when the event took place	0-3/3
	Author's Affect	The emotional state of the subject after the event	0-3/3
	Aftermath	Any action that occurred after the event	0-3/3
	Others Present	Anyone around subject during the event	0-3/3
	Others Affect	Emotional state of any others after the event	0-3/3

Appendix 5. Scoring canonical feature guidelines for free recall portion of protocol

Free Response Scoring Rules: Cancer Diagnosis

Activity = (Activity of the narrator – that occurs within a few minutes before the diagnosis)

0	There is no activity mentioned or implied.
1	Any amount of activity is (1) implied OR (2) explicitly stated but vague: the scorer CANNOT physically imitate the activity of the narrator without any doubt.
2	One activity is (3) explicitly stated and specific: the scorer CAN physically imitate the activity of the narrator without any doubt.
3	Two or more activities are (3) explicitly stated and specific: the scorer CAN physically imitate the activity without any doubt.

Location = (Location at which the diagnosis occurred)

0	There is no location mentioned or implied.
1	Any amount of location is (1) implied OR (2) explicitly stated and within an area greater than 100 feet.
2	One location is (3) explicitly stated and within an area of 100 feet.
3	Two or more locations are (3) explicitly stated and within an area of 100 feet.

Time = (Time at which the diagnosis occurred)

0	There is no time given or implied.
1	Any amount of time is (1) implied *OR* (2) relative to another event OR (3) explicitly stated and greater than one day. (1) *("I was eating breakfast…" implies morning, "In the dark" "Just got home from work")* (2) (*"it was April" "during the Summer" "Two years ago" Near Halloween")*
2	One time is (4) explicitly stated and less than or equal to a day. (4) *("It was 10:45" "morning" "Friday" "New Years Eve" "October 3rd" "that night")*
3	Two or more times are (4) explicitly stated and less than or equal to a day.

Others Present = (People or collectives around the narrator – that are present within a few minutes before the diagnosis, during the diagnosis, or within a few minutes after the diagnosis. This should NOT include the doctor)

0	There are no other's present mentioned or implied.
1	Any amount of people or collectives are (1) implied OR (2) explicitly stated, but the narrator most likely wouldn't be able to pick the person/collective out of a lineup. 1) *("We were in the doctors office)* 2) ("*People were talking" "Someone" "Surrounded by friends")*
2	One person or collective is (3) explicitly stated, and the narrator most likely would be able to pick the person/collective out of a lineup OR (4) there is a specifically stated lack of others present. (3) *("my best friend" "Jessica" "wife" "husband" "Josh was talking" "Mom" "Dad")* (4) (*"I was completely alone")*
3	Two or more people or collectives are (3) explicitly stated, and the narrator most likely would be able to pick the person/collective out of a lineup.

Author's Affect = (Mental state of the narrator – that is experienced within a few minutes before the diagnosis, during the diagnosis, or within a few minutes after the diagnosis)

0	There is no author's affect mentioned or implied.
1	Any amount of author's affect is (1) implied OR (2) explicitly stated but vague: the scorer cannot mentally imitate the emotion without a doubt. (1) by the description of thoughts *("Couldn't believe it" "Thinking is this really happening?")* by the description of the diagnosis (*"It was awkward" "it was weird"* by action *("Freaking out" "Cried")* (2) (*"Felt so many feelings at once" "Felt like I Could cry" "was Dying inside")*
2	One author's affect is (3) explicitly stated and specific: the scorer can mentally imitate the emotion without a doubt.

	(3) *("I was shocked" "I felt awkward" "I was scared" "I was breathless" "Heart was racing" "felt relieved")*
3	Two or more author's affects are (3) explicitly stated and the scorer can mentally imitate the emotion without a doubt.

Others' Affect = (Mental state of people around the narrator -- that is experienced within a few minutes before the diagnosis, during the diagnosis, or within a few minutes after the diagnosis)

0	There is no other's affect mentioned or implied.
1	Any amount of other's affect is (1) implied OR (2) explicitly stated but vague: the scorer cannot mentally imitate the emotion without a doubt. (1) by the description of thoughts *("Couldn't believe it" "Thinking is this really happening?")* by the description of the diagnosis (*"It was awkward" "it was Weird")* by action *("Laughed" "Freaking out" "Cried")* (2) (*"Felt so many feelings at once" "Felt like I Could cry" "Felt a Rush" "was Dying inside")*
2	One other's affect is (3) explicitly stated and specific: the scorer can mentally imitate the emotion without a doubt. (3) *("I was shocked" "I felt awkward" "I was scared" "I was Breathless" "Heart was racing" "felt relieved")*
3	Two or more other's affects are (3) explicitly stated and the scorer can mentally imitate the emotion without a doubt.

Aftermath = (Activity of the narrator -- that occurs within a few minutes after the diagnosis)

0	There is no activity mentioned or implied.
1	Any amount of activity is (1) implied OR (2) explicitly stated but vague: the scorer CANNOT physically imitate the activity of the narrator without any doubt. (*1) ("at dinner" implies eating…"I was on my way to work…" implies walking or driving… "After a movie" implies watching* (2) ("*I went," "I arrived" "I was hanging out at my house" "I pulled up to my driveway" "I dropped him off" "I joined the group")*
2	One activity is (3) explicitly stated and specific: the scorer CAN physically imitate the activity of the narrator without any doubt. (3) *("We were walking" "I was eating" "We were standing" " We drove back" "I got in my car" "I asked" "I said" "waiting"*)
3	Two or more activities are (3) explicitly stated and specific: the scorer CAN physically imitate the activity without any doubt.

Appendix 6. Probe Responses

Probe	Description	Quantity Score
What were you wearing	Subject's clothing at the time of the diagnosis	0-2/2
Exact date	Date of diagnosis (month, day, year)	0-2/2
Day of the week	Day of the week the diagnosis was given	0-2/2
Time of day	Time of day that the diagnosis was given	0-2/2
Informant's name	Name of the person that informed the subject about diagnosis	0-2/2

What was your informant wearing	Informant's clothing at the time of the diagnosis	0-2/2
What did your informant tell you about your diagnosis	Information the informant gave the subject when the diagnosis was revealed	0-2/2
How did you learn about your diagnosis	Medium of communication	0-2/2
What location	Where the subject was when the diagnosis was given	0-2/2
Weather	What the weather was like when the day the diagnosis was given	0-2/2
What kind of support did you receive	Amount of support received by subject after the diagnosis was given	0-2/2

Appendix 7. Scoring guideline for probing questions portion of protocol

Cancer Probed Response Scoring Rules

What were you wearing:

0	No answer is given. *("clothes")*
1	One article of clothing is stated *("Jeans" "Hoodie")* or an outfit is vaguely mentioned. *("shorts and a shirt" "nothing" "track uniform")* Guess is made. *("Maybe jeans")* Single brand name without clothing article. *(Under Armor")*
2	Outfit is explicitly explained with specific descriptor/color *("Jean skirt and a black tank top" "favorite pair of basketball shorts" "Hollister shirt")*

Exact date:

0	No answer is given.
1	One aspect of the date is given. *("July" "Monday")* Day is missing. *("September 2008")*
2	The entire, specific date is given. ("April 21, 2006")

Day of week:

0	No answer is given.
1	Vague answer is given. *("Middle of the week" "Over the weekend" "Monday or Tuesday")*
2	Exact day is given. *("Tuesday")*

Time of day:

0	No answer is given.
1	General time of the day is given. *("Morning" "Late afternoon")* Time span. *("Between 1:30-2:30" "≈/approximately")*
2	Specific time is explicitly stated. *("2:00 PM" "11:47 in the morning")*

Informant's name:

0	No name is given.
1	One name is given *("Kyle" "Smith")* or reference is made *("Some girl I met at a party")*
2	Full name is given *("Cindy Patterson")* Answer is definitely known, but withheld. *("I truly know, but choose not to answer")* Type of specialty of the doctor is provided (*"Radiologist" "Oncologist")*

What was your informant wearing:

0	No answer is given. *("clothes")*
1	One article of clothing is stated *("Jeans")* or an outfit is vaguely mentioned *("shorts and a shirt")*
2	Outfit is explicitly explained with specific descriptor/color (*"dress pants and a button up shirt with tie")*

What did your Informant tell you about your diagnosis:

0	No answer is given.
1	You have cancer and no other details mentioned
2	Diagnosis is explained further or explained in more detail. Tests are mentioned, medication, support groups available, etc.

How did you learn of your diagnosis:

0	No answer is given.
1	One answer is given. In person, over the phone, an email etc
2	Specific details are mentioned about the learning of the diagnosis

What location:

0	No answer is given.
1	Implied or vague answer, cannot be pinpointed to a specific place within 10 feet. *("outside")* Single specific place. *("My kitchen" "In the office" "bed")*
2	More than one location is mentioned, or an explicit is further specified within 10 feet. *("In his office on the examining table" "in the ER on the hospital bed")*

Prior Knowledge:

0	No answer given
1	Implied or vague indication, cannot be pinpointed to one specific symptom
2	More than one indication is mentioned, or an explicit idea is further elaborated upon

Weather:

0	No answer is given.
1	General temperature is given, or two vague answers. *("Chilly" "Warm" "70's")*
2	Specific weather condition is explicitly stated *("The sun was beating down" "overcast" "fog" "clear" "humid")* Vague condition is further explained. Use of ing/ny *("sunny" "snowing")*

Support:

0	No answer is given.
1	No or NA
2	More than one help devise is mentioned.

Medication NOT including chemotherapy agents:

0	No medication
1	Yes medication but no way of how it affected the person

2	More than one affect is mentioned, or a medication is named and side effects elaborated on

Burden/Relief:

0	No answer is given.
1	Implied or vague answer. It didn't really affect me. Or a little amount of affect was shown. (*"I was a little relieved/upset")*
2	Feeling is explained showing high affect *("I was greatly upset/relieved")*

Other Changes:

0	No answer is given or no changes were mentioned
1	One change , *"I feel more insecure"*
2	More than one change is mentioned, or an explicit is further specified.