THE POWER AND FRAGILITY OF ONTOGENETICALLY-BASED AND PHYLOGENETICALLY-BASED THREATS AND PLEASURES

by

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Abstract

Memory has evolved as an adaptive process in the lives of humans. While some have argued that memory serves an adaptive function resulting in enhanced memory for survival-relevant information, others have suggested in detection and attention domains that threat-relevance (regardless of developmental origin) and experience/learning are crucial – findings that may extend to memory accuracy. It also has been suggested that emotional valence plays a crucial role in memory accuracy such that negatively-valenced stimuli may be better remembered than other stimuli. This thesis examined memory accuracy (Experiment 1) and memory fallibility (Experiment 2) for phylogenetically-based and ontogenetically-based threats and pleasures.

Specifically, I investigated whether phylogenetically-based fearful stimuli (e.g., a snake) are better remembered but more susceptible to misinformation than ontogenetically-based stimuli (e.g., a handgun) and whether phylogenetically-based pleasures (e.g., salmon) are better remembered but more susceptible to misinformation than ontogenetically-based pleasures (e.g., money). In Experiment 1, participants \( N = 50 \) received a memory test after viewing images depicting a phylogenetically-based threat, ontogenetically-based threat, phylogenetically-based pleasure, ontogenetically-based pleasure, and a neutral object. As predicted, memory accuracy for threats was significantly higher than memory for pleasures. However, contrary to my predictions, ontogenetically-based threats were recalled with the greatest accuracy. In Experiment 2, the same procedure was followed except misleading information was presented. The main finding relating to memory for threats versus pleasures was replicated. However, memories for pleasures were significantly more susceptible to misinformation than for threats. The results of this thesis, being the first simultaneous examination of phylogenetically-based and ontogenetically-based threats and pleasures in a memory accuracy and misinformation context,
have theoretical importance and can contribute to resolving current debates in the field regarding emotion and memory.
Preface

Ethics approval for this research was granted by the University of British Columbia’s Behavioural Research Ethics Board on June 22nd, 2013. The ethics approval certificate number for the current study is H12-01284. To date, the research included in this thesis has not been published.
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My sanity would not have been kept if it weren’t for the support of my family throughout this process. Your constant open arms (and open door) as a place to share the ups and downs of graduate school was invaluable. Your support, encouragement, and pride kept me motivated and focused.
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Dedication

To my family [including Tucker].
Chapter 1 Introduction

*There seems something more讲话ingly incomprehensible in the powers, the failures, the inequalities of memory, than in any other of our intelligences.*

- Jane Austen, Mansfield Park (1890/2008)

Human memory likely has evolved to be adaptive in informing future decisions and actions (e.g., Nairne, Pandeirada, & Thompson, 2008). Indeed, throughout evolutionary history, humans have had to identify threatening situations and predators in a quick and efficient manner to maximize the likelihood of survival and reproduction (natural and sexual selection; Nairne et al., 2008). Despite the likelihood that memory evolved to be adaptive, not all autobiographical events are remembered reliably, and some are recalled poorly or even falsely recalled (e.g., Laney & Loftus, 2013). How are memories preferentially selected for retention? What types of memories warrant accurate recollection and which are prioritized for updating/alteration? From an evolutionary perspective, human cognition has been subjected to adaptive pressures so that events and objects maximally relevant to survival would be recalled reliably to aid decision-making upon subsequent encounters and to ensure survival. It has been argued further that memories associated with threatening experiences also paradoxically may be more likely to be adjusted or revised to include new – and sometimes misleading – information as it becomes available (e.g., Porter, Taylor, & ten Brinke, 2008). For example, negative events are likely to be remembered with greater accuracy – but also are subjected to more revisions upon encountering additional information – than other events. But, when it comes to survival, are scenarios or objects that would have been encountered by distant ancestors prioritized in memory or are scenarios and objects most relevant to survival experienced in the modern world more clearly
kept in memory? In other words, is phylogeny or ontogeny prioritized in the human memory system?

1.1 Emotional Memories

Relative to mundane, everyday events, emotional memories subjectively seem to be particularly durable in human memory. Indeed, research has found a robust effect of emotion on memory: Emotional events are better recalled than neutral events in a variety of different contexts and via different research paradigms (e.g., Bradley, Greenwald, Petry, & Lang, 1992; Choi, Kensinger, & Rajaram, 2013; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002; Levine & Edelstein, 2009). For example, Lindstrom and Bohlin (2011) examined the effect of highly arousing positive, negative, and neutral stimuli on working memory and found that emotional stimuli facilitated both response reaction time and accuracy. In particular, negatively-toned events (including potential phylogenetically-based threats) seem to be more reliably recalled over time than neutral ones (e.g., Kensinger, 2007; Wilson, Darling, & Sykes, 2011). Such facilitating enhancement effects appear to be related to a unique processing of affective stimuli. Areas of the brain, such as the amygdala and orbitofrontal cortex, associated with affective processing modulate other areas of the brain (i.e., fusiform gyrus and hippocampal formation) that facilitate encoding of sensory detail and consolidation of detail (e.g., Hamann, Ely, Grafton, & Kilts, 1999), resulting in greater encoding capabilities of affective stimuli relative to neutral stimuli. This modulating relationship between affective processing and encoding and consolidation of detail also seems to be a basic function across species as it has been evidenced in humans (e.g., Kensinger & Corkin, 2004; Richardson, Strange, & Dolan, 2004) and other non-human animals (see McGaugh, 2004).
Despite the empirical support for the enhancing effects of emotion on memory, there is debate regarding whether emotion in general is responsible for this effect or whether negative emotion specifically is most important (e.g., Kensinger, 2009; McNally, 2005; Otani, Jaffa, Libkuman, Goernert, & Kato, 2012; Porter, ten Brinke, Riley, & Baker, under review). In other words, is enhanced memory associated with negative events, specifically, or does general emotional arousal alone lead to enhanced memory? Although enhanced memory has been found for various affective categories, such as better memory for highly negative scenes (violent death) and positive scenes (sexual scenarios) but not neutral scenes (Lindstrom & Bohlin, 2011), other studies have found that memory prioritizes negative events or objects specifically (e.g., Bradley et al., 1992; Choi et al., 2013; Kensinger et al., 2002; Levine & Edelstein, 2009). The latter suggest that negative stimuli may activate a unique memory storage process relative to positive or neutral stimuli. Indeed, the areas of the brain activated during affective processing (i.e., amygdala and fusiform gyrus) seem to have greatest activation during encoding of negative events (e.g., Kensinger, Garoff-Eaton, & Schacter, 2007). Accordingly, affective stimuli/events varying in valence (i.e., positive versus negative) activate the same neural pathways, but negative stimuli seem to activate them with greater magnitude than positive stimuli.

From an evolutionary perspective, enhanced memory for negative/threatening events or objects arguably would be valuable to maximize one’s chances of survival during a subsequent, related encounter. Porter et al. (2008) proposed the Paradoxical Negative Emotion (PNE) hypothesis with the first tenet positing that negative, potentially threatening/“dangerous” events should be given preferential attention and be recalled better over time than other events in order to avoid, or survive, related events in the future. In line with this theory and the neurological distinctions between positive and negative affective processing, numerous studies have shown
that negative information is associated with enhanced memory quality, such as a greater sense of vividness and visual detail (Kensinger et al., 2007). Further, negative information is more often self-reported as being “remembered” versus “known” than positive items during recognition tasks (e.g., Bless & Schwarz, 1999; Dewhurst & Parry, 2000; Ochsner, 2000; Peace, Porter, & ten Brinke, 2008). Similarly, in a social action context, memory for threatening others seems to be prioritized. Children recall more details of the actions of “mean” targets than those deemed to be “nice” (Baltzar, Shutts, & Kinzler, 2012) and adults have enhanced memory for “cheaters” and other “threatening targets” (Kinzler & Shutts, 2008; Rule, Sleipan, & Ambady, 2012; Baltzar et al., 2012). Naturalistic studies find similar patterns of memory enhancement for negative events. For example, Porter and Peace (2007) found that negative memories (e.g., violent victimization) remained highly consistent (objectively & subjectively) after 5 years whereas positive autobiographical memories by the same rememberers were relatively inconsistent and distorted. Other studies have examined widely publicized events by comparing memory quality between people with different preferences for the outcome, such as the 2004 final American league playoff game (Kensinger & Schacter, 2006), the O. J. Simpson trial (Levine & Bluck, 2004), and the fall of the Berlin Wall (Bohn & Bernsten, 2007). Each study found that those who were not in favour of the subsequent outcome better recalled details associated with the specific event. The general methodology in these latter studies was highly innovative in that they employed a single common stimulus event interpreted as negative or positive by different observers. However, although this addresses a limitation of laboratory studies comparing memories for distinct positive and negative stimuli, there is a lack of control over encoding and recall, such as the potential effect of rehearsal (e.g., Breslin & Safer, 2011).
Another unresolved issue is the relation between emotional valence and memory as it relates to false memory susceptibility. Some researchers have proposed that negative memory increases susceptibility to misinformation (e.g., Brainerd, Stein, Silveria, Rohenkohl, & Reyna, 2008; Valentine & Mesout, 2009), whereas others argue that it is a protective factor against distorting influences (e.g., Kensinger, 2007) and may even be adaptive (e.g., Otgaar & Howe, in press). Brainerd and colleagues have suggested that negative events are encoded as “gists” (fuzzy trace theory), allowing the rememberer to “fill in the blanks,” often erroneously (e.g., Brainerd, Holiday, Reyna, Yang, & Toglia, 2010). Another proposal is that negative emotion may serve to enhance memory in general, but also increases memory’s susceptibility to misinformation. For example, the second tenet of the PNE hypothesis (Porter et al., 2008) suggests that negative emotion will sometimes reduce memory reliability by heightening its susceptibility to misinformation, contributing to false memories (see Brainerd et al., 2008). The incorporation of information into memory concerning the “threat” provided by credible others, although generally adaptive in preparing for a related future event, can potentially lead to false memories if the suggested information is erroneous. That is, negative memories may be modified by information received from an authoritative source to enhance the potential reliability of our future fitness-based recollections.

Despite the evidenced strength of negative emotional memories, their fragility is betrayed by findings that entire negative events can be falsely recalled. For example, participants have recalled seeing (non-existent) footage of the car crash that killed Princess Diana (Ost, Vrij, Costall, & Bull, 2002) and the first plane crashing into the World Trade Centre (Pezdek, 2003). One relevant observation is that although false memories have been experimentally induced for entire positive and negative events, the latter is associated with the highest induction rate (e.g.,
Loftus & Pickrell, 1995; Pezdek, 2003; Porter, Yuille, & Lehman, 1999). Using a memory implantation paradigm, people can be led to recall false stressful childhood events, such as getting lost in a shopping mall (Loftus & Pickrell, 1995). In the first study with direct evidence for the relatively high susceptibility of negative events to misinformation, Porter, Spencer, and Birt (2003) found that memory for negative images was twice as susceptible (80% of participants) to major misleading questions than positive and neutral conditions. More recently, Shaw and Porter (in preparation) found a 68% induction rate of false memories for committing a violent assault in participants’ childhood. As such, despite the potential enhanced memory for negative events, these memories also are highly vulnerable to error in the presence of misinformation.

Although collectively these findings suggest that negative memories may be more susceptible to misinformation than other (i.e., positive or neutral) memories, research has not yet examined them in a survival-relevant context as extensively as general memory accuracy has been examined (e.g., Nairne, VanArsdall, Pandeirada, & Blunt, 2012). Two recent studies examining false memories for word lists and concept lists that included survival-relevant categories found that false memories were more likely for survival-relevant items (Howe & Derbish, 2010; Howe, Garner, & Patel, in press). In my thesis, I sought to extend this question to threatening and pleasurable objects to explicate the evolutionary basis of memory and its susceptibility to misinformation. Based on the robust findings for the effect of negative emotion on memory, it was anticipated that negatively-valenced (i.e., threatening) objects would be recalled better but also would be more susceptible to misinformation than positively-valenced (i.e., pleasurable) objects.
1.2 A Phylogenetic or Ontogenetic Foundation of Memory?

As previously mentioned, it has been argued that negative, and specifically threatening, stimuli are prioritized in the human memory system to ensure survival. This adaptive framework of memory would suggest that natural responses to threat-relevant stimuli, such as an activation of the amygdala generating a fear response, would have likely been shaped by evolution (e.g., Fox, Griggs, & Mouchlianitis, 2007; LoBue & DeLoache, 2008; Ohman, 1993; Ohman & Mineka, 2001). However, if memory does have an evolutionary foundation, could this argument also be extended to suggest that objects encountered within evolutionary history (i.e., those with a phylogenetic basis) also would be remembered better than those present more recently (i.e., modern, ontogenetically-based)? Research examining memory and other related processes (e.g., attention) seem to indicate a prioritization of objects with survival-relevance (e.g., Barclay & Lalumiere, 2006), suggesting a phylogenetic foundation of memory and other aspects of human cognition. For example, phylogenetically-based threats (e.g., a snake ready to attack in the grass) have been found to result in a memory advantage compared to ontogenetically-based threats (e.g., a gunman) during a matched-pair memory task, in that phylogenetically-based threats were associated with significantly fewer errors (e.g., Wilson et al., 2011). Further, survival-relevant threats also have been found to be detected more automatically than neutral stimuli (e.g., Blanchette, 2006; Flykt, 2005; LoBue & DeLoache, 2008; Ohman, Flykt, & Esteves, 2001).

Interestingly, the manner in which a stimulus is presented seems to influence processing patterns: Words presented in a “survival” hunter-gatherer scenario are better remembered in a surprise memory task than the same words presented in control scenarios (Nairne, Pandeirada, Gregory, & Van Arsdall, 2009; see also Howe et al., in press). Collectively, these findings suggest that survival and threat relevance play an important role in facilitating memory.
Similarly, if the neurological fear response (e.g., activation of amygdala) indeed has evolved over time in such a manner it should be more strongly activated by biologically relevant stimuli. The biological preparedness theory argues that preferential associations are formed between certain phylogenetically-based stimuli with fear and aversiveness resulting in quicker conditioned responses (Ohman & Mineka, 2001; Seligman, 1970, 1971). Support for this argument can be found in the phobia literature with intense fears and phobias typically representing objects and situations of a phylogenetic nature (Agras, Sylvester, & Oliveau, 1969; Costello, 1982; deSilva, Rachman, & Seligman, 1977; Seligman, 1971), and this has been suspected to derive from these preferential associations. Additionally, experiments investigating conditioned responses have consistently found enhanced resistance to extinction of responses (i.e., skin conductance) to such biologically-relevant stimuli (McNally, 1987; Ohman & Mineka, 2001). A vast body of research supports the biological preparedness theory in both nonhuman primates and humans (see Ohman & Minkea, 2001 for review). For example, Cook and Mineka (1989) demonstrated that laboratory-reared rhesus monkeys can develop a fear response to snakes from viewing a video of another monkey displaying a fear response to a toy or real snake. However, when the video is edited to depict a fear response to flowers, the monkey viewing the video failed to develop a fear response to the flowers when they were presented subsequently, suggesting that the fear response may be selective for phylogenetically-based threat-relevant stimuli.

Despite the evidence for the prioritization of survival-relevant stimuli, it does not fully substantiate an evolutionary basis to memory because alternative explanations, such as experience and learning, are not ruled out. It has been argued that threat-relevance in general (i.e., no effect of phylogenetic or ontogenetic origin; e.g., Fox et al., 2007) and
experience/learning (e.g., Lobue, 2010) are critical components that facilitate attention, detection, and memory. From the threat-relevance perspective, threats in general – including those with phylogenetic basis and ontogenetic basis – should be prioritized because they are relevant. Indeed, in a visual-spatial attention task, Fox et al. (2007) examined the evolved fear module activation between phylogenetically-based (i.e., snake) and ontogenetically-based (i.e., gun) threat-relevant stimuli. The researchers found no detection differences between the two types of threats and both were detected quicker than neutral stimuli, suggesting that threat-relevance in general may be more important than phylogenetic origin (also see Blanchette, 2006; Brosch & Sharma, 2005). This relevance argument may further suggest that ontogenetically-based threats would facilitate memory more because they are more relevant in the modern lives today.

Similarly, researchers have argued that although humans may have evolved to prioritize phylogenetically-based stimuli, learning also may serve as an underlying mechanism resulting in a prioritization of more modern (i.e., ontogenetically-based) threatening stimuli (e.g., Blanchette, 2006; LoBue, 2010). This proposition has been examined using threat detection in preschool children with modern threatening objects which they would have experienced (i.e., syringes) and threatening objects for which they would not have developed fear yet (i.e., knives). LoBue (2010) found an attentional bias for syringes compared to a neutral object (i.e., pens), but not a bias for knives in comparison to another neutral object (i.e., spoons). These findings would suggest that experience and learning might play a crucial role in attention and subsequent memory.

In order to adequately determine whether alternative explanations (e.g., experience/learning) can be ruled out, a direct examination comparing memory for
ontogenetically-based objects relative to phylogenetically-based objects is necessary. In my studies, I sought to address this gap in the literature. Based on past findings, I hypothesized that the evolutionary foundation of memory evident with negative/threatening stimuli would extend to developmental origin, prioritizing phylogenetically-based objects.

1.3 The Current Thesis

In this thesis, I examined the strength and potentially heightened susceptibility of memory for images varying in emotional valence and developmental origin with a novel memory task and a misinformation paradigm, extending on previous methodologies. I investigated whether survival-relevant positively and negatively valenced objects (i.e., associated with pleasures and threats) facilitated memory relative to non-emotional objects. Although threatening stimuli have been the focus of numerous investigations, pleasures – a specific type of positive object – largely have been ignored in the literature. Moreover, I examined the phylogenetic basis of human memory by examining whether objects experienced by our early ancestors that were essential to survival are prioritized in memory relative to more modern, ontogenetically-based objects experienced during one’s lifetime. The memory task involved recalling details of images that varied in image valence and developmental origin (i.e., phylogenetically-based vs. ontogenetically-based). Additionally, memory susceptibility was examined in Experiment 2 by presenting one piece of (major) misinformation about each object. In line with the PNE hypothesis, I predicted that overall negatively-valenced objects (i.e., threatening) would be remembered with greatest accuracy but they also would be most susceptible to misinformation compared to positive and non-emotional objects. Based on the current evidence for the phylogenetic basis of memory, attention, and detection, I anticipated that phylogenetically-based objects would be associated with greatest memory accuracy but also more susceptible to misinformation. Because others
have found that learning and experience play a larger role than evolutionary presence, there also was the possibility that ontogenetically-based stimuli, and threats in particular, would be associated with memory enhancement.
Chapter 2 Pilot Study

2.1 Participants

A convenience sample pilot study ($N = 28$) was conducted to obtain several ratings on potential stimuli for the use in the subsequent studies.

2.2 Materials

Images depicting my categories of interest (i.e., phylogenetically-based threats, ontogenetically-based threats, phylogenetically-based pleasures, ontogenetically-based pleasures, and neutral objects) were selected from the Internet for inclusion in the pilot study based on past research.

Five versions of each of three target objects were selected. For example, three target objects (spider, snake, and maggots) were selected to represent the phylogenetically-based threat category and five versions of each target object were included in the complete sample of images. As such, each category contributed 15 images for a total of 75 sample images. Target objects representative of ontogenetically-based threats included a gun, knife, and dirty syringe. Phylogenetically-based pleasures included fruit, salmon, and turkey whereas ontogenetically-based pleasures included a sports car, yacht, and money. Finally, neutral objects consisted of a clock, tissue box, and lamp.

2.3 Procedures

Participants viewed a total of 75 images, one at a time and provided a series of ratings following each image. Participants were asked to rate the emotional valence of each image on a 7-point Likert-type scale, ranging from 1 (Negative) to 4 (Neutral) to 7 (Positive). Further, they were asked to rate the degree of emotional arousal experienced from viewing each image on a 7-point Likert-type scale, ranging from 1 (Not at All Arousing) to 4 (Somewhat Arousing) to 7 (Extremely Arousing).
2.4 Results

2.4.1 Emotional valence.

Emotional valence ratings were examined to select images for the subsequent main experiments that best fit the desired patterns. Three images for each category of interest (i.e., one per target object) were selected for their emotional valence ratings, such that the most positively rated images intended to represent pleasures and the most negatively rated images intended to represent threats were selected. Similarly, images rated as closest to neutral (i.e., rating of 4) were selected to represent the neutral category. See Table 2.1 for means and standard deviations of selected images for each category.

Table 2.1

Means and Standard Deviations of Emotional Valence Ratings for Each Selected Target Object

<table>
<thead>
<tr>
<th>Category</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylogenetically-based</td>
<td></td>
</tr>
<tr>
<td>Threat</td>
<td></td>
</tr>
<tr>
<td>Snake</td>
<td>1.82 (.91)</td>
</tr>
<tr>
<td>Spider</td>
<td>1.68 (.98)</td>
</tr>
<tr>
<td>Maggots</td>
<td>1.36 (.62)</td>
</tr>
<tr>
<td>Ontogenetically-based</td>
<td></td>
</tr>
<tr>
<td>Threat</td>
<td></td>
</tr>
<tr>
<td>Gun</td>
<td>1.36 (.68)</td>
</tr>
<tr>
<td>Knife</td>
<td>1.43 (.69)</td>
</tr>
<tr>
<td>Syringe</td>
<td>1.61 (.83)</td>
</tr>
<tr>
<td>Phylogenetically-based</td>
<td></td>
</tr>
<tr>
<td>Pleasure</td>
<td></td>
</tr>
<tr>
<td>Fruit</td>
<td>5.82 (1.31)</td>
</tr>
<tr>
<td>Salmon</td>
<td>5.43 (1.298)</td>
</tr>
<tr>
<td>Turkey</td>
<td>5.18 (1.37)</td>
</tr>
<tr>
<td>Ontogenetically-based</td>
<td></td>
</tr>
<tr>
<td>Pleasure</td>
<td></td>
</tr>
<tr>
<td>Sports Car</td>
<td>5.39 (1.26)</td>
</tr>
<tr>
<td>Yacht</td>
<td>5.39 (1.29)</td>
</tr>
<tr>
<td>Money</td>
<td>5.96 (1.07)</td>
</tr>
</tbody>
</table>
2.4.2 Emotional arousal.

Based on the nature of my stimuli, it was anticipated that there may be significant differences in arousal. For example, ontogenetically-based pleasures (e.g., money) likely would be self-reported as being more emotionally arousing than phylogenetically-based pleasures (e.g., salmon). As such, emotional arousal was considered but image selection was primarily based upon emotional valence and similarity of arousal levels within image categories. Images selected for best fit with the desired emotional valence pattern were compared, to test emotional arousal similarity. A series of paired-sample $t$ tests comparing mean arousal ratings of target images within each category of interest revealed no significant differences, $p$s > .05.

Target images then were collapsed and each category was compared to one another. Results indicated that phylogenetically-based pleasures were rated as significantly less arousing ($M = 3.78$, $SD = 1.73$) than ontogenetically-based pleasures ($M = 4.61$, $SD = 1.65$), $t(82) = -3.95$, $p < .001$, $d = .49$. No differences were identified between phylogenetically-based threats ($M = 5.28$, $SD = 1.73$) and ontogenetically-based threats ($M = 5.26$, $SD = 1.75$), $p = .95$, $d = .01$.

Further, all pleasures and threats had significantly higher arousal ratings than the neutral category ($M = 1.63$, $SD = 1.19$), $p$s < .001. See Table 2.2 for the $t$ statistics associated with each paired-samples $t$ test.
Table 2.2

*Paired-samples t Test Values for Comparisons Between Neutral and Each Image Category*

<table>
<thead>
<tr>
<th>Comparison Category</th>
<th>t statistic (df)</th>
<th>d values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylogenetically-based Threats</td>
<td>17.56 (83)</td>
<td>2.45</td>
</tr>
<tr>
<td>Ontogenetically-based Threats</td>
<td>16.05 (82)</td>
<td>2.43</td>
</tr>
<tr>
<td>Phylogenetically-based Pleasures</td>
<td>11.23 (82)</td>
<td>1.44</td>
</tr>
<tr>
<td>Ontogenetically-based Pleasures</td>
<td>15.30 (83)</td>
<td>2.07</td>
</tr>
</tbody>
</table>
Chapter 3 General Method

3.1 Overview

In the experiments reported here, I used a paradigm adapted from previous memory research (e.g., Porter et al., 2008; Porter et al., under review) to assess both memory for phylogenetically-based and ontogenetically-based threats and pleasures (Experiment 1) and memory vulnerability associated with each of these categories (Experiment 2).

3.2 Stimuli and Materials

3.2.1 Images.

Fifteen images (three phylogenetically-based threats, three ontogenetically-based threats, three phylogenetically-based pleasures, three ontogenetically-based pleasures, and three neutral objects) were selected based on valence and arousal ratings collected in the pilot study for inclusion in the main study. See Appendix A for image examples for each category.

3.2.2 Vignettes.

Vignettes providing documentary-like descriptions about the objects in the images were created for the purpose of these experiments. Each vignette consisted of 3-5 sentences providing background information about the object in the corresponding image. Most details concerning the vignettes were not asked about during the subsequent memory test. However, each vignette had one detail that would later be followed up in one of the questions in the memory test in both Experiment 1 and Experiment 2. In Experiment 1, this detail was accurate (i.e., no fangs were visible in the snake image and, in reality, no fangs were visible) whereas in Experiment 2 this detail was misleading (i.e., two fangs were visible but, in reality, no fangs were visible). See Appendix B for vignette examples.
3.3 Procedures

3.3.1 Session One.

Participants were led into the research lab (one at a time) and proceeded to view images on a computer having been told that the purpose of the study was to examine the processing of animate and inanimate objects. Participants first completed a practice trial of four images (i.e., a computer, a horse, a person, and a house) in order to become familiar with the viewing time of the target images and rating procedures. After the trial run was complete, participants viewed five images, each appearing on the same black, neutral background – one each of a phylogenetically-based threat, an ontogenetically-based threat, a phylogenetically-based pleasure, an ontogenetically-based pleasure, and a neutral image, randomly selected from each category of images, as chosen based on pilot study ratings. Further, presentation order was counterbalanced. Participants viewed each image for 1 s and indicated whether the object was alive/animate or not alive/inanimate. Also, participants rated the emotional valence of each object on a 7-point Likert-type scale, ranging from 1 (Negative) to 4 (Neutral) to 7 (Positive), and the degree of emotional arousal of the object, ranging from 1 (Not at All Arousing) to 4 (Somewhat Arousing) to 7 (Extremely Arousing).

Following a filler task consisting of a series of individual difference measures that served as a delay prior to a surprise memory test, a researcher kept blind to the study’s purpose read five vignettes, one pertaining to each previously presented image. Participants were told that the vignette being read was taken directly from a National Geographic documentary that produced a special episode on the corresponding target image. During the vignette readings, participants were asked to visualize the objects as the description was given. In Experiment 1, this information was totally accurate, but in Experiment 2, this information contained one piece of
misinformation. Next, a second filler task was administered consisting of another series of questionnaires. After the questionnaires were complete, participants were informed that there would be a memory test. The same researcher verbally asked four questions corresponding to each of the five previously viewed images (see Appendix C for a question set example).

### 3.3.2 Session Two.

Participants were asked to return after a 2-day delay under the pretense of completing a similar study but viewing different stimuli. In fact, memory for each image seen during Session One was unexpectedly re-tested. The researcher blind to the study’s purpose verbally asked the same four questions corresponding to each of the five previously viewed images, as in Session One. After all verbal responses were recorded, participants completed a recognition task during which they viewed 25 images (5 previously viewed images and 20 foils) and were asked to identify the images they had seen and rated in Session One.
Chapter 4 Experiment 1

Experiment 1 focused on memory accuracy for phylogenetically-based and ontogenetically-based threats and pleasures and the quality of memory for these objects over time.

4.1 Participants

Undergraduate participants ($N = 50$) attending a Canadian university were recruited through an online research participant pool and received course credit for the completion of the study. The sample consisted of 33 women and 16 men (one participant did not report his/her gender) with a mean age of 19.67 years ($SD = 1.62$).

4.2 Method

As mentioned, Experiment 1 differed from Experiment 2 with regard to the vignettes read to participants following exposure to the images. Each vignette consisted of 3-5 sentences providing background information about the object in the corresponding image. Most details concerning the vignettes were not included in the subsequent memory test. However, each vignette contained one detail that would later be followed up in one of the questions in the memory test. In Experiment 1, this one detail correctly suggested that a certain characteristic of the target object was not present. For example, the vignette associated with a snake explicitly stated that no fangs were visible on a truly fangless snake.

4.2.1 Data treatment.

Participant responses to each of the four questions per image category (i.e., 20 questions in total) were coded as correct or incorrect and a total percentage accuracy score for each image type was calculated. As such, participants had a memory accuracy score for the phylogenetically-based threat, ontogenetically-based threat, phylogenetically-based pleasure, ontogenetically-based pleasure, and neutral image that they viewed. Further, two dependent variables were created...
from recognition task responses. A total percentage accuracy score was calculated for the four foil images for each image category and a dichotomous variable was calculated representing whether or not the participant had identified the correct image as being the one that had been seen previously.

4.3 Results

4.3.1 Manipulation check.

Participant ratings of emotional valence and intensity of each image were examined to establish that the manipulation was successful. First, a 2 (developmental origin: phylogenetic vs. ontogenetic) × 2 (image valence: threat vs. pleasure) repeated measures ANOVA was conducted on emotional valence ratings. There was no significant difference between phylogenetically-based (M = 3.82, SD = 1.31) and ontogenetically-based (M = 3.73, SD = 1.35) objects, p > .05, η² = .01 on these ratings. However, a significant main effect of image valence (i.e., threat/pleasure) was evident, F(1, 45) = 187.04, p < .001, η² = .81, indicating significantly different emotional valence ratings between threats and pleasures. This mean emotional valence ratings associated with threats and pleasures were 2.17 (SD = 1.44) and 5.38 (SD = 1.22), respectively. No significant interaction was evidenced, ps > .05, η² = .01. Follow-up t tests indicated that all image types had significantly different valence ratings from the neutral (M = 4.10, SD = .83) image type (ps < .001). See Table 4.1 for statistics.
Table 4.1

Paired-samples t Test Statistics for Comparisons Between Neutral and Each Image Category

<table>
<thead>
<tr>
<th>Category</th>
<th>Valence M (SD)</th>
<th>t values (df)</th>
<th>d values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylogenetically-based Threat</td>
<td>2.33 (1.49)</td>
<td>-6.81 (47)</td>
<td>1.54</td>
</tr>
<tr>
<td>Ontogenetically-based Threat</td>
<td>2.08 (1.40)</td>
<td>-8.20 (47)</td>
<td>1.74</td>
</tr>
<tr>
<td>Phylogenetically-based Pleasure</td>
<td>5.38 (1.12)</td>
<td>6.53 (47)</td>
<td>1.12</td>
</tr>
<tr>
<td>Ontogenetically-based Pleasure</td>
<td>5.37 (1.29)</td>
<td>6.02 (45)</td>
<td>1.17</td>
</tr>
</tbody>
</table>

Next, a 2 (developmental origin: phylogenetic vs. ontogenetic) × 2 (image valence: threat vs. pleasure) repeated measures ANOVA was conducted on emotional intensity ratings. There was no significant difference identified between phylogenetically-based (M = 4.15, SD = 1.54) and ontogenetically-based objects (M = 4.54, SD = 1.66), F(1, 45) = 2.69, p = .06, η² = .08. However, a significant main effect of image valence was evidenced, F(1, 45) = 41.44, p < .001, η² = .48. Threats (M = 5.21, SD = 1.56) were identified as having significantly higher intensity ratings than pleasures (M = 3.49, SD = 1.66).

Further, a significant interaction was evidenced between developmental origin and image valence for emotional intensity, F(1, 45) = 4.66, p = .04, η² = .09. Follow-up paired-sample t tests were conducted to further examine the nature of this interaction. While phylogenetically-based and ontogenetically-based threats did not differ significantly, mean intensity ratings for ontogenetically-based pleasures were significantly higher than phylogenetically-based pleasures (see Table 4.2). Further, reiterating the evidenced main effect of image valence,
phylogenetically-based threats and pleasures were significantly different, and ontogenetically-based threats and pleasures were significantly different in a similar fashion (i.e., threats were rated significantly more intense than pleasures), $ps < .001$.

**Table 4.2**

*Means and Standard Deviations of Emotional Valence and Intensity Ratings for Each Image Category Ratings*

<table>
<thead>
<tr>
<th>Category</th>
<th>Valence $M (SD)$</th>
<th>Intensity $M (SD)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phylogenetically-based Threat</td>
<td>2.26 (1.47)</td>
<td>5.26 (1.44)</td>
</tr>
<tr>
<td>Ontogenetically-based Threat</td>
<td>2.09 (1.41)</td>
<td>5.22 (1.66)</td>
</tr>
<tr>
<td>Phylogenetically-based Pleasure</td>
<td>5.39 (1.14)</td>
<td>3.12 (1.62)</td>
</tr>
<tr>
<td>Ontogenetically-based Pleasure</td>
<td>5.37 (1.29)</td>
<td>3.87 (1.67)</td>
</tr>
<tr>
<td>Neutral</td>
<td>4.10 (.83)</td>
<td>1.74 (1.45)</td>
</tr>
</tbody>
</table>

*a Intensity ratings for phylogenetically-based threats were significantly higher than phylogenetically-based pleasures, $t(48) = 7.01, p < .001, d = 1.40$.  
*b Intensity ratings for ontogenetically-based threats were significantly higher than ontogenetically-based pleasures, $t(45) = 4.33, p < .001, d = .81$.  
*c Intensity ratings for ontogenetically-based pleasures were significantly higher than phylogenetically-based pleasures, $t(46) = -2.59, p = .01, d = .46$.

**4.3.2 Memory accuracy.**

The overall memory accuracy score for participants was 66.25% ($SD = 9.96\%$). The minimum and maximum accuracy score was 40.00% and 83.00%. Overall accuracy for phylogenetically-based threats and phylogenetically-based pleasures was 73.13% ($SD = 19.91\%$) and 62.92% ($SD = 21.97\%$), respectively. Overall percentage accuracy for ontogenetically-based threats and ontogenetically-based pleasures was 90.94% ($SD = 15.28\%$) and 53.75% ($SD = 19.15\%$), respectively. Further, overall accuracy for neutral images was 63.82% ($SD = 31.16\%$).

To examine memory accuracy, a 2 (developmental origin: phylogenetic vs. ontogenetic) × 2 (image valence: threat vs. pleasure) × 2 (time: Session One vs. Session Two) repeated measures ANOVA was conducted with accuracy scores as the dependent variable. First, a
significant main effect of image valence was evidenced, \( F(1, 39) = 70.30, p < .001, \eta^2 = .65 \) with threats \( (M = 82.03\%, SD = 17.60\%) \) having significantly higher accuracy scores than pleasures \( (M = 58.33\%, SD = 20.56\%) \).

Further, a significant interaction was evidenced between developmental origin and time, \( F(1, 39) = 4.27, p = .046, \eta^2 = .09 \). A series of follow-up paired-samples \( t \) tests were conducted to further elucidate the interaction. Ontogenetically-based objects \( (M = 74.50\%, SD = 11.96\%) \) had significantly higher accuracy scores than phylogenetically-based objects \( (M = 64.94\%, SD = 15.76\%) \) in Session One, \( t(48) = -3.61, p < .001, d = .25 \), but not in Session Two, \( t(39) = -.33, p > .05 \). Although there was no significant effect of time on accuracy scores for phylogenetically-based objects, the relationship between Session One accuracy and Session Two accuracy for ontogenetically-based objects was approaching significance \( (p = .057) \), with accuracy decreasing from Session One \( (M = 74.38\%, SD = 11.65\%) \) to Session Two \( (M = 70.31\%, SD = 14.62\%) \).\(^1\)

A significant interaction also was evidenced between developmental origin and image valence, \( F(1, 39) = 28.56, p < .001, \eta^2 = .42 \). A series of follow-up paired-samples \( t \) tests were conducted to further elucidate the interaction. Although a significant effect of developmental origin was evidenced for both threats and pleasures, they were in opposite direction. Ontogenetically-based threats \( (M = 91.16\%, SD = 13.76\%) \) had significantly higher accuracy scores than phylogenetically-based threats \( (M = 73.17\%, SD = 18.02\%) \), \( t(40) = -5.50, p < .001, d = 1.12 \). However, phylogenetically-based pleasures \( (M = 62.92\%, SD = 19.79\%) \) had significantly higher accuracy scores than ontogenetically-based pleasures \( (M = 53.75\%, SD = 17.03\%) \), \( t(40) = 2.28, p = .03, d = .49 \).

\(^1\) The same analysis was conducted with accuracy scores generated from the three questions not associated with the misinformation in Experiment 2 as the dependent variable to get a more pure comparison across studies; however, the same findings were evidenced.
Next, accuracy for each image was compared to accuracy for neutral images in a series of paired-samples $t$ tests. Accuracy for both ontogenetically-based objects across the two sessions was significantly different from accuracy for the neutral image, $ps < .01$. Ontogenetically-based threats had higher accuracy rates than neutral images in each session, whereas ontogenetically-based pleasures had lower accuracy than neutral images in each session. However, no accuracy differences were evidenced between phylogenetically-based objects and neutral objects, $ps > .05$.

**4.3.3 Recognition accuracy.**

The recognition task allowed me to examine whether the correct image was identified as being seen previously and the accuracy at which participants correctly rejected the foils. Generalized Estimating Equations (GEE; Liang & Zeger, 1986; Zeger & Liang, 1986) was employed to allow for the examination of the current within-subjects measures and binary outcome variables (i.e., correct image not identified versus correct image identified in each image category). As such, valence, developmental origin, and an interaction term were entered into the model to identify potential relationships associated with correct image identification. No significant effects were evidenced, $ps > .05$. Next, each image category was then compared to correct image identification associated with the neutral image. Only ontogenetically-based pleasures had significantly different correct identification odds than neutrals, $p = .02$. The odds ratio indicated that as there is an increase from baseline (i.e., neutral) to ontogenetically-based pleasures, the odds of correctly identifying the correct image compared to not correctly identifying the correct image is 2.96. No other frequencies were significantly different than neutral, $ps > .05$. However, the relationship between ontogenetically-based threats was approaching significance, $p = .06$, with an odds ratio of 2.61.
Next, foil image recognition accuracy was examined using a 2 (valence: threat vs. pleasure) × 2 (developmental origin: phylogenetic vs. ontogenetic) repeated measures ANOVA with foil image recognition accuracy as the dependent variable. Although there were no significant relationships present, \( ps > .05 \), a main effect for valence was approaching significance \( (p = .06, \eta^2 = .12) \) with phylogenetically-based foil images having a higher accuracy rate \( (M = 98.52\%, SD = 11.49\%) \) than ontogenetically-based accuracy \( (M = 96.32\%, SD = 9.87\%) \).

Further, foil image accuracy for each image category was compared to foil image accuracy for neutral images. No significant relationships were identified, \( ps > .05 \). However, the relationship between ontogenetically-based pleasure foil accuracy \( (M = 94.86\%, SD = 10.26\%) \) and neutral foil accuracy \( (M = 98.53\%, SD = 5.97\%) \) also was approaching significance, \( p = .06 \).

### 4.3.4 Memory and self-reported emotion characteristics.

A series of Pearson correlations was conducted to examine potential relationships between emotional interpretation (valence and arousal) of images and memory accuracy. Valence ratings for ontogenetically-based threats were negatively related to the corresponding Session One accuracy scores, \( r = -.48, p < .001 \). In other words, the more negatively participants rated the image, the greater memory accuracy for that image. Valence ratings of ontogenetically-based pleasures in Session One also were significantly, and positively, related to later memory accuracy, \( r = .29, p = .045 \), meaning the more positive the image was rated, the greater memory accuracy for that image. No significant relationships between valence ratings and memory accuracy were evident for phylogenetically-based objects in Session One, and no significant relationships emerged for Session Two accuracy. Finally, no significant relationships between emotional intensity ratings and memory accuracy were evident in either session.
Chapter 5 Experiment 2

Experiment 2 expanded upon Experiment 1 by including both a general memory accuracy test and a test to examine memory fallibility for phylogenetically-based and ontogenetically-based threats and pleasures. As such, misleading information was presented about a single feature of each object to determine its effect on memory.

5.1 Participants

A different sample of undergraduate participants (N = 50) attending a Canadian university were recruited through an online research participant pool and received course credit for completion of the study. The sample consisted of 31 women and 19 men with a mean age of 20.28 years (SD = 2.26).

5.2 Method

As in Experiment 1, each vignette in Experiment 2 consisted of 3-5 sentences providing background information about the object in the corresponding image. Most details concerning the vignettes were not included in the subsequent memory test. However, in Experiment 2 each vignette had one major misleading detail that would later be followed up in one of the questions in the memory test. A major misleading detail was defined as the suggestion of the presence of a detail that had not actually been in the image. In other words, this one piece of information (incorrectly) suggested that a certain characteristic of the target object was present in the image when it actually was not. For example, it was explicitly stated that two fangs were visible on a fangless snake. See Appendix B for an example.

5.2.1 Data treatment.

Participant responses to three of the four questions in each of the image categories were coded as correct or incorrect and a total percentage accuracy score for each image type was calculated.
The question associated with the misinformation detail was not included in the calculation of accuracy scores. Responses to the question associated with the misinformation were dichotomously coded (misinformation not incorporated versus misinformation incorporated). For example, if participants reported that the snake had two visible fangs they would receive a “misinformation incorporated” code. Thus, participants had an accuracy score and misinformation score for the phylogenetically-based threat, ontogenetically-based threat, phylogenetically-based pleasure, ontogenetically-based pleasure, and neutral image that they viewed. Further, two dependent variables were created from recognition task responses. A total percentage accuracy score was calculated for the four foils of each image category. A dichotomous variable representing whether or not the misleading information was reported also was calculated.

5.3 Results

5.3.1 Manipulation check.

Participant ratings of emotional valence and intensity of each image were examined to establish that the manipulation was successful. First, a 2 (developmental origin: phylogenetic vs. ontogenetic) × 2 (image valence: threat vs. pleasure) repeated measures ANOVA was conducted on self-reported emotional valence ratings. There was no significant difference identified between phylogenetically-based ($M = 3.67, SD = 1.37$) and ontogenetically-based ($M = 3.61, SD = 1.09$) objects, $p > .05$, $\eta^2 = .003$. As anticipated, threats and pleasures had significantly different valence ratings in both phylogenetically-based ($M = 2.10, SD = 1.50$ and $M = 5.25, SD = 1.23$, respectively) and ontogenetically-based categories ($M = 1.56, SD = .96$ and $M = 5.68, SD = 1.21$, respectively).
Further, a significant interaction was evidenced between developmental origin and image valence, $F(1, 48) = 12.20, p = .001, \eta^2 = .20$. Planned pairwise comparisons were conducted to examine the nature of this interaction further. Although emotional valence for pleasures did not vary across developmental origin, $p > .05$, threats did vary, $p = .01, d = .43$. Ontogenetically-based threats ($M = 1.56, SD = .95$) were rated significantly more negative than phylogenetically-based threats ($M = 2.10, SD = 1.49$). Finally, follow-up $t$ tests indicated that all image types had significantly different valence ratings from the neutral image type ($ps < .001$).

Next, a 2 (developmental origin: phylogenetic vs. ontogenetic) $\times$ 2 (image valence: threat vs. pleasure) repeated measures ANOVA was conducted on emotional intensity ratings. A main effect emerged for image valence, $F(1, 48) = 96.63, p < .001, \eta^2 = .69$. Pleasures and threats had significantly different intensity ratings in both developmental origin categories in a similar fashion (i.e., threats rated significantly more intense than pleasures), $ps < .001$.

A significant interaction was evidenced between developmental origin and image valence, $F(1, 48) = 4.31, p = .04, \eta^2 = .08$. Follow-up paired-sample $t$ tests were conducted to further examine the nature of this interaction. Although phylogenetically-based threats ($M = 5.42, SD = 1.44$) and ontogenetically-based threats ($M = 5.56, SD = 1.40$) did not differ significantly in intensity ratings, pleasures varied across developmental origin, $t(48) = -3.46, p = .001, d = .54$. Mean intensity ratings for ontogenetically-based pleasures were significantly higher ($M = 3.74, SD = 1.88$) than phylogenetically-based pleasures ($M = 2.82, SD = 1.54$).^2

5.3.2 Memory accuracy.

The overall memory accuracy score was 70.93% ($SD = 9.45\%$). The minimum and maximum accuracy score was 47.00% and 87.00%. Overall percentage accuracy for phylogenetically-based

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^2 Intensity ratings for all image types were significantly higher than intensity ratings for the neutral category, $ps < .001$. 

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threats and phylogenetically-based pleasures was 74.82% ($SD = 20.74\%$) and 63.70% ($SD = 24.42\%$), respectively. Overall percentage accuracy for ontogenetically-based threats and ontogenetically-based pleasures was 90.74% ($SD = 18.09\%$) and 48.34% ($SD = 19.27\%$), respectively. Further, overall accuracy for neutral images was 76.63% ($SD = 26.05\%$).

To examine memory accuracy, a 2 (developmental origin: phylogenetic vs. ontogenetic) × 2 (image valence: threat vs. pleasure) × 2 (Session One vs. Session Two) repeated measures ANOVA was conducted with accuracy scores\(^3\) as the dependent variable. A significant interaction was evidenced between developmental origin and image valence, $F(1, 44) = 24.03, p < .001, \eta^2 = .35$. Planned pairwise comparisons were conducted to further examine this interaction. A significant simple main effect of developmental origin was present for both threats and pleasures. Phylogenetically-based threats ($M = 74.81\%, SD = 10.34\%$) had significantly lower accuracy scores than ontogenetically-based threats ($M = 90.74\%, SD = 17.25\%$), $t(44) = -4.44, p < .001, d = .92$. However, phylogenetically-based pleasures ($M = 63.70\%, SD = 22.27\%$) had significantly higher accuracy scores than ontogenetically-based pleasures ($M = 48.34\%, SD = 19.27\%$), $t(44) = 3.16, p = .003, d = .74$. Within the phylogenetically-based category, threats ($M = 74.82\%, SD = 20.89\%$) had significantly higher accuracy scores than pleasures ($M = 63.70\%, SD = 24.42\%$), $t(44) = 2.58, p = .01, d = .74$. Similarly, threats ($M = 90.74\%, SD = 18.09\%$) and pleasures ($M = 48.34\%, SD = 21.83\%$) had significantly different accuracy scores within the ontogenetically-based category, $t(44) = 9.90, p < .001, d = 2.12$.

5.3.3 Incorporation of misinformation details.

As in Experiment 1, Generalized Estimating Equations (GEE; Liang & Zeger, 1986; Zeger & Liang, 1986) was used because of the repeated measures nature of the current data and the binomial outcome variable (i.e., no misinformation incorporation vs. misinformation

\(^3\) Accuracy scores were created using the three questions that were not associated with the misinformation detail.
incorporation). As such, a developmental origin term, valence term, session term, and resulting interaction terms were entered into the model. A significant interaction between valence and session was evidenced, $b = 0.87, z = 2.19, p = .01$. To interpret the nature of the interaction, the frequency tables were examined. Frequency of misinformation incorporation was higher for pleasures in Session One (count = 48) than threats (count = 24) but there was no difference between pleasures and threats in Session Two (see Figure 5.1). A subset of the data also was selected to examine the simple main effects and provide additional evidence for this conclusion. The effect of session was examined using GEE when valence was restricted to threats and then pleasures separately. Analyses revealed that the odds ratio for the relationship between session and pleasures is higher (1.81) than the relationship between session and threats (.91).

![Figure 5.1. Frequency of Misinformation Incorporation for Threats and Pleasures](image)

Further, a significant interaction was present between developmental period and session, $b = 0.98, z = 2.45, p = .007$. Frequency tables were examined to determine the nature of this interaction. Although misinformation incorporation did not vary across phylogenetically-based
and ontogenetically-based images in Session One, ontogenetically-based images had a higher frequency of misinformation incorporation (count = 48) than phylogenetically-based images (count = 36) in Session Two (see Figure 5.2). See Figure 5.3 for frequencies for each image category. Similar to the above analysis, subsets of the data also were selected to examine simple main effects and substantiated this conclusion further. The effect of session was examined using GEE when developmental period was restricted to phylogenetically-based objects and then ontogenetically-based objects separately. Analyses revealed that the odds ratio for the relationship between session and ontogenetically-based origin is higher (1.56) than the relationship between session and phylogenetically-based origin (1.01).

![Frequency of Misinformation Incorporation for Phylogenetically-based and Ontogenetically-based Objects](image)

**Figure 5.2.** Frequency of Misinformation Incorporation for Phylogenetically-based and Ontogenetically-based Objects
Further, misinformation incorporation frequency for each image category then was compared to misinformation incorporation frequency for the neutral image category. Similar to the above findings, ontogenetically-based pleasures had significantly different frequency of misinformation incorporation than neutral images, $p = .02$. The odds ratio indicated that as there was an increase from baseline (i.e., neutral) to ontogenetically-based pleasures, the odds of incorporating misinformation compared to not incorporating misinformation is 2.15. No other frequencies were significantly different than neutral, $ps > .05$. 

Figure 5.3. Frequency of Misinformation Incorporation for Each Image Category
5.3.4 Recognition accuracy.

The recognition task in this experiment allowed me to examine whether misinformation was reported for the correct image and percentage accuracy at correctly rejecting the foils. As in Experiment 1, Generalized Estimating Equations (GEE; Liang & Zeger, 1986; Zeger & Liang, 1986) was employed to allow for the examination of the current within-subjects measures and binary outcome variable (i.e., misinformation not reported versus misinformation reported). As such, valence, developmental origin, and an interaction term were entered into the model to identify potential relationships associated with correct image identification. No significant effects were evidenced, \( ps > .05 \). Each image category was then compared to correct image identification associated with the neutral image. No significant relationships were present, \( ps > .05 \).

Next, foil image recognition accuracy was examined using a 2 (valence: threat vs. pleasure) × 2 (developmental origin: phylogenetic vs. ontogenetic) repeated measures ANOVA foil image recognition accuracy as the dependent variable. A main effect for developmental origin was present, \( F(1, 42) = 4.19, p = .047 \), with recognition accuracy for phylogenetically-based foil images being higher (\( M = 98.00\%, SD = 10.71\% \)) than ontogenetically-based accuracy (\( M = 94.90\%, SD = 14.34\% \)). Further, foil image accuracy for each image category was compared to foil image accuracy for neutral images. No significant relationships were identified, \( ps > .05 \). However, the relationship between ontogenetically-based pleasure foil accuracy (\( M = 94.86\%, SD = 10.26\% \)) and neutral foil accuracy (\( M = 98.53\%, SD = 5.97\% \)) was approaching significance, \( p = .06 \).
5.3.5 Memory and self-reported emotion characteristics.

A series of Pearson correlations was conducted to examine potential relationships between emotional interpretation (valence and intensity) of images and memory accuracy. No significant relationships were evidenced between participants’ emotional valence ratings and Session One accuracy scores. However, in Session Two, participants’ emotional valence ratings for ontogenetically-based pleasures were significantly, and negatively, related to memory accuracy, $r = -.30, p = .049$. Further, no significant relationships were evidenced between self-reported intensity ratings and memory accuracy, $ps > .05$. 
Chapter 6 Conclusion

Although insight has been gained about the fallibility of human memory over the last several decades (see Loftus, 2005), the specific emotional factors contributing to accuracy and susceptibility to misinformation continue to be debated. For example, are emotionally charged memories in general, or those with a negative (and potentially threatening) valence, prioritized? Similarly, it is not been clear whether the human memory system prioritizes memories with evolutionary roots or those more relevant to the modern world. The present thesis, for the first time, examined these questions simultaneously and in relation to misinformation incorporation building off of past research. In Experiment 1, I examined general memory performance (both detail recall and recognition) in relation to phylogenetically-based and ontogenetically-based threats and pleasures, allowing for a simultaneous examination of both the impact of valence and developmental origin on memory. In Experiment 2, a similar approach was used (replication) but instead, misleading information was presented to participants, and the potential incorporation of misinformation across image categories was examined. Thus, I was interested in the validity of both PNE hypotheses, that negative emotional valence would be associated with enhanced memory and greater susceptibility to the distorting influence of (major) misinformation relative to other emotional stimuli. It also was predicted that objects with a phylogenetic basis would be given precedence in human memory – a system thought to have evolved to be adaptive in informing future decisions and actions (e.g., Nairne et al., 2008).

Here, I found strong support for the unique effect of negative emotion on memory accuracy that replicated across both studies and therefore supported the first tenet of the PNE hypothesis, consistent with past findings (e.g., Kensinger & Schacter, 2006; Porter & Peace, 2007; Peace et al., 2008). Threatening objects, regardless of developmental origin, were recalled
with greater accuracy than pleasures across both studies, arguably resulting from enhanced amygdala/hippocampal activation (e.g., Brainerd, Rena, & Howe, 2009; Kensinger, 2007). This finding is consistent with the PNE hypothesis which argues that throughout evolutionary history it was likely adaptive to remember negative – and more specifically, threatening – encounters to prepare for a related event in the future and ensure survival.

Building off of this adaptation argument, I predicted that phylogenetically-based threatening objects would be associated with enhanced memory, in accordance with recent research (e.g., Nairne et al., 2012; see also Howe et al., in press; Wilson et al., 2011). However, it also has been argued that relevance in general (i.e., no differences between phylogenetically-based and ontogenetically-based threats; e.g., Fox et al., 2007) and experience/learning (e.g., LoBue, 2010) may be superior in detection and attention domains, suggesting that ontogenetically-based objects may be associated with enhanced memory as well. In line with the experience/learning argument, details of ontogenetically-based threats were remembered with significantly greater accuracy than phylogenetically-based threats. Indeed, in both studies, threats were recalled with the highest accuracy rate. Thus, support was found for the evolutionary foundation of memory in relation to valence, suggesting survival relevance is important for enhanced memory; however, this result suggests that when it comes to developmental origin, memory enhancement is more related to survival relevance in a modern world.

Not only was memory accuracy in general examined in this thesis but susceptibility to misinformation also was examined (Experiment 2). Again, according to the PNE hypothesis and based on past research, I predicted that memory for threatening objects would be most susceptible to misinformation and that phylogenetically-based objects, in particular, would be as well. Surprisingly, pleasures were associated with significantly higher rates of misinformation
incorporation than threats in the first session; however, this significant relationship was not consistent across sessions. This finding also is inconsistent with past research that has found greater susceptibility to misinformation for negative events and objects (e.g., Kensinger & Schacter, 2006; Loftus & Pickrell, 1995; Pezdek, 2003; Porter et al., 1999; Porter et al., under review). Although this seems inconsistent, past research has primarily focused on positive stimuli in general and this finding may suggest that there is an alternative processing of these objects (i.e., pleasures, specifically) that resulted in an increase in positive mood. Past research has found that positive affect is associated with increased susceptibility to misinformation, theorized to be a consequence of a more holistic and heuristic evaluation process (e.g., Forgas, Laham, & Vargas, 2005). In the present context, viewing a stack of money could potentially be generating an increase in participants’ mood that may be related to the increase in misinformation incorporation, such as a $1000 bill being present that was not actually there.

This thesis was the first to examine both the effect of emotional valence and developmental origin on memory accuracy and susceptibility to misinformation. Future research should further tease apart the relationship evidenced here between susceptibility to misinformation and pleasures, specifically, by examining the effect of positive and negative mood induction. Further, future research should attempt to introduce different types of stimuli representing each image category. For example, an obvious phylogenetically-based pleasure would be some form of sexual stimuli; however, this type of stimuli was purposefully not included in the present thesis to avoid introducing a social component that may have differentially influenced memory. Additionally, a limitation of the current thesis was the recognition task. High accuracy rates for the recognition tasks were evidenced in both studies, indicating a potential ceiling effect and suggesting that the recognition task could have been
made more difficult to ensure an accurate measure of participants’ recognition abilities was achieved. Images were selected for the recognition task based on similar “themes” (i.e., images of yachts similar in nature were selected to be foils for the actual yacht image); however, more advanced image editing techniques could have been used to generate foils that were more similar to the actual image in order to gain a better understanding of recognition memory.

In summary, threatening objects – a specific, survival relevant example of negatively-valenced objects – were found to be associated with enhanced memory for details across two studies. In contrast to my initial prediction, memory for details of ontogenetically-based threats was most accurate, indicating experience/learning may be prioritized in human memory rather than phylogenetic origin. Incorporation of misinformation, however, occurred more frequently in pleasures than in threats, a finding that needs to be explored further. These findings are novel in that they simultaneously examine the effect of developmental origin and emotional valence on memory accuracy and susceptibility to misinformation. These findings begin to help unravel the complex influence of emotion on memory accuracy, supporting the evolutionary perspective of memory as an adaptive mechanism for the avoidance of future threats but that seems to prioritize threats present in modern society.
References


Appendices

Appendix A: Examples of Target Objects

Phylogenetically-based Threat:

Ontogenetically-based Threat:

Phylogenetically-based Pleasure:
Ontogenetically-based Pleasure:

Neutral Object:
Appendix B: Examples of Non-Leading and Misleading Vignette

Experiment 1 Phylogenetically-based Threat Vignette: The eastern diamondback rattlesnake is the largest venomous snake in North America. Some reach 8 feet in length and weigh up to 10 pounds. The sample specimen here has *no fangs* [no italics in the study] that are visible. These stout-bodied pit vipers generally live in the dry, pine flatwoods, sandy woodlands. When cornered, rattlers feverishly shake their iconic tails as a last warning to back off.

Experiment 2 Phylogenetically-based Threat Vignette:

The eastern diamondback rattlesnake is the largest venomous snake in North America. Some reach 8 feet in length and weigh up to 10 pounds. The sample specimen here has *two small curved fangs* [no italics in the study] that are visible. These stout-bodied pit vipers generally live in the dry, pine flatwoods, sandy woodlands. When cornered, rattlers feverishly shake their iconic tails as a last warning to back off.
Appendix C: Examples of Phylogenetically-based Threat Question Set for Experiment 1 and Experiment 2

1. What colour is around the snake’s mouth?
2. What general colours are evident on the snake’s skin?
3. How many fangs are visible?
4. List the major sections of the snake that are visible (e.g., head, body, tail).