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Learning Requires Attention for Binding Affective Reinforcement to Information Content

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LEARNING REQUIRES ATTENTION FOR BINDING AFFECTIVE REINFORCEMENT TO INFORMATION CONTENT

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Abstract

Humans are limited in their capacity to process information about the environment; to choose the most salient details to process, we have to make rapid value appraisals and prioritize our attentional resources. In this proposed study, it is expected that attention is required to learn from affective information. Learning is measured by the difference between update (the difference between the first and second estimation) and the estimation error (the difference between the average likelihood and the first estimation). Using a belief-updating paradigm, participants will be asked to estimate their likelihood of encountering a negative event, once before and once after they receive the average likelihood information. By comparing the difference in estimations after being exposed to desirable or undesirable information and a positive or negative reinforcer across three levels of attentional load, the effects of attention on learning from affective reinforcement can be examined. It is proposed that attention mediates learning from affective information. This is demonstrated by the failure to learn differentially from affective information under high attentional load, while in a no load condition participants will learn differentially according to the type of news and affective reinforcer that they receive. The expected result would indicate that attention is a necessity for optimal learning outcomes, especially when learning from affective information. This has implications in the effectiveness of communicating affective information, such as in the health care field.

Keywords: Optimism Bias, Attention Modulation, Affective Reinforcement, Learning

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"Look on the bright side," - a common consoling advice given to someone who is in the midst of a difficult situation. The nature of this advice implies that life ought to be full of positive events, which is a puzzling attitude given the reality of the world. It is theorized that this optimistic tendency is caused by a selective bias to learn better from desirable information compared to undesirable information. Due to a limited capacity in our ability to process information, attention is necessary to select the most pertinent details; furthermore, the valuation of information also contributes to the selection process. Currently, it is unknown whether attention is needed to process affective information. This study proposes that straining visual attention will result in a failure to process both information and the affective tag, leading to a failure to learn from affective information. As such, when there is no attentional load, participants will learn differentially according to the type of information (desirable or undesirable) and affective reinforcer (positive or negative) that they receive. In a high attentional load condition, which is categorized by the strain of peripheral vision, participants will fail to learn from the affective information. Differential learning under no attentional load is expected because the optimistic learning bias posits that people learn better from desirable than undesirable information, and past studies have shown that people learn better under positive reinforcement compared to negative reinforcement. As value assignment of information primarily operates through visual attention, straining visual attention will result in the inability to assign an affective value to information. By using a belief-updating paradigm where participants are asked to estimate their likelihood of experiencing a negative event once before and after receiving the average likelihood information of the event, a comparison between estimations

after being exposed to desirable or undesirable information and a positive or negative reinforcer across three levels of attentional load can be made.

Unrealistic optimism refers to the tendency of believing that the future is much brighter for us than for others, but as this is statistically impossible and without warranted evidence to prove that the future is positive, such optimism is often termed as unrealistic. Unrealistic optimism appears to extend into many situations involving risk perception and behavior; college students underestimate their chances of contracting sexually transmitted diseases (Brown, 1999), smokers underestimate their health risk (Weinstein, Marcus & Moser, 2007) and we generally overestimate our abilities, life expectancy (Puri & Robinson, 2007) as well as success in the job market (Lovallo & Kahneman, 2003). Research on unrealistic optimism is often applied to fields concerning risk perception and behavior, as optimistically believing that one is invulnerable to risk would cause a lack of preventative action. This is especially emphasized in health psychology (Weinstein, 1999) where researchers are worried about individuals underestimating their chances of contracting a disease that could have been avoided by some preventative measure. If we can understand the underlying mechanism through which optimism operates and its influence on judgment in risky situations, then it would be possible to avoid unnecessarily risky actions by communicating information effectively.

Tali Sharot and her colleagues have suggested that general optimism is facilitated by an unconscious selective learning bias known as the optimism bias. This bias is the tendency to learn from and use more desirable information in our judgment than undesirable information (Sharot, 2011) and will be referred to in this paper as the optimistic learning bias. Unlike the simple prediction and comparison method commonly used in studies on unrealistic optimism, studies on the optimistic learning bias focus on the robustness of learning from desirable or

undesirable information and influencing factors that contribute to this bias. Past research suggest that affective reinforcers, which are stimuli that have some rewarding or negative valuation, can influence the optimistic learning bias by either stimulating or inhibiting the amount by which one updates their beliefs. However, there appears to be a discrepancy in the amount of attention needed to process the affective reinforcers as a consequence of additional visual stimuli based on a past study (Foo, 2014). In this proposed study, the effects of attentional load on affective reinforcement in learning and its implications will be examined.

Humans are persistently optimistic about their future. For example, newlyweds underestimate their likelihood of undergoing a divorce, despite evidence indicating that divorce rates are increasing in the Western world (Amato, 2010). Being an expert on the subject matter does not exempt us from this phenomenon; divorce lawyers hugely underestimate their own chances of getting a divorce (Baker & Emery, 1993). Despite the distorted perception of our future, more importantly, being optimistic motivates people to continue living and trying harder to achieve their goals through a positive belief in the future, making it adaptive and beneficial. For example, being optimistic about one's professional trajectory can result in an optimist working harder and earning more (Puri & Robinson, 2007), while having a positive outlook on life is important for self-efficacy (Taylor & Brown, 1988). Optimism and its adaptive nature is therefore important for ensuring that individuals are resilient against negative events, as well as encouraging exploration of future opportunities even if one experiences setbacks. Suffice to say that without optimism, progress will stagnate because there will be no motivation to continue working towards a goal.

While there is no set definition of what optimism is, a key element that is generally agreed upon is the inclination for people think that they are more likely to encounter positive

events as well as less likely to encounter negative events compared to the average person (Weinstein, 1980). At the heart of the debate whether optimism is unrealistic or not are the two differing perspectives of probability: the Frequentist and the Bayesian. The objective Frequentist perspective, which is rooted in the physical properties of events occurring, assumes that probability is simply the frequency of some phenomenon. As such, Frequentists believe that it is irrational to pre-assign a probability to an event because all events occur at a stable and persistent rate in the long run. In most unrealistic optimism studies where individuals are asked to predict the likelihood of future events happening to them in comparison to the average person, a Frequentist approach is used.

Smaller samples tend to enhance differences between outcomes because minorities are underrepresented, thus skewing the distribution. Noting the statistical discrepancies in unrealistic optimism studies due to smaller samples, Hahn (2014) argues for the use of Bayesian probability in considering what constitutes as rationality. Rationality is the quality of being reasonable based on valid facts, which implies that one's behavior is aligned with their reasons. Bayesian probability represents a state of knowledge or belief, which is when people assign a probability to an event occurring based on their knowledge. If an individual only has their past experience to base their expectations on for future events, then this thought process is entirely rational according to Bayesian theory because it is a logical extension of knowledge. These "priors", or one's optimistic experiences, can cause a multitude of problems, especially since most studies use Westerners as their default sample. Westerners, when comparing themselves to the rest of the world, perceive that they are generally much better off in the quality of life and the events that they experience (Chang, Asakawa & Sanna, 2001). While it may be a cultural difference in that Eastern cultures do not see positive events as desirable as in Western cultures (Miyamoto &

Xiaoming, 2011), this could account for the Western self-perception as being more likely to encounter positive events compared to the rest of the world, and in turn be the reason for the general trend of rating oneself better than the general populations.

Optimism

Early research suggested that optimistic tendencies were evidence of defensiveness or wishful thinking meant to produce positive feelings (Weinstein, 1980), which is due to individuals being motivated to feel satisfied with their lives. One would be defensive if their sense of self was being attacked, and as optimistic beliefs are fairly impervious to change, individuals protect their self-image through optimism. Lacking complete information, individuals tend to be unrealistically optimistic when they assess risk. This lack of information carries over when judging the base rate of the population and thus distorting one's perception of reality. The tendency to be optimistic also has implications in the Economic theory of rationality; if one is overtly optimistic and tends to discount negative information, it could be said that they are not acting in a rational manner. Economic theory assumes that individuals are rational and take into consideration the probability of each event in decision making. This is according to Bayes' Rule, which concerns the law of conditional probability based on some knowledge of the event. Bayes' Rule also implies that while individuals incorporate desirable information into their existing beliefs, there is also an aversion to incorporate adverse information (Eil & Rao, 2011) as well as discount the impact of the negative information (Koszegi 2006), which is consistent with the process of the optimistic learning bias. However, Ulrike Hahn (2014) has suggested that because human experience is fairly limited and subject to errors because of bounds on attentional and short-term memory capacities, acting on a lack of information should

not be taken as a mistaken belief nor as a sign of irrationality. Rather, it is rational that an individual makes inferences about the world based on their own experience, which is consistent with a Bayesian perspective on probability. For example, if a Westerner compares themselves to the rest of the world, they will naturally conclude they are much better off because they do not face as many adverse events such as war and famine. Especially with reinforcement from the media from excessive coverage of negative events in the rest of the world, a Westerner may feel overall more optimistic about their own future compared to others in the world. This optimistic tendency can carry into optimism studies that primarily use Western individuals in their sample.

Research on general optimism can be traced back to studies on the Pollyanna Principle by Matlin and Stang, as well as Weinstein's experiments on unrealistic optimism. The Pollyanna Principle, termed by Matlin and Stang (1978), is the tendency for individuals to give precedence to pleasant events over unpleasant ones. This phenomenon has been observed in various situations, such as recalling pleasant items earlier, recognizing pleasant stimuli faster and producing more pleasant words in a free association task. A study by Matlin and Gawron (1979) found that Pollyannaism measures moderately correlated with optimism and happiness, but less optimistic people had higher expectations for their happiness to improve compared to optimistic people. Dember and Penwell (1980) noted that, like with any phenomenon, some individuals deviated from the norm, such as listing negative items before positive ones. They suggested that those who deviated from the Pollyanna Principle were of a minority group that held pessimistic outlooks on life, but the lack of an accurate method of measuring optimism and the simplicity of some of the Pollyanna tasks prevented them from making further inferences.

Weinstein (1980), in his studies on what he termed errors of judgments as unrealistic optimism, noted that people tend to be self-centered and think of themselves as invulnerable

compared to their peers. Weinstein outlined several hypotheses, among them motivational reasons, lack of information, past experiences and controllability for individuals to be unrealistically optimistic about the future, which represents the pattern of reasoning throughout time for this phenomenon. The earliest suggestion for unrealistic optimism was that individuals partake in wishful thinking about their future as a defensive mechanism to protect their sense of self, and as a consequence they distort reality. Later studies (Miller & Ross 1975: Ross, Greene & House 1975) indicated that this was partly due to lack of information about other people, as individuals have more information about themselves readily available compared to others. Weinstein gathered college students and had them predict their expectations for several future events. In order to avoid drawing conclusions from simple comparisons between optimistic and pessimistic responses, Weinstein ensured that his participants made comparative judgments between their own predictions and their predictions of the population average. He found that there was a systematic bias in both positive and negative events, but the latter correlated strongly with optimism, perceived controllability and stereotype salience. Stereotype salience indicated that individuals typically compare themselves to the stereotypical victim of the negative event and judged if they had the power to take some preventative action. If they do not fall into the stereotypical victim category and they believed that they had some power to prevent the event from occurring, individuals would naturally conclude that there are less susceptible to the negative than the average person.

Harris and Hahn (2010) however suggest that optimism in previous studies may simply be a statistical artifact rather than a human bias, and that statistical confounds implies that there is currently less known about unrealistic optimism as a phenomenon than it is assumed. Harris and Hahn were concerned by the relatively rare events in what they termed the “direct” method

of prediction used by Weinstein; these relatively rare events were open to statistical problems such as scale attenuation, minority undersampling and base rate regressions. Scale attenuation refers to the lack of range on a scale and as a result causes scores to be clustered towards either the top or the bottom of the scale. This could be a potential problem because scores would be distorted and inaccurate. Similarly, minority undersampling causes an inaccurate inference of an optimistic tendency, as the proportion of people who experience mostly adverse events are likely to be the ones who are underrepresented in the samples used in any of the studies on unrealistic optimism. This would naturally result in a skewed pattern that individuals are more optimistic than not, because there is more data on optimistic individuals. On the other hand, base rate regression is the statistical tendency for any extreme score to return to the average; this would cause measurements to appear to have changed significantly when no such thing occurred. Harris and Hahn suggest that present techniques should be improved in order to avoid the above three problems so that compelling evidence for the existence of optimism can be provided.

Several of the studies illustrated above demonstrate that humans appear to be optimistic, or at least show a preference for a positive future. Whether this optimistic tendency is unrealistic or not would depend on the use of knowledge and experience in making predictions; the Bayesian perspective on probability would argue that it is entirely rational to do so. Nevertheless, Harris and Hahn caution that there are several issues with the methodology through which optimism is measured, namely scale attenuation, minority undersampling and base rate regressions. In the proposed study, these issues will be avoided through a carefully designed paradigm that will be used.

Causes of Optimism. Taking into account the research on general optimism and rationality, there are several theories for causes of optimism, including cognitive, motivational

and emotional factors, with the most common being cited as a self-serving motivational bias that protects our self-esteem. Unrealistic optimism appears to encompass a variety of well-known biases that protects our self-esteem; these biases included the planning fallacy, the illusion of control, "better than average" effect as well as overconfidence in judgment. Motivational factors were first assumed to be the biggest mediator in optimism, but since the emergence of research on cognitive biases there has been a shift towards cognitive factors being a robust source of bias in judgment.

Early research postulates that some form of motivation is the underlying biasing agent for individuals being unrealistically optimistic. Motivation for being optimistic takes several forms, the most commonly cited being self-enhancement and adapting to fear. As optimistic expectations are fairly impervious to change, they are ideal beliefs as individuals are highly motivated to protect their self-esteem (Klein & Weinstein, 1997). To even consider any alternative would be detrimental to one's self-concept (Alicke, 1985) and thus undesirable. Motivation to see one in the best possible light is logical as an adaptive measure to ensure mediation of fear and anxiety in undesirable events (Klein & Weinstein, 1997; Taylor & Armor, 1996). As emotional regulation differs across age, young individuals under the age of 22 are generally riskier as a result of discounting the importance of undesirable information and being optimistic about their vulnerability status (Chowdhury, Sharot, Wolfe, Duzel & Dolan, 2012). The actions of these young individuals are also highly influenced by emotions because of competing emotional and societal factors as well as a lack of maturity in the brain regions that regulates emotions and cognitive control. As such, motivations and emotions appear to have some role in general optimism and the amount of risk individuals are willing to take based on appraisal of the situation.

Cognitively, individuals tend to be egocentric, or are self-centered, when comparing themselves to others in terms of risk (Chambers & Windschitl, 2004). In order to explain the comparative optimism effect where individuals believe that they are less susceptible to negative events than their peers, Chambers and Windschitl created a framework that suggested non-motivational mechanisms in the judgment process as well as information processing limitations. Weinstein (1983) tested whether reducing egocentrism in a study on comparative risk judgment could subsequently reduce the tendency to be optimistic about the future. By reducing the egocentrism through providing information on the base rates of risk, Weinstein was able to reduce the optimism of the participants. Conversely, the participants who did not receive the information on their peers were more unrealistic in their predictions. One major limitation of Weinstein's study is his sample being solely comprised of college students. Adolescents are generally more limited in their future predictions as they tend to focus more on the present (McCandless, 1970; Robbins & Bryan, 2004), thus giving unrealistic predictions of the future. These tendencies of judging oneself in better light than others are well known in the field of cognitive bias.

Cognitive Biases. The tendency to be optimistic is a form of cognitive bias, which is defined as pattern of deviation in judgment (Tversky & Kahnerman, 1974). Tversky and Kahnerman conceptualize cognitive biases as mental shortcuts that individuals utilize to preserve cognitive economy. These inclinations help individuals to make decisions quickly and efficiently, which is beneficial in situations that demand prompt action. Derived from one's perception and inferences of the world, cognitive biases can lead to irrational conclusions due to their subjective nature. This failure to be objective may cause errors that result in irrational conclusions with unaccounted consequences (Haselton, Nettle & Andrews, 2005). There are several cognitive

biases that contribute to general optimism, such as the representative bias and the availability heuristic. As suggested by Weinstein (1980), individuals may use the representativeness heuristic to judge the probability of one experiencing an event through comparison to individuals who have experienced the event. The individual uses this heuristic to examine the degree to which they themselves are similar to salient features of the members who have experienced the event, but in the process ignore the base rate. For example, if one doesn't see themselves fitting into the stereotypical image of an alcoholic, the individual will likely conclude that they themselves won't become an alcoholic. On the other hand, when individuals utilize the availability heuristic, they tend to rely and weigh more heavily on recent information as this heuristic relies on easily and quickly recalled information.

General optimism is thus the result of a variety of factors but specifically the underlying mechanism of the optimistic learning bias comes from cognitive bias theory. A significant portion of research into cognitive biases has proven that individuals display a learning pattern when presented with either desirable or undesirable information (Armor & Taylor 2002; Taylor & Brown 1988). This ubiquitous behavior can be attributed to the optimistic learning bias, which occurs when individuals selectively integrate more positive information into their judgment and disregards the impact of negative information. However, in order to select what information to process and learn from, we are first required to attend to that piece of information.

Attention

At its simplest, a consequence of not paying attention in the natural world can result in being killed by a predator. In today's increasingly distracting world, we are required to pay attention or else risk a delayed response, missing out on critical information and risk many other

undesirable outcomes. Attention can be referred to as the process of concentrating on a certain aspect of information in the environment or the allocation of limited processing resources (Anderson, 2005). Several studies have indicated that directing attention to a location or to distinguishing features of a target can evoke the appropriate neural response (Carrasco, 2011). Specifically, visual attention appears to operate through the sharpening of features of a target in the visual field (Posner, 1980; Eriksen & James, 1986); this target is then given priority to be processed. We are however, limited in our ability to attend to details owing to the limited energy available in the brain and the high-energy cost required for neuronal activity in visual processing (Lennie, 2003).

Attentional Load. As humans have a limited ability to process information, attention acts as a buffer in which important or salient stimuli is given priority. The demand for our attention when undertaking selective information processing is known as attentional load. Proposing that attention is primarily determined by motivation, Lang, Bradley and Cuthbert (1997) defined attention as "information processing that involves procedures of selection and evaluation of motivationally relevant input."

Attentional load is part of an area of study known as cognitive load, which itself is largely studied in the field of memory. Miller (1956) first described the limitations of our memory capacity, and based on such limitations, Baddeley and Hitch (1974) developed a model on working memory. Baddeley and Hitch proposed that there is a control system known as working memory whereby information can be manipulated. Cognitive load refers to the amount of mental effort being utilized in one's working memory, as working memory is limited in both its processing and storage capacity. Studies focusing on cognitive load can be traced back to theories by Sweller (1988) concerning schema usage in problem solving; schemas are mental

structures of preconceived ideas and aids efficiency in decision making by organization of information into categories. Sweller theorized that the use of problem solving as a learning tool is ineffective and instead interferes with learning because it conflicts with the cognitive process of schema acquisition. Noting that selective attention and limited cognitive processing resources were the two related mechanisms in learning, Sweller concluded that failure to acquire the schema during problem solving could plausibly be due to the heavy use of limited cognitive process and diverted attention.

Attention and Affect. In a previous experiment (Foo, 2014), an affective reinforcer, or stimuli that have some rewarding or negative valuation, was hypothesized to trigger the optimistic learning bias. It was suggested that naturally, positive information would trigger a reward reinforcer signal that stimulates learning, while negative information triggers a "punishment" signal that would inhibit learning. To manipulate the proposed mechanism, a positive, negative and neutral symbol was created. The positive symbol was a green sterling pound sign, the negative symbol a red sterling pound sign and the neutral symbol denoted a normal learning condition that differed according to the study. Two studies were carried out: where Study 1 did not have a distinct neutral signal, Study 2 had a grey N to indicate the neutral signal. In Study 1, although reinforcer type did not cause significant differences in the desirable news condition, there was a trend towards significance for the undesirable news condition when combined with the negative signal. However, adding the third neutral symbol caused the results to become insignificant in Study 2. A plausible explanation for the disappearance of significance could be that learning from negative news requires more attentional resources and the added neutral symbol decreased the capacity to attend to the reinforcer. The added condition could have resulted in some interference with one's attentional and working memory capacity, thus

rendering the employment of such additional attention impossible, resulting in a failure in participants to adjust their beliefs about the future in response to undesirable news. Cognitive load theory posits that there are two mechanisms influencing attention, which are cognitive and perceptual. Generally, the manipulation of cognitive load results in reducing optimal performance due to the lack of resources available to fully attend to the necessary information. This may be a possible reason for the significance of the positive reinforcer in the bad news condition in the following study but the disappearance of the significance when an additional visual stimulus was implemented.

It is plausible that the addition of the extra visual stimuli caused depleted attentional resources needed to process the affective reinforcer; in order to test this, a manipulation of one's visuospatial attention is necessary. Perceptual load theory posits that in low perceptual load conditions, the irrelevant distractors were perceived, whereas in high perceptual load conditions the distractors were excluded from perception (Lavie et al. 2004). High perceptual load conditions were proposed to exhaust the perceptual capacity, as combined with the processing task relevant stimuli leaves no spare capacity to process the distractor processing. These studies suggest that in order to manipulate attention in a controlled manner, the visual task used must not be too straining on one's perceptual capacity that it causes the participants to completely ignore the distractor.

Attentional Load Task. Rapid serial visual presentation (RSVP) involves the continuous replacement of items within the same spatial location at high rates and the detection of a target within the serial presentation. As the RSVP paradigm is used to examine the temporal aspect of attention due to the control of the speed at the items are being replaced, a rapid sustained visual presentation will instead be used to affect perceptual capacity. Most studies involving peripheral

vision and attention involve a visual search for the target; their results can help formulate the design of the attentional load task to ensure that attentional capacity is truly being strained. Muller and Findlay (1988) examined the effects of visual attention in relation to single and multiple displays and found that there were different mechanisms for spatial orienting, which contributes to different interruptability in uncued stimuli. In order to avoid these differences, participants will have practice trials where the location of the low and high attentional load will be shown, thus equalizing the effect of each visual stimuli under a single display. Nuechterlein, Parasuraman and Jiang (1983) note that sensitivity to visual targets degrades over time due to high stimulus processing rates and a lack of attentional resources. As such, adequate time must be given not only for the participants to process the information but to ensure that they have enough attentional resources throughout the session to process all of the information.

Learning

Learning requires attention in order to effectively process relevant information and store it in our long-term memory (Ericsson & Kinstchm, 1995; Craik & Lockhart, 1972), and various studies has demonstrated that desired learning outcomes can be strengthened through reinforcement (Ferster & Skinner, 1957). While the role of attention in learning and the role of reinforcement in learning are well established, the role of attention in processing affective stimuli remains relatively unclear.

Learning and Affect. Recent studies in the area of decision neuroscience have generally agreed that the brain chooses between its options by first designating a value to all choices under consideration and then comparing them (Wallis, 2007; Rangel et al., 2008). Lim, O'Doherty and Rangel (2011) have proposed that this value assignment and comparison process is guided by

visual attention, based on previous studies demonstrating that exogenous changes in fixation patterns affected choices (Armel & Rangel, 2008; Gold & Shadlen, 2002). If then the brain utilizes visual attention to compute and compare values of choices, it is clear that attention plays some role in the processing of affective stimuli, and in turn can have an influence on learning from information that has been assigned an affective value.

Learning requires information to be processed into long-term memory. Previous studies have demonstrated that attention is vital for this process to occur, but the ability to attend is limited due to the high cost of energy required for visual processing. As a result, humans must be selective in the details that they choose to attend to and it is theorized that this selectivity occurs through a value assignment of choices under consideration that primarily operates through visual attention. The use of rapid sustained visual presentation is proposed so as to allow the processing of information content and the affective reinforcer without over straining the participant's attentional capacity. To summarize, this study will explore the necessity of attention in processing affective information, where a high attentional load is operationalized by the extensive use of one's peripheral vision. High attentional load exerts more attentional resources away from the affective reinforcer and the information content, leading to a failure to process both types of content into long-term memory.

The Underlying Mechanism of Optimism: Optimistic Learning Bias

Reality is fraught with undesirable information, yet individuals maintain an optimistic outlook on their future. It is believed that individuals maintain such optimism through a learning bias called the optimistic learning bias. Specifically, the optimistic learning bias can be defined as the tendency for individuals to expect that they are less susceptible to negative events

compared to the average likelihood (Sharot, Riccardi, Raio & Phelps, 2007). A phenomenon that is observed throughout all genders, race, nationality and age, the bias is theorized to be due to individuals selectively integrating more desirable information in their judgments compared to negative information. Due to this tendency of selectiveness in information type integration, the optimism bias can be thought of as a learning bias that is inclined to incorporate positive information more so than negative information. It differs from general optimism in regards to the optimistic learning bias being more of an underlying mechanism of processing information that facilitates general optimism. The optimistic learning bias has been observed across gender, race, culture (Chang, 2000), species (Harding, Paul & Mendl, 2004; Mahetson, 2008) and age (Isaacowitz, 2005), which imply that it is an integral part of human nature (Sharot, 2011). While the optimistic learning bias may be beneficial in choice exploration, individuals are also more unlikely to take precautionary actions against negative events. A paradigm formulated by Sharot, Korn and Dolan (2011) is the main method used to measure the optimism learning bias.

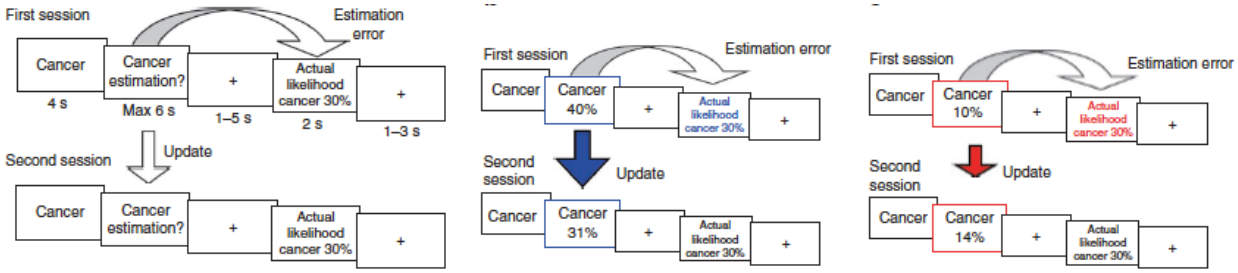

Figure 1: The belief updating paradigm created by Sharot, Korn and Dolan (2011). In the first session, feedback on the average likelihood is given after the first estimation is made. Depending upon desirable or undesirable news that is given, participants updated differentially.

Paradigm. The belief-updating paradigm that is used to measure and test the optimism bias was developed by Sharot et al. (2011) (see Figure 1 for paradigm design). By challenging

the belief update system when individuals are faced with new information, Sharot et al. are able to provide an explanatory framework of how optimism is maintained. The paradigm involves two sessions; the first where participants were asked to estimate the likelihood of experiencing a negative event, followed by the presentation of the average likelihood of the event occurring to a person with a similar socioeconomic status. In the second session that follows immediately after, the participant again estimates their likelihood of experiencing the negative event. By comparing the difference between the first estimation and the second estimation, the learning bias of information update can be assessed. If the first estimation was higher than the average probability, the average probability information will be taken to be as "good news" and thus participants are expected to lower their estimation towards the average probability information as a sign of the optimistic learning bias. In the case where the participant's first estimation was lower than the average probability, this would be taken as "bad news" and theoretically they should raise their second estimation closer to the given probability. However, the optimistic learning bias in non-depressed individuals leads to a failure to do so, and the difference between estimations after desirable news and estimations after undesirable news is significant among all studies that have used this paradigm (Sharot et al. 2011; Moutsiana, Garret, Clarke, Lotto, Blakemore & Sharot, 2013; Garrett & Sharot, 2014). Estimation errors, which are operationalized as the difference between the first estimate and the average likelihood, also gives insight into the differential processing of desirable and undesirable information. The paradigm has been adapted in several studies by Sharot and her colleagues to determine the robustness of the optimism bias and the situations that it operates in. Harris and Hahn's (2011) major concern that only rare events were used in Weinstein's studies are avoided as a mix of common and rare

events are used in Sharot's paradigm (e.g. card fraud, miss a flight, household accident, back pain, etc.).

Sharot's paradigm also takes into consideration alternative explanations for the differences in estimations between the sessions. Memory, emotional arousal, familiarity and past experiences were tested as alternative explanations for the optimistic learning bias, and studies that use the paradigm to assess the optimistic learning bias show that these variables do not explain differential updating between desirable and undesirable information (Sharot et al. 2011; Chowdhury, Sharot, Wolfe, Duzel & Dolan, 2013). Differential memory for both types of information was insignificant, as tested by the difference between the average likelihood and the remembered average likelihood (Garret et al. 2014). Emotional arousal, familiarity and past experiences of listed events did not differ between healthy individuals and depressed individuals. A major limitation in several of the studies discussed below is that they all use this paradigm, resulting in a lack of convergent validity due to there being no other measure of the optimistic learning bias.

Properties of the Optimistic Learning Bias. Although the underlying mechanism of this tendency to learn from more desirable information is unknown, there are several aspects of this learning bias that have been examined. One of the hallmarks of the optimistic learning bias is that it appears to operate quickly and efficiently (Kappes & Sharot, 2014). Kappes and Sharot used a similar paradigm that manipulated the duration of the average likelihood shown and utilized cognitive load. The average likelihood was either shown for 4 seconds or 500 ms, while for the cognitive loading condition, participants were asked to either remember a password or not while viewing the average likelihood information. Both conditions showed that this optimistic learning bias occurs efficiently.

In a study of comparison between predictions about oneself and the population, Garret and Sharot (2014) found that past experience, or the participant's first estimation and number of trials, could account for biased updating in base rates of the population. Base rates are estimations of the population's average likelihood. Garret and Sharot also found that the valence dependent updating of self risk reported previously is not contingent on the method by which trials are labeled as "desirable" or "undesirable", as this experiment revises the labeling method by asking participants to define desirable and undesirable trials as well as dividing the trials into two different ways (estimates of self risk and estimates of base rates). This clarifies the ambiguity of the information, such as when a participant is given a base rate that is worse than their self-risk estimate but better than their base rate estimate. This indicates that the optimistic learning bias exist across different definitions of positive and negative information.

Individual Differences in the Optimistic Learning Bias. The degree of one's optimism bias would naturally differ across individuals. Although there is not a significant gender difference (Sharot et al. 2011), there are significant age differences in both updating of beliefs and risk behavior. Furthermore, there is one subset of the population does not exhibit the optimism learning bias; depressed individuals appear to have the ability to mediate both positive and negative information equally. These studies enable us to judge the degree to which the optimistic learning bias exists in certain groups, and provides information on specific demographics to exclude when examining the optimistic learning bias on a deeper level.

Age Differences. One would expect the elderly to have encountered more negative events compared to adolescents, as is the nature of a long life. Older individuals would face a declining quality of life due to negative events such as their declining physical and cognitive functioning, reduced social interaction and the expectation of their demise (Rowe & Kahn, 1987). However,

research suggests that older adults are less pessimistic than their counterparts (Carstensen et al. 2011) and experience less negative arousal for adverse events such as anticipation of financial loss (Samanez-Larkin et al. 2007). A recent study by Chowdhury, Sharot, Wolfe, Duzel & Dolan (2014) examined the relationship between the anterior cingulate cortex, an area of the brain known to be implicated in depression (Cotter, Mackay, Landau, Kerwin & Everall, 2001), and the difference in updating of beliefs among ages. Older adults were found to have greater belief updating compared to younger adults because of a significantly lower update for the undesirable condition, as well as a greater initial estimation error. While older adults made more memory errors, the errors were similar for both desirable and undesirable information, indicating that valence of information was not responsible for any differential memory errors. Additionally, older adults rated all events as more emotionally arousing and positive events more familiar than younger adults, suggesting that that the greater update bias in older adults was not due to lack of engagement or lack of relevance of the task.

Children and adolescents are known to be riskier than adults due to their still developing frontal lobes that are unable to completely assess risk (Steinberg, 2005). Risky behavior and the limited effect of campaigns against such behaviors could be explained by the optimism bias, as they are less likely to take precautionary actions. In a study by Moutsiana, Garret, Clarke, Lotto, Blakemore and Sharot (2013), it was found that younger age was associated with significantly inaccurate updating of their perception of vulnerability to undesirable information. Older individuals typically have higher levels of emotional well being compared to youths, as well as a decline in their experiences of negative information (Stone et al. 2010). Moutsiana et al. (2013) compared the results between younger adults and older adults and found that while all individuals updated better from desirable information more than negative information, there was

also a marked difference in updating due to age; older participants updated their beliefs less than younger participants in the undesirable information condition. As both younger and older individuals updated similarly in response to positive information, this suggests that older adults had a greater update bias due to the lower update in the negative information condition.

Depressed Individuals. In today's world, there is an unprecedented rate of depression (Lambert, 2006), with one in ten adults being diagnosed with depression in the United States (Centers for Disease Control and Prevention [CDC], 2011). Studies on depressed individuals have revealed that they do not have the optimism bias due to a strong ability to mediate both positive and negative information. As part of the post-scanning questionnaire, Beck's Depression Inventory (BDI) was used in the studies to identify the severity of participant's depression. Individuals with a BDI score more than 13 were excluded from the studies, as highly depressed individuals tend to not display any optimistic learning bias (Strunk et al. 2006), making them inappropriate for determining the conditions in which the optimistic learning bias operates.

More recently, Garret et al. (2014) found that depressed individuals had unbiased updating of information due to a close coding of negative estimation errors, contrary to the diminished coding of negative estimation errors by healthy individuals. Depressed individuals updated their beliefs in response to negative information in a similar manner to desirable information, suggesting that depressed individuals are more realistic and do not discount bad news. Emotional arousal, familiarity and past experiences of listed events did not differ between healthy individuals and depressed individuals, but depressed individuals rated undesirable news as less aversive than desirable events in contrast to healthy individuals. Additionally, Garret et al. noted that their study only included moderately depressed individuals and suggested that more severe depression could cause a negatively bias in update.

The optimistic learning bias indicates that people selectively choose to learn from more desirable information compared to undesirable information. While the precise mechanics of how this bias operates is unknown, it is plausible that attention has a role in the processing of affective information, as previous studies have indicated that attention is necessary to encode information into the long-term memory store for learning. In consideration of the appropriate sample to test the hypothesis of attention mediating affective reinforcement in learning, depressed individuals, young adolescents under the age of 18 and older adults above the age of 65 will be excluded. These populations cannot be used to test the degree to which attention mediates affective reinforcement in a normal population as studies have indicated that depressed individuals appear to lack the optimistic learning bias, while the two extreme ends of the age range have skewed updating of beliefs.

Proposed Study

An integral part of decision making involves learning from information and integrating our inferences into our judgment. Information is seldom plainly neutral; our feelings and mood often color them with a positive or negative affect. Furthermore, people are rarely in a distraction free environment; without unlimited attentional capacity, we naturally have to filter out the irrelevant information to not process and focus on the relevant information. Using the optimism learning bias as a window into an information processing operation that permeates daily life, this study will examine the relationship between attention, learning and affect.

From a previous study (Foo, 2014), there appears to be a discrepancy between the two studies conducted in terms of the stimuli that the two participant groups were exposed to. Since the significance of the positive reinforcer in the undesirable news condition disappeared when

there was an additional reinforcer condition, it implies that the three different reinforcers contributed to depleting the attentional resources that were needed to learn from undesirable news condition. This proposed study will examine the use of attention in order to learn from affective reinforcers, instead of simple updating through reinforcement.

Sharot's paradigm assesses update, namely the difference between the participant's first estimation and the second estimation. While the updating of one's belief is important as it measures learning from information indirectly, it does not take into account the initial estimation error made before learning the average likelihood. As such, this study will use the difference between update and the estimation error to examine if individuals adjusted their second estimation in relation to how much estimation error they made in the first place. This measures learning more accurately as it takes into account the initial error made and not just updating one's beliefs as a proxy for learning. Thus, instead of the normal update (2^{nd} estimation - 1^{st} estimation) used in Sharot's paradigm, the update after learning (2^{nd} estimation - average likelihood) will be used to assess the effect of attentional load on the reinforcers. It is proposed that under no attentional load, individuals will update their 2^{nd} estimation by a similar amount to their initial estimation error. Individuals will learn best when they are under not attentional load, in a desirable news condition and receive a positive reinforcer, but will minimally learn or not at all under high attentional load when receiving both desirable and undesirable news regardless of reinforcer valence because there will be an inability to process any information.

Gaining an understanding of how the optimism bias functions and its underlying mechanism is important in our understanding of human behavior and decision making, as they are largely influenced by our own expectations and predictions of the future. In particular, examining the attentional capacity needed to learn from valuations of information is important,

as there are varied implications for information communication and learning. If attention is not required to learn from affective reinforcers, then Model 1 is true and affective "tags," or information valuation, is processed without attention. However, if it is indeed the case that attention is required to process both information and the affective tag, then Model 2 is true (see Figure 2). Regardless of whichever model is accurate, more on the influence of attention on affective reinforcement will be known.

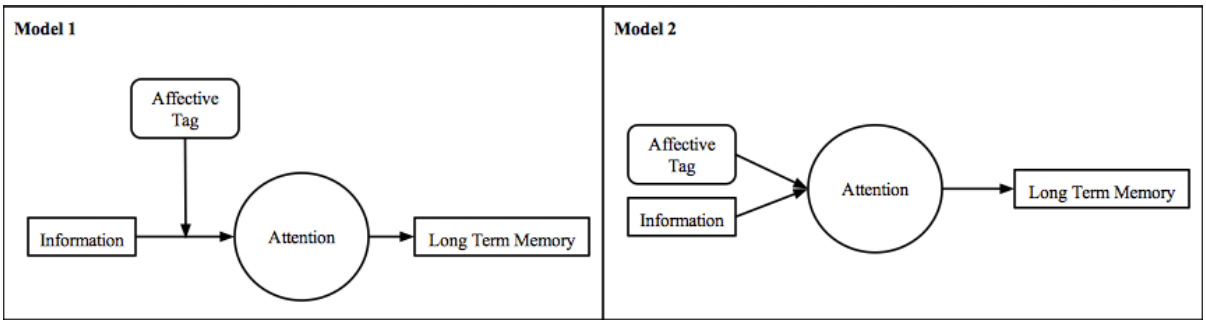

Figure 2: Model 1 assumes that attention is not required to process an affective tag, while it is known that information requires attention to be stored into long-term memory. Model 2 assumes that attention is needed for both information and the affective tag to be processed and stored into long-term memory. It is proposed that attentional load mediates the affective reinforcer when learning from desirable or undesirable information, and that a high attentional load would result in failure to process and learn from the information and the affective tag (Model 2).

Proposed Method

Participants

30 college students (age $M = 19.5$, $SD = 2$, female = 15) will be recruited by flyers posted around campus, Facebook events and classroom advertisement. Participants should be within the range of 18 to 65 years old. Ideally, participants will be prescreened for any diagnosed

depression and be excluded. Participants will be compensated $11 for their participation in the study and will be given class credit if needed.

Materials

General Task Design. The task design was adapted from Sharot, Korn and Dolan (2011). Using MatLab, a program used for testing models, the randomly presented stimuli will consist of 80 short descriptions of negative life events, such as a family member dying or the chances of getting osteoporosis (see Appendix A for list of events). Trials are carefully selected to include a range of common, uncommon and rare negative events. On each trial, participants will be asked to estimate the likelihood of experiencing the negative event. They will be informed that all the averages were in a range of 3% to 77%, which is due to a Matlab program limitation that does not allow for over or underestimation. After participants give their estimation, the average probability of the event occurring will be shown, with a random chance of a reinforcer appearing. For each event, the average likelihood of the event was fabricated. Specifically, it will be programmed so that for half of the trials, participants will receive good news (i.e., the participant's estimate was higher than the average likelihood) and for the other 40 trials the participants will receive bad news (i.e., the participant's estimate was lower than the average likelihood). Each news condition will furthermore be paired with a low, high or no attentional load task. In essence, the screen presented after participants give their first estimation will contain the average likelihood information, an affective reinforcer and an attentional load condition (see Figure 2 for overall task flow and permutations of all conditions). After completing all 80 events, participants were asked once to estimate their chances of experiencing the negative event in another 80 trials. In this session, they will not see the average likelihoods.

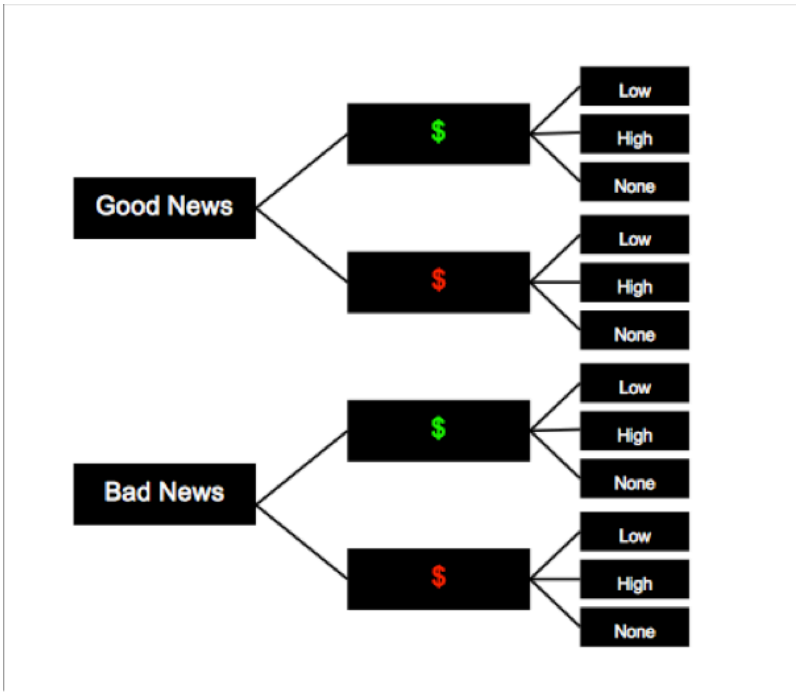

Figure 2: Task Flow. All participants will go through 80 trials in each session. There will be 40 trials where participants receive desirable information, while the other 40 consist of undesirable information.

Affective Reinforcers. Each trial will be paired with either a positive or negative reinforcer that is intended to stimulate or inhibit learning respectively. The positive reinforcer will be a green dollar symbol with a plus sign in its center that is designed to stimulate learning, while the negative reinforcer will be a red dollar symbol with a minus sign in its center that is designed to inhibit learning. This results in two affective conditions with 20 trials each per news condition. As such, each news condition has 20 trials with a positive reinforcer and 20 trials of a negative reinforcer (i.e. 20 trials where good news is paired with the reinforcer, 20 trials where good news is paired with the negative reinforcer, etc.). Participants will be told that these

symbols are distractors that contributed to their chance of earning or losing 20 cents towards the extra $4 that could be gained, so that they are motivated to pay attention.

Attentional Load. In order to test if attentional load has an effect on learning from visually presented affective reinforcers, a visual distractor task that places attentional load onto participants will be used. Through the use of rapid sustained visual presentation, attentional load will be increased in three levels to assess its effects on learning.

Each trial will be paired with a low, high or no attentional load. The design of the attentional load task strains the participant's peripheral vision further as the load increases, thus utilizing more of their attentional resources. Participants will be told that there will be a random amount of trials where they will be asked to report the number of dots that appear on the screen. In the low attentional load condition, a semi circle consisting of small dots will be displayed at the bottom of the affective reinforcer, so the participant only exerts a minimal amount of attentional resources to count the number of dots that appear. In the high attentional load condition, the semi circle of dots will appear above the average likelihood number, marginally further away from the center of the screen (see Figure 3 for feedback screen design). This ensures that participants have to devote more attention to their peripheral vision in order to count the amount of dots. Additionally, to ensure that the task does not impact learning overall, only on randomly selected trials will participants be asked to count the number of dots that appear during the presentation of the average likelihood. Participants will be asked to input the number of dots that appeared in only 8 trials. These trials will appear at random but specifically for each unique interaction between the variables (i.e., once where good news, positive reinforcer and low attentional load interacts, once where good news, positive reinforcer and high attentional load interacts, etc.).

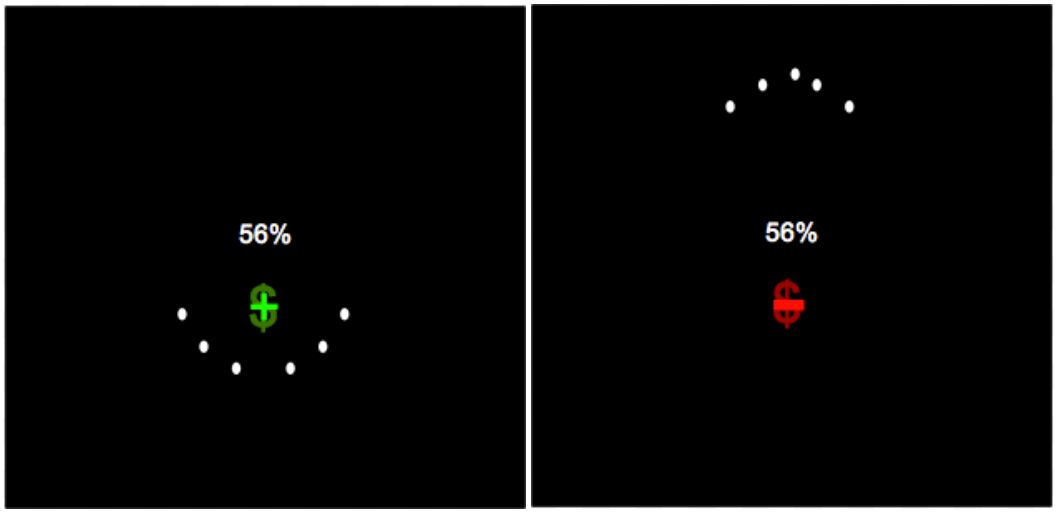

Figure 3: The feedback screen will show the average likelihood, an affective reinforcer and an attentional load condition. In the left screen, the positive reinforcer appears below the average likelihood, and there is a low attentional load as the dots are closer towards the reinforcer. The right side will appear under a negative reinforcer condition and when there is a high attentional load, as demonstrated by the dots being further away from the reinforcer.

Learning. Participants will be asked to estimate their likelihood of encountering a specific negative event twice: once before being shown the average likelihood information and once after. The update in their belief is computed by the difference between their 2nd estimation and their 1st estimation.

$$Update = 2^{nd}\ Estimation - 1^{st}\ Estimation$$

The estimation error is calculated by the difference between the average likelihood given and the participant's first estimation.

$$Estimation\ Error = Average\ Likelihood - 1^{st}\ Estimation$$

Learning is operationalized as the difference between the update and the estimation error.

$$| \textit{Learning} | = \textit{Update} - \textit{Estimation Error}$$

$$| \textit{Learning} | = [2^{nd}\ \textit{Estimation} - 1^{st}\ \textit{Estimation}] - [\textit{Average Likelihood} - 1^{st}\ \textit{Estimation}]$$

$$| \textit{Learning} | = 2^{nd}\ \textit{Estimation} - \textit{Average Likelihood}$$

This operationalization of learning takes into account the initial estimation error made by the participant. If the participant adjusts their 2nd estimation exactly by the amount that their first estimation was wrong by, they have accurately remembered their initial error and have learned the average likelihood information. Failure to learn thus occurs when participants are unable to recall their estimation error and subsequently fail to adjust their estimation in accordance with the average likelihood information.

Optimism and depression. Participants will complete the Life Orientation Test (LOT-R) that measures trait optimism, as well as the Beck Depression Inventory (BDI) to measure the severity of their depression as part of the post-scanning questionnaire. The BDI consists of 21 multiple-choice self-report questions with items including thoughts about suicide, punishment and loss of pleasure. Individuals with a BDI score more than 13 will be excluded from the analysis as a score of below 13 implies mild to no depression, while highly depressed individuals tend to not display any optimism bias (Strunk et al. 2006), making them inappropriate for determining whether attention mediates the affective reinforcers when learning from desirable or undesirable information.

Properties of stimuli. At the end of the second session, participants will given a questionnaire to complete, where they will rate the events on five scales: vividness, familiarity, prior experience, arousal and negativity (see Appendix B for questions). Each scale can be given a score from 1 to 6, where 1 indicates low arousal, no experience, or not negative while 6

denoted high arousal, experienced and extremely negative. When participants are finished, they will also be given a debriefing questionnaire on their thoughts about the study.

Procedure

The researcher will meet the participants at the lobby of the Psychology Department. Participants will be brought up to the experiment location and told that the study concerned decision making under distractions. The researcher will remind participants that they will be paid $7 for their time and they will have the chance of winning up to $4 extra based on luck. If participants need credit, they will also receive it in addition to the $11 that will be ultimately received.

Participants will be assigned to cubicles and asked to sign the informed consent forms. Once they return the forms, participants will be told that they would first have some practice trials to get acclimated to the format of the program, after which they will be questioned on the instructions to ensure comprehension. Participants will be asked about the range of numbers that could be entered, the method of entering a single digit and the meaning of the symbols. Once the researcher is assured that the participants understood the instructions, the study will begin.

First, participants will estimate the likelihood of all 80 negative life events and receive average likelihood information. Regardless of the news condition (i.e., good news or bad news), participants saw a reinforcer (i.e., positive or negative) and a type of attentional load (i.e. low, high or none). Immediately following this first session, participants once again estimated the likelihood of all the 80 trials; this time, they will not receive average likelihood information. Thereafter, they will answer the post-scanning questionnaire consisting of the LOT-R, the BDI, and the ratings of the stimuli. Finally, they will be given the debriefing questionnaire. After

completing the debriefing questionnaire, participants will be debriefed and assured that the average likelihood statistics are fabricated. The participants will also be given resources on positivity and optimism. All participants will then be paid and thanked for their time.

Ethics

The proposed study examines the effect of attentional load on an individual's optimistic learning bias under reinforcement. Although the participants of the study are not from a protected population, only individuals who have not been diagnosed with depression can participate in this study as past research has shown that depressed individuals do not display an optimistic learning tendency. Furthermore, participants with a high BDI score of 13 will be excluded as a score of 13 and above implies some form of depression. The exclusion of depressed individuals is necessary as they are unsuitable for examining the normal parameters of the optimistic learning bias.

There is some level of minimal risk involved in this study, as there may be fatigue arising from staring at the computer screen for an hour and the negative subject matter being distressing. It is unlikely that individuals are subjected to a constant stream of undesirable information and asked to imagine their own probability of encountering such negative events for an hour in daily life. However, if we can identify the specific conditions that the optimistic learning bias operates in, we can optimize learning outcomes and prevent unaccounted for consequences in the future. The use of affective reinforcers can also potentially help stimulate desired outcomes or inhibit undesirable behaviors, which would be beneficial in a vast array of learning situations. Knowing the amount of attentional load that would prevent individuals from benefiting from these

affective reinforcers will also be advantageous as this knowledge ensures that we derive the optimal amount of learning from affective reinforcers.

Participation in the study is voluntary and all information collected is anonymous and confidential. The study will be advertised as offering $7 for participation, with the opportunity of gaining an extra $4 based on random chance. The initial amount of $7 offered is similar to the minimum wage paid to college students for an hour of work; as the study would take at least an hour, this compensation seems fair and would encourage voluntary participation. Furthermore, as the amount is not excessive, it will not have an overjustification effect on the performance of the participants. The chance of gaining up to $4 provides motivation for participants to focus on the task and the affective reinforcers. However, all participants will receive the extra $4 as a surprise monetary compensation would help in removing the negative feelings arising from the study. Finally, the data collected in this study will be anonymous and confidential, as the participants are not asked to give their name during their session and are instead given a reference number in the MatLab program. The collection of consent forms will be kept in a secured location.

Sharot's paradigm involves presenting participants with various negative events and asking them to estimate their probability of experiencing an event. Post scanning questionnaires also ask the participants to rate on a scale their familiarity, vividness, past experience and perceived negativity with the event. Naturally, some individuals are able to imagine in greater detail their likelihood of encountering some of the events due to past experiences or familiarity with the event, which could be disturbing to them. In order to mitigate any negative side effects from the prolonged session of being exposed a constant stream of undesirable information and using the information to make a judgment of their own future, participants will be paid the full sum of $11 regardless of performance on the task. Additionally, participants will be told that the

average probability numbers are fabricated and will be given information on resources about positivity and optimism. Asking participants to go through this process of estimating their likelihood of experiencing a variety of negative events is necessary to examine the optimism bias because it provides an explanation for how individuals can maintain optimism in the face of reality, which has undesirable information that may undermine an individual's beliefs.

The study involves minimal deception, as participants are not told the purpose of the affective reinforcers and are instead told that they are random symbols that tabulate their chances of winning the extra $4. This ensures that their performance is not intentionally biased towards learning better in the positive reinforcer condition or worse in the negative reinforce condition, which is essential in proving that the optimistic learning bias can be manipulated with affective reinforcers and that it operates on an unconscious level. Participants will be debriefed about this deception after the study. Overall, the benefits of learning more about the optimistic learning bias and the effects of attention on affect outweighs the minimal risk of exposure to a series of thoughts on negative events and the resulting slight discomfort that can be reversed.

Expected Results

It is proposed that attention mediates the affective reinforcers that can stimulate or inhibit the optimism learning bias. Learning was operationalized by the difference between the participant's second estimation and the average likelihood, as this follows that if one learned more, then the update (2^{nd} Estimation - 1^{st} Estimation) should be closer to the initial estimation error (Average Likelihood - 1^{st} Estimation). As there are 80 trials in total with 12 conditions, each participant will have an average score taken from 7 trials for each learning condition depending on the news valence (good or bad news), type of affective reinforcer (positive or

negative) and the level of attentional load that will be imposed (none, low or high). One trial from each actual attentional load condition that asked the participant to perform the counting task will be discarded in the final analysis of main and interaction effects, thus each condition will have an average value from 6 trials. The discarded trials, which will be one for each of the eight attentional load conditions (i.e., good news with a positive reinforcer and high attentional load, good news with a positive reinforcer and a low attentional load etc.) will be compared to learning under no attentional load and when not asked to recall the amount of dots on the task.

To ensure that participants in this sample do demonstrate an optimistic bias in learning, a one-sample t test that compares the means of learning under good news and bad news will be carried out. Based on previous studies (Sharot et al., 2011), it is proposed that there is a significant effect of news valence on learning, $F(1,29) = x$, $p = y$, indicating that participants updated their estimates differently based on the type of news they received.

Based on a previous study (Foo, 2014), the affective reinforcers were found to trend towards significance. With an adjustment to the paradigm, a within subject repeated measure that compares the difference between the means of learning under a positive reinforcer and learning under a negative reinforcer will be carried out. It is proposed that there will be a significant effect of affective reinforcer type, $F(1,29) = x$, $p = y$, which indicates that participants learned differently based on the type of affective reinforcer they are exposed to.

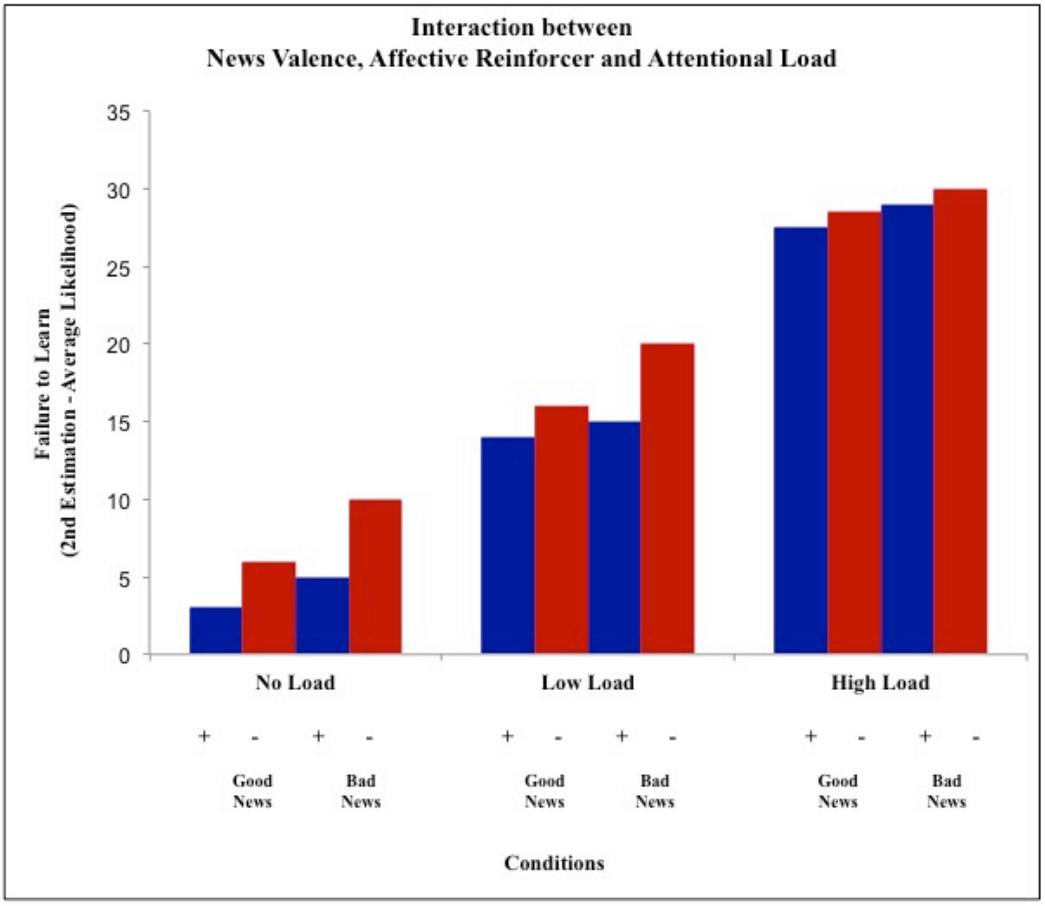

Figure 4: It is proposed that under high attentional load, the effect of learning under affective reinforcers did not differ significantly among news valence conditions, as per Model 2.

A three way factorial ANOVA will be employed to evaluate the effects of attentional load, news valence, and affective reinforcer upon learning. It is proposed that there will be a statistically significant three-way interaction between news valence, affective reinforcer and attentional load, $F(2, 29) = X$, $p = Y$, as well as significant effects for news valence, $F(2, 29) = X$, $p = y$; affective reinforcer $F(2, 29) = X$; attentional load $F(2, 29) = X$; news valence x affective reinforcer, $F(2, 29) = X$, $p = y$; and affective reinforcer x attentional load, $F(2, 29) = 6.01$, $p = .015$, with a MSE of X for each of these effects. In order to determine whether attention

mediates the effect of affective reinforcers, the interactions were investigated further by evaluating the simple main effects of attentional load separately for no, low and high attentional load. High attentional load is proposed to significantly cause failure to learn (*M* = X, *SD* = Y) than low attentional load (*M* = X, *SD* = Y) and no attentional load (*M* = X, *SD* = Y) (see Figure 4 for differences in failure to learn across news valence, affective reinforcer and attentional load conditions).

To determine if there was a difference in effect of performing the attentional load task or not, a within subject repeated measures was carried out. The estimate marginal means for the attentional load task (*M* = X, *SD* = Y) and the no attentional load task (*M* = X, *SD* = Y) differed significantly, $F(1,29) = x$, $p = y$, indicating that participants did not learn when asked to perform the attentional load task.

Discussion

Consistent with past findings (Sharot et al. 2011), the proposed results indicate that people updated better under desirable than undesirable information as well as updated better under a positive reinforcer than negative reinforcer. It is proposed that the main hypothesis of attention mediating the affective reinforcers is supported by these results, which indicates that Model 2 is true and that learning under affective reinforcement requires attention.

Provided that we accept that there is an optimistic tendency of integrating more desirable information into our judgment compared to undesirable information, and that this can be affected by the amount of attentional load one is under, Model 2 is accurate and there are several implications for learning that can be extrapolated. If there is absolutely no effect of the affective reinforcer regardless of desirability of the information when under high attentional load, it is then necessary that the amount of distraction in the environment be reduced in order for one to benefit

from affective information. Furthermore, as there is a significant difference in failure to learn between performing the counting task and not, this implies that one cannot be overloaded with additional tasks otherwise no information will be processed. For example, communicating undesirable information effectively would be best if the person is under minimal distraction, thus allowing for the full use of the attentional capacity to process the undesirable information and the affect associated with the information. This can be seen in a health setting, where communicating information on risk of a disease and preventative action to a patient must be done without distractions to allow for full attention on encoding the information, especially since the information on risk may have a negative affect while preventative action information may come with a positive affect. Patients should first process the information on risk, and then after a delay, the preventative action information, because it is known that more attention is needed to learn from undesirable information with a negative affect. If patients were given the information sequentially without the chance of their attentional resources to be replenished, the information on preventative care could be remembered wrongly due to the lack of attentional capacity to fully process the affective information, and patients will not learn from such information.

Yet, even if the opposite was true and Model 1 is instead accurate, this model informs us that affective information is processed separately from regular information and does not require attention to be processed into the long-term memory store. This implies that affective information may be influenced by other factors besides attention, perhaps at a deeper unconscious level. Nevertheless, there are several limitations of this study that may reduce the real world applications of these results.

Sharot's paradigm assumes a Frequentist perspective on events in that it is assumed people judge event outcomes as being equally likely of occurring. However, her sample may

have encountered more optimistic priors compared to a larger sample, which would naturally show an optimistic tendency when learning from information as an extension of Bayesian probability. This may be a problem in the paradigm that is used to show that attention mediates the affective reinforcer, because the sample appears to be naturally optimistic regardless of any condition. A further limitation of the task design is the unverifiability of whether the attentional load conditions truly exerted the participant's visual attentional capacity. As participants are unaware of the purpose of the attentional load task, a manipulation check would not suffice in determining if the task had any effect on attention.

Future studies could examine other elements of attentional capacity that could have an influence on processing the affective tag. According to Baddeley's model of working memory, a phonological loop that is required for rehearsal of information can be disrupted and encode information wrongly into long term memory. Instead of using a visual attention task, an auditory task could be used in place to examine the effects of auditory disruptions, which also occurs frequently in the real world. If we are able to fully determine the influence of attention on processing affective information, then we would be able to communicate information more effectively. This would hopefully cause less risky behavior deriving failure to learn as a result of failure to encode both information content and affective reinforcement.

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Appendix A

List of Negative Events

Alzheimer's disease
Abnormal heart rhythm
Anxiety disorder
Arteries hardening (narrowing of blood vessels)
Artificial joint
Asthma
Autoimmune disease
Being cheated by husband/wife
Being convicted of crime
Blood clot in vein
Bone fracture
Cancer (of digestive system/lung/prostate/breast/skin)
Car stolen
Card fraud
Chronic high blood pressure
Death before 70
Death before 80
Death by infection
Dementia
Depression
Diabetes (type 2)
Disease of spinal cord
Domestic burglary
Drug abuse
Epilepsy
Fraud on internet purchases
Gallbladder stones
Having a stroke
Having fleas/lice
Heart failure
Hepatitis A or B
Hernia (rupture of internal tissue wall)
Herpes
House vandalized
Household accident
Infertility
Irritable bowel syndrome (disorder of the gut)
Kidney stones
Knee osteoarthritis (causing knee pain and swelling)
Limb amputation
Liver disease
Migraine
Miss a flight
More than £30000 debts
Mouse/rat in house
Obesity
Of bullying at work (nonphysical)
Osteoporosis (reduced bone density)
Serious hearing problems
Severe injury due to accident (traffic or house)
Severe insomnia
Severe teeth problems when old
Sexual dysfunction
Sport related accident
Theft from person
Theft from vehicle
Ulcer
Victim of mugging
Victim of violence at home
Victim of violence by acquaintance
Victim of violence by stranger
Victim of violence with need to go to A&E
Witness a traumatizing accident

From Sharot et al. 2011

Appendix B

Post Scanning Questionnaire

How vividly can you imagine this event?

How familiar is this event regardless whether you have experienced it before? (from TV, friends, movies and so on)

Has this event happened to you before?

How emotionally arousing is this event?

How negative is this event for you?

From Sharot et al. 2011