UNIVERSITY OF CALIFORNIA, SAN DIEGO

Affect, Value and Choice:
How Incidental Affect Influences Decisions

A dissertation submitted in partial satisfaction of the requirements for the degree of
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in

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by

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The Dissertation of Galit Hofree is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

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DEDICATION

This dissertation is dedicated to my parents, who inspired, encouraged and supported me.

To Aba, who instilled in me a spark of curiosity and a passion for learning. To Mom, who showed me what hard work and determination can do.

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ABSTRACT OF THE DISSERTATION

Affect, Value and Choice:

How Incidental Affect Influences Decisions

by

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Everyday decisions are never made in a void – a busy environment surrounds a decision maker as he or she makes a choice. Previous research has clearly demonstrated that unrelated factors, specifically incidental affect, can influence decisions, often in an unwanted and unnoticed manner (Wilson & Brekke, 1994). However, there has yet to be a systematic examination of the influence of incidental affect on decision-making processes.

This dissertation explores the effects of incidental affective stimuli on financial decisions. Through this work I aimed to demonstrate global effects across stimuli categories, characterize the type of decisions susceptible to influence, and uncover insights on the process through which affect is incorporated into decision making

processes, specifically valuation.

Chapter 1 presents 3 studies that demonstrated robust evidence for the influence of incidental affective pictures on gamble decisions. We found that affective stimuli drive predictable changes in gamble acceptance, and that affective reactions to the pictures mediate this effect. Our results further show that affect influences choice indirectly, by altering valuation parameters such as loss aversion, and that these effects specifically target gambles that are ambiguous in value. These findings have important implications for integrating affect into models of financial choice.

Chapter 2 examined more closely the relation between affect and valuation, through a motivation framework. Using a paradigm that paired different types of affective judgments and approach/avoidance response tendencies, we found that hedonic 'liking' judgments differed from 'wanting' judgments (judgments of motivational value) across genders, in their susceptibility to motivational state, and finally in their relation to approach/avoidance actions. Bridging the data from both studies through a combined analysis demonstrated evidence that 'wanting' judgments were more broadly predictive of gamble acceptance, than 'liking' judgments. These findings support the hypothesis that incentive evaluations transfers from incidental reactions into decision valuation calculations, thus influencing choice.

Introduction

We rarely consider the environment in which me make our decisions, and how it might influence our judgments. Yet research clearly demonstrates that factors in our environment can influence our decisions, sometimes without our awareness (e.g., Saunders, 1993; Winkielman, Berridge, & Wilbarger, 2005). This influence is not necessarily detrimental. Context sensitive behavior is a crucial part of intelligent and adaptive behavior. Nonetheless, there are situations where the influence of incidental factors in our environment on behavior is unwanted. Many would agree that important life decisions, such as college admissions, should not be susceptible to incidental factors. However, university admission judgments were shown to be influenced by weather on the day applications were reviewed (Simonsohn, 2007).

Emotional reactions play a key role in the influence of incidental factors on judgments. They enable us to quickly assess and react to stimuli according to learned patterns of behavior. Emotional reactions are broadly defined as intense brief states that involve many levels of phenomenology, including cognitive attributions and appraisals. Examples are happiness, sadness, and surprise. Underlying emotions are basic affective reactions, shared with other mammals and even lower order organisms (Panksepp, 1998). Affective reactions are widely thought to comprise of two dimensions: valence and arousal (Russell, 1980). Valence refers to a differentiation across a positive-negative spectrum. Arousal refers to differentiation across a calm-excited spectrum. Much of the neuroscience literature focuses on affective reactions, as those can be measured in animal models used in the research. Affective reactions occur automatically, with or without awareness (Winkielman & Berridge, 2004). Importantly, incidental affective reactions have been demonstrated to influence judgments and behavior (for reviews, see Lerner, Li, Valdesolo, & Kassam, 2015; Loewenstein & Lerner, 2003; Pham, 2007).

The focus of this dissertation is on the influence of incidental affective reactions on decisions. Incidental affective influences comprise an important subtype of affective influence. Being by definition independent from the decision, incidental affect can be manipulated separately from the decision parameters. This allows a more controlled assessment of affect's influence on choice. Understanding this phenomenon, however, is of practical importance as well. This research can bring awareness to the importance the environment of a decision holds and enables both decision makers and decision designers to control such environments to their benefit.

Models of Affective Influence on Decisions

Several types of models exist that can explain how incidental affect could influence decisions. One important type of model proposes that affect can *directly* influence behavior and judgment. Affect-as-Information proposes that affective reactions serve as a source of information that can be used in judgment (Schwarz, 1990; Schwarz & Clore, 1988). Certain interpretations consider the use of affect in this way a heuristic, where instead of considering other important sources of information when evaluating an event or stimulus, we use our current affective state, which may or may not provide relevant information. Finucane et al. (2000) demonstrate that risk and benefit evaluations, theoretically considered independent, are in practice negatively correlated. They argue that this effect can be explained by the use of an 'affect heuristic', meaning that people use immediate affective reactions to evaluate both the risk and benefit of a given option.

Dual process models propose that associative processes (such as affective reactions) and deliberate processes (such as integrating relevant decision parameters) operate separately to direct choice, and that associative processes can 'override' deliberate processing to directly influence decisions (Evans, 2003; Sloman, 1996). Risk-as-Feelings provides a more comprehensive model in which affective and cognitive processing of a decision operate in parallel (with reciprocal influences) but can diverge, in which often affective processing is more likely to determine choice (Loewenstein, Weber, Hsee, & Welch, 2001).

Affect can also produce *indirect* influences on judgments and decisions. As an informational source, affect can also provide information regarding *how* to engage with our environment. Schwarz and Bless (1998) propose that different situations require different modes of processing. If a positive state indicate that our current environment is safe, then it might be a chance to try out different tactics in a more exploratory fashion (Fredrickson, 2001). There is evidence for enhanced creativity (Isen, Daubman, & Nowicki, 1987), flexibility in categorization (Isen & Daubman, 1984), and broader attention (Fredrickson & Branigan, 2003) under low intensity positive states (for a review, see Isen, 1999). Low intensity negative affect has been shown to induce more systematic processing, as a negative state might indicate a problematic situation which we need to alleviate (Schwarz, 1990). People in sad moods have increased ability to estimate covariation from scatterplots (Sinclair & Mark, 1992), tend to make judgments that rely less on stereotypes and other general knowledge structures (Bless, Clore, et al., 1996; Bodenhausen, Kramer, & Süsser, 1994). Overall, the theory and evidence demonstrate how affect can alter the way we choose to process and act upon information.

Of specific interest to our work, are models that describe indirect influence of affect on decisions, by altering the underlying decision parameters. It is important to note that the influence of affect on specific parameters may be direct – for example, probabilities or risk might be directly influenced by affective reactions, yet the overall influence on choice is indirect as it is mediated by cognitive integration of valuation and risk. Several models demonstrate that affective reactions influence our perceptions or calculations of risk and value (e.g., Hsee & Rottenstreich, 2004; Lerner & Keltner, 2001; Lerner, Small, & Loewenstein, 2004). Famously, Bechara and colleagues demonstrated that risk assessment depends on physiological arousal reactions to risky choices (Bechara, Damasio, Damasio, & Anderson, 1994). Affect has also been shown to influence valuation in decision making. For example, Hsee and Rottenstreich demonstrate that product valuation is influenced by affective reactions to the consumer goods being evaluated (Hsee & Rottenstreich, 2004). Interestingly, these types of models suggest that affective influence can be incorporated into existing decision models (such as prospect theory: Kahneman & Tversky, 1979; Tversky & Kahneman, 1992) to predict choice. However, the research conducted so far has only demonstrated discrete effects on decision parameters (e.g., comparing the value of 1 vs. 10 CDs in Hsee & Rottenstreich, 2004), using only specific affective states (e.g., only negative states in Lerner, Small & Loewenstein, 2004). A broader distribution across affective states while testing decisions across a range of representative financial decisions (that include both gains and losses), as carried out in Chapter 1 of this dissertation, can enable drawing more concrete conclusions on how to incorporate affect into decision models.

Integrating these different types of theories, we can test whether affect influences financial choices directly, indirectly through processing methods, or indirectly through influence of specific decision parameters. Specifically in our research, I test these theories with particular focus on the process of valuation, as this process is integral to decisions with and without risk involved. For this reason, we now consider the relationship between affect and valuation to understand how incidental affective reactions might influence valuation of financial decisions.

The Relationship between Affect and Value

Affect and valuation processes share common neural systems, and are considered to work in concert to produce context-sensitive goal-directed behavior. Affective reactions are associated with approach/avoidance action tendencies through evolutionary (or learned) mechanisms (Lang, Bradley, & Cuthbert, 1990). Incentive valuation is also closely associated with approach/avoidance tendencies. Appetitive stimuli are associated with approach behavior while aversive stimuli are associated with avoidance, and even in some cases inhibition of action (Chiu, Cools, & Aron, 2014; Schneirla, 1965). Furthermore, this relationship can be reciprocal: inhibition of action can cause devaluation of stimuli (Wessel, O'Doherty, Berkebile, Linderman, & Aron, 2014), and approach behavior can lead to greater valuation (Cacioppo, Priester, & Berntson, 1993). Modern motivational theories posit that affective reactions influence subsequent valuation through conditioning learning processes (Berridge & Kringelbach, 2008). That is, we learn to value items that produced positive experiences for us. However, valuation and affective reactions to stimuli sometimes diverge, through habituation/sensitization processes (Berridge, 1996; Winkielman & Berridge, 2003), demonstrating that the relationship is not one-to-one. A healthy eater might react positively when seeing a delicious piece of chocolate cake, but will have a low incentive to approach and eat it. On the other hand (as is most often the case), one might have high motivation to eat such a cake (and lack control to resist such a treat), yet have ambivalent affective reactions upon viewing it due to contrasting motivational goals such as hunger vs. weight loss. Importantly, measuring affective reactions, particularly through subjective ratings, can tap into either hedonic affect or valuation, or both (Havermans, 2011). Chapter 2 of this dissertation presents a study, in which these reactions are measured separately in order to disentangle which component is associated with subsequent effects on decisions.

In light of these theories, what could be the process in which incidental stimuli influence decision valuation calculations? One explanation would be that *valuation* of the irrelevant stimuli transfers (through contingency in time and shared neural circuitry) over to valuation of the decision's prospects. For example, seeing an attractive individual (a highly positive incentive) walk by the poker table elicits a positive reaction but also a positive evaluation, which is transferred into the evaluation of the gamble at hand. Such an explanation aligns with social psychology misattribution effects. It is also supported by neuroscience research demonstrating brain activity associated with valuation mediates effects of incidental affective stimuli on choice (Knutson, Wimmer, Kuhnen, & Winkielman, 2008). In addition, it relates to motivational research on spillover of motor excitability (Gupta & Aron, 2011), as well as evidence for a general approach system (Corbit & Balleine, 2005), which when activated by a specific positive stimulus promotes approach to other stimuli in the environment. Many of these findings, however, demonstrate effects of rewarding stimuli, which have been found to have a broader (if more shallow) effect on behavior (positivity offset, see Cacioppo & Berntson, 1994). Our findings provide evidence for value transfer from incidental stimuli into decisions, and attempts to broaden the theory to include the effects of negative as well as positive stimuli.

Current Research

In the next 2 chapters, I demonstrate the effects of incidental pictures on risky financial decisions, and show that valuation judgments of these irrelevant stimuli are incorporated into value calculations of the decisions. Our studies included a large number of pictures that ranged across valence, arousal and subject (food items, people), so that we could measure broad effects across affective components and generalize our findings beyond specific types of environmental stimuli. We utilized a mixed gambles paradigm with widely varying outcomes (ranging from -$20 to $40), and constant risk (50/50 odds), in both incentive compatible and hypothetical choice situations. This enabled us to fit decision models and test whether affect influences choice directly (where decision models would not be predictive of choice), indirectly through processing methods, or through valuation calculations. Measuring affective and valuation judgments separately in chapter 2 for the same stimuli used in Study 1 of Chapter 1 enabled us to distinguish between hedonic reactions ('liking') and incentive valuation ('wanting') of the pictures, and to test the relationship between these judgments and key motivational factors such as motivational state (hunger), and approach/avoidance tendencies. Importantly, we were able to test whether value judgments of stimuli were more predictive of subsequent decision, strengthening the evidence for the valuation transfer hypothesis.

Overall, this dissertation provides robust evidence for effects of incidental stimuli on valuation of financial decisions under risk. It provides important insights for models incorporating affect into risky and riskless decisions, and for theories on the relationship of affect and valuation. Importantly, this work brings to our attention the ways in which incidental stimuli in our environment can influence our decisions. This information will hopefully promote careful consideration of the environment one makes decisions in, as well as research on effective means of controlling such influences.

Chapter 1:

The Influence of Incidental Affect on Financial Choice

Introduction

Throughout our lives we are constantly faced with choices, ranging from mundane, such as what to buy for breakfast, to profound, such as what career path to follow. Complex social behaviors, such as financial markets, medical diagnosis, and policy making all rely on human decisions. It is not surprising, therefore, that researchers have made great efforts to understand the processes underlying decisions and judgments. Furthermore, there is a practical interest in using our knowledge to predict individual and group decisions, whether in a market, or in a political office.

It has long been recognized that many decisions involve affect. Some of the affect is elicited by the decision object itself and as such is "integral" to the choice (e.g., positive affect elicited by a cookie we are currently evaluating for consumption). However, decisions are also shaped by affective stimuli and reactions that are "incidental" to choice, in the sense that they are not directly related to the parameters of the specific decision (Bodenhausen, 1993). For example, positive affect elicited by a cookie in the context of making an unrelated financial decision.

There is now extensive evidence that incidental affect influences decision (for a review see Lerner, Li, Valdesolo, & Kassam, 2015; Winkielman, Knutson, Paulus, & Trujillo, 2007). Critically, some of these effects occur in real-life settings. For example, weather-induced affect can influence subjective judgments of well-being (Schwarz &

Clore, 1988), stock market prices (Saunders, 1993), and even college admission decisions (Simonsohn, 2007). Such affective stimuli and reactions are sometimes unnoticed by the decision maker (Winkielman & Berridge, 2004), their effects can have lasting repercussions (Andrade & Ariely, 2009), and they can be perceived as unwanted and detrimental to choice (Wilson & Brekke, 1994).

Open Questions Regarding Affective Influence on Decision Making

The past decades produced many important models and theories on how affect and emotion influence judgments and decisions (Damasio, 2005; Finucane, Alhakami, Slovic, & Johnson, 2000; Forgas, 1995; Lerner & Keltner, 2000; Loewenstein, 1996; Loewenstein, Weber, Hsee, & Welch, 2001; Mellers, Schwartz, Ho, & Ritov, 1997; Schwarz & Clore, 1988). There are many important and subtle differences between these theories and models, but for the purposes here we will only highlight some of the major assumptions made by these frameworks that are relevant to the current studies.

The importance of *current* affective experiences *during* decision making is highlighted by several models, including “Feeling-as-information” (Schwarz & Clore, 1988), “Risk-as-feelings” (Loewenstein et al., 2001), “Somatic Marker Hypothesis” and “Affect Heuristic” (Finucane et al., 2000). All these models agree that when confronted with a prospect perceivers essentially ask themselves “How do I feel about it?” (Schwarz & Clore, 1988). The target of the feeling could depend on the particular question asked by the decision (Is it risky? What is the expected value? Shall I accept it?). Overall, these models highlight that supposedly pure ‘cognitive’ estimates can be influenced by incidental affective reactions.

Affect as heuristic or a cue? One critical issue in all these models, and relevant to our studies, is whether affect influences decisions *directly*, bypassing the calculative processes, or *indirectly*, by influencing decision calculation processes or components. On some readings of the above models affect serves as an alternative means of making a choice (e.g., Schwarz & Clore, 1988). According to this interpretation, the perceiver massively simplifies the choice process and uses current affect as a simple heuristic which can lead, for example, to an indiscriminate acceptance of gambles when the perceiver is feeling good and an indiscriminate rejection of gambles when the perceiver is feeling bad. Empirically, this predicts a main effect of affect across a variety of decision parameters (e.g., relatively good and relatively bad gambles). However, another interpretation of the above models suggests that affect serves as an input to judgment and is flexibly integrated with other pieces of information about the "goodness" of the gamble. Empirically, this predicts that affective influences will be visible predominantly in situations where gamble value is undetermined or ambiguous, as the relative value of affect cue exceeds the value of other cues. We will later return to the more subtle distinctions later (note that such empirical pattern is also possible when perceiver resort to affect only if it is needed as a way of breaking the tie).

How is affect integrated into a decision? If affect serves as a cue in decision making, how it is integrated into a decision remains to be understood. Several models suggest that affect influences processing style and depth (e.g., Schwarz & Bless, 1998). These models propose that decision processing can be more or less calculative, depending on the presence of affect. Some theories suggest that presence of any affect induces less calculative processing (Evans, 2003), while others suggest that negative affect induces a more calculative processing, while positive affect has the opposite effect (Schwarz & Bless, 1998). In gamble decisions, these influences predict that incidental affect will influence sensitivity to the gamble's overall expected value.

Affect can also influence particular components of choice. Research in affective neuroscience demonstrates that neural correlates of affect and reward are tightly connected, and that value calculation during a decision relies on activation of affective systems (Knutson, Taylor, Kaufman, Peterson, & Glover, 2005; Rangel, Camerer, & Montague, 2008). These suggest that incidental affect can activate value calculation systems and thereby influence choice. The anticipatory affect model (Knutson & Greer, 2008) posits that incidental stimuli lead to activation in incentive calculation systems, thereby influencing subsequent calculations of value. This model predicts that positive arousal, associated with approach behaviors, will lead to a focus on potential gains (and a higher likelihood of accepting risky gambles), whereas negative arousal, associated with avoidance, will lead to a focus on potential losses (and a lower likelihood of accepting risky gambles). According to the anticipatory affect model, incidental affect will influence the importance gains and losses hold in our decisions. Evidence for this was demonstrated in a fMRI study, where incidental positive affect caused choices to shift to high-risk options from previous low-risk choices (Knutson et al., 2008). However, this study only allowed for a decision between two possible choices, thus did not allow for a more systematic analysis of the effects of these stimuli on valuation. In addition, the limited choice of stimuli and the restricted set of participants (15 males) did not allow for generalization of the effect.

Formalizing When and Where Affect Exerts Influence Over Decisions

Testing different models of affective influence necessitates variation in the decisions on both positive and negative outcomes, and overall value. Our research focused on monetary decisions, and utilized a mixed gambles task for these purposes. This enabled us to enlist formal decision models to pinpoint which decisions are considered ambiguous, and therefore most likely to be influenced.

Financial decision models also enable us to address the question of whether affective states produce a general change in choice, or influence specific evaluative processes underlying decisions. One important model, prospect theory, has proven useful in answering these questions with our current observations. Prospect theory was originally developed as a descriptive model of financial decision making under risk (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992). Prospect theory models decisions through a value function (related to the utility function of earlier decision models) and a probability weighting function. The value function is characterized by 3 parameters: λ – loss aversion (the extent by which individuals weigh losses more heavily than gains), α, β – curvature of the gain and loss functions, respectively. This curvature implies diminishing sensitivity to changes in value (Kahneman & Tversky, 1979), such that a difference between $10 and $20 is estimated to be greater than a difference between $110 and $120. Thus, both gain and loss functions are curved (concave for gains, convex for losses).

Few studies demonstrate affective influence on value parameters. Lerner, Small and Loewenstein (2004) demonstrated differential effects of incidental sadness and disgust on loss aversion in the endowment effect. Similarly, Li, Kendrick and colleagues

(2012) demonstrated effects of men’s mating motives on loss aversion in social decisions. However, both studies show effects on riskless choice, which might differ from risky decisions. Research conducted by Hsee and Rottenstreich (2004) demonstrate differences in gain curvature, or sensitivity to scope, when prospects considered were either “affect-rich” (e.g., cute pandas) or “affect-poor” (e.g., symbolic and not cute representations of pandas, such as dots). For “affect-rich” prospects, evaluations of prospects and monetary decisions (e.g., to donate money to save pandas) appeared to be sensitive mainly to the presence or absence of a stimulus, but relatively insensitive to the fine variations in scope (such as the exact number of pandas that can be saved). Note that affective reactions in this paradigm are “integral” to the decision. It remains to be tested whether incidental affect will produce such an effect. Importantly, the difference in sensitivity to scope was ascribed to a change in evaluation strategy, evoked by affective response (“evaluation by feelings”, Hsee & Rottenstreich, 2004). However, there is no comparison to a negative affective condition, leaving open the question whether it is specifically positive affect, general affect, or even arousal (increased arousal has been demonstrated to reduce working memory capacity and utilization of diagnostic cues, e.g., Humphreys & Revelle, 1984; Pham, 1996), that might induce these effects.

Overall, these studies evaluate changes in value of a single prospect (such as a mug) or just a few hypothetical monetary options and thus make it difficult to generalize conclusions on how such parameters might change across a range of values (e.g., Li et al., 2012). This is important as a proper assessment of loss-aversion and curvature requires several prospects using a reasonably wide range of values (e.g., loss aversion reverses for small amounts of money, Harinck, Dijk, Beest, & Mersmann, 2007). As described shortly, the design of current studies allows us to address these issues and test for effects on loss aversion and curvature.

Characterizing the Mediating Role of Affect

For any comprehensive evaluation of affect in decision making, it is important to consider not only the affect richness of the incidental stimulus or the prospect itself, but also the influence of such stimuli on the decision-maker's affective state. In that context, current models of affect highlight the critical independent contribution of valence (+/-) and arousal (Russell, 1980, 2003). Dimensional approaches (i.e., approaches that conceptualize affect as a continuous space spanning dimensions such as valence and arousal) enable us to focus on the processes that underlie a variety of emotions, thereby specifying their influences in a more global manner. Further, it is critical to measure the actual affective state itself (e.g., by subjective ratings, or physiological measurements) independently from the affective value of the stimulus to ensure affect is mediating the changes in choice. This enables us to distinguish between effects of underlying affective states from other effects generated by the stimuli, such as semantic priming. For example, sexual stimuli can influence choice through an affective reaction, or through an association with risky behavior. We can further test whether valence and arousal play different roles in this effect. These distinctions allow us to evaluate various theories of affective influence on decision making.

This approach not only enables us to characterize global effects of positive and negative affect, it also allows us to relate our work to the extensive body of literature on affect and motivation, and their underlying neural systems. We aimed to address these issues through systematic introduction of various types of incidental stimuli (emotional pictures) before a gamble decision, and separately measuring affective reactions to these same stimuli. This paradigm is designed to enable a larger variation in affective response, within basic affective categories such as negative, neutral, and positive, for a parametric analysis of the effects of affective stimuli on decisions.

Current Study

This study investigates how incidental affective stimuli, ubiquitous in our environment, might produce systematic effects on our decisions. In a series of three studies, we demonstrate the effects of affective stimuli of various types (food in Study 1, and humans in Studies 2 and 3) on mixed gamble decisions. Our paradigm (see Figure 1) presents either a positive, negative or neutral picture, followed by a gamble with 50/50 odds and with varying gains and losses, which a participant can either accept or reject.

This paradigm allows us to test different models of affective influence. Through characterization of the gambles accepted under different conditions, we can determine whether affect broadly determines choice, or whether it serves as a cue for particular types of gambles. Furthermore, it enables us to test for effects on specific value components, such as loss aversion. Overall it enables us to address open questions in the literature regarding the role of affect in decisions.

We make several predictions regarding the effects of affective stimuli on gamble choices. First, we predict specific effects for positive and negative stimuli on choice. Most theories predict that incidental affect will influence the likelihood that a gamble will be accepted. Both direct and indirect models of affective influence predict that gamble acceptance will increase following positive stimuli, and decrease following positive stimuli.

Hypothesis 1: Participants will accept fewer gambles following negative stimuli, and more gambles following positive stimuli, as compared to neutral.

We would expect these effects to take place, however, only if affective stimuli led to actual changes in underlying affective states. Therefore, we test that the stimuli presented to the participants lead to changes in underlying affective states, measured both explicitly (Studies 1 and 2 – subjective ratings) and implicitly (Study 3 – facial EMG), and that these states mediate the effects of stimuli on choice.

Hypothesis 2: Effects of stimuli on decisions are mediated by underlying affective states.

Decision-making models enable us to closely examine the attributes of the gambles that are associated with these changes in behavior. As mentioned above, some interpretations of theories such as Feeling-as-Information suggest that affect will only influence decisions that are difficult to evaluate (Schwarz & Clore, 1988). In accordance with these theories, we expected that affect would specifically influence decisions regarding a particular set of gambles – those that are of more ambiguous value. Given previous research on loss aversion, we predicted that gambles with a gain/loss ratio of around 2 would be those most affected, as these have an overall expected value of 0 (Kahneman & Tversky, 1979).

Hypothesis 3: The impact of affect will depend on gamble properties.

Of particular interest is whether affect influences overall choice, decision strategy, or specific decision components. These can be tested by examining changes in decision components, such as loss aversion, or in weighting of valuable components in the decision, such as overall expected value. We predicted that affect will be integrated into valuation and will therefore produce effects on loss aversion and gain/loss curvature, as opposed to general effects on processing style, or general effects on choice.

Hypothesis 4: Affect will influence choice through changes in valuation parameters, such as loss aversion and scope sensitivity.

Overall, this work aims to systematically characterize the effects of incidental affective stimuli on decisions, and to provide insights on how affect can be incorporated into prevalent decisions models.

Methods and Results

General Methods

Task

We employed a paradigm in which positive, neutral, or negative affective images were presented incidentally before gambles (the overall logic of the task was adapted from Knutson, Wimmer, Kuhnen, & Winkielman, 2008, see Figure 1). Each trial was comprised of two sections, a picture segment and a gamble segment. Both the pictures and gambles were a unique combination in each trial; each picture and gamble was chosen without replacement from a set of pictures/gambles detailed below. Subjects were instructed that these two segments were unrelated.

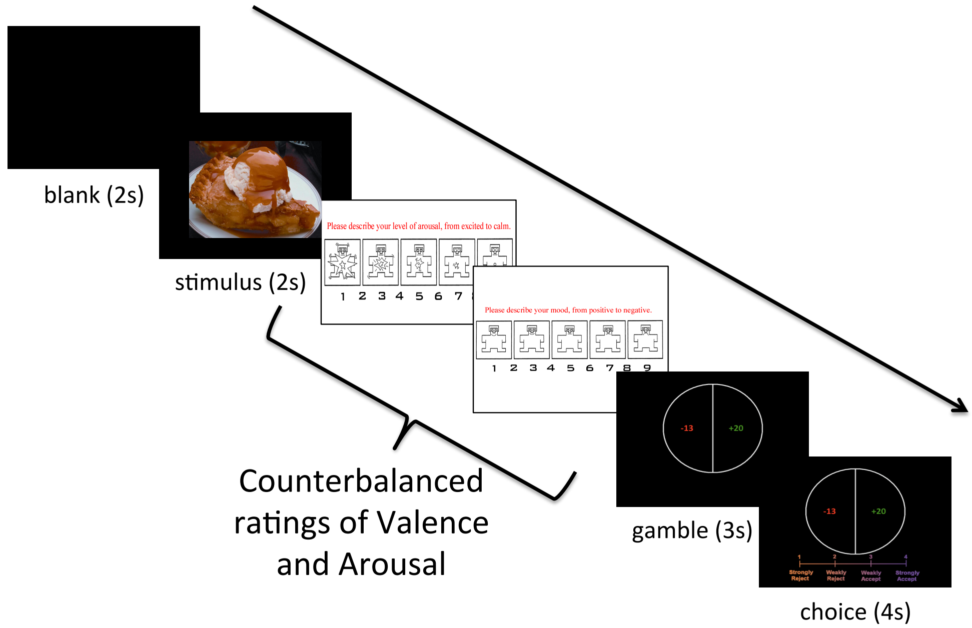

Figure 1.1: Affect gamble task studies 1 & 2. During each task, participants first viewed a picture, and then were asked to rate it on valence and arousal, using SAM rating charts. They were then presented with a gamble, and then asked to make a choice on a 4-point scale, ranging from Strongly Reject to Strongly Accept.

In the picture segment, subjects viewed a picture for two seconds, and were instructed to acknowledge the appearance of the picture with a button press. Pictures were chosen from a predetermined set of positive, neutral and negative pictures from a specific category – food in Study 1, and humans in Studies 2 and 3. In Studies 1 and 2, participants were then asked to rate this picture on valence and arousal using a 9-point SAM (self-assessment manikin; rating slides were those used in the IAPS studies, see Bradley & Lang, 2007). In Study 3, affect was measured using EMG (see Study 3 methods below).

The gamble segment included a decision and an action. Each gamble presented to the subject included a gain and a loss, with a 50/50 chance of each outcome. This part of the task was modeled after Tom, Fox, Trepel, & Poldrack, 2007. Participants were asked on each trial to decide whether to accept or reject the gamble presented to them.

Gamble gains and losses were randomly drawn from the following ranges: Losses: -$6 – -$20 (in $1 increments), Gains: $12 – $40 (in $2 increments). All possible combinations of gain and loss created 225 unique gambles – gambles were selected randomly without replacement for each trial to ensure that each stimuli category maintained the same distribution of gamble parameters. Note that the range chosen for the gains is twice the range of that of the losses. This distribution takes into consideration loss aversion (which has been estimated at around a 2:1 ratio of losses and gains for the general population, see Kahneman & Tversky, 1979) and behaviorally ensures that participants will accept roughly half of the gambles. Choices were made on a 4-point scale (strongly accept – weakly accept – weakly reject – strongly reject) so that subjects would not stick to a simple yes/no strategy. However, for most analyses, both accept-responses are collapsed into 'gamble acceptance' and both reject-responses are collapsed into 'gamble rejection'. Participants answered a short questionnaire following the experiment in Studies 1 and 2, which included several questions regarding relevant behaviors and attitudes (for instance, dietary habits for Study 1), understanding of the study's objectives and choice behavior, as well as several other questions. We discuss findings regarding decision behavior and assumptions about the study's objective in the Results section of Studies 1 and 2.

Analyses Strategy

We proceeded with four main stages of analyses. First, we examined changes in overall rates of acceptance in the affective conditions. This enables us to test *Hypothesis 1*. We estimated a two-level linear model with subject-level random intercepts and gender as covariate. Second, we tested whether these changes were mediated through changes in underlying affective states (*Hypothesis 2*). This was conducted by analyzing participant ratings of the affective stimuli in Studies 1 and 2, and EMG and SCR activity in Study 3. Third, we examined changes in predicted probability of accepting a gamble over different gain-loss combinations, again using a two-level linear model with subject-level random intercepts and gender as covariate. This enabled us to see if certain types of gambles were more susceptible to be accepted/rejected under affective conditions (*Hypothesis 3*). We focused on two characterizations of gambles: by the gain/loss ratio of the gamble, and by its expected value. This was important because predictions based on gain/loss ratio versus expected value do not always coincide (e.g., de Langhe & Butoni, 2015). Finally, we tested whether the changes found in probability of accepting a gamble across stimulus conditions could be characterized as changes in underlying decision-making parameters, as described in prospect theory (*Hypothesis 4).* Specifically, we were interested in whether affective stimuli would influence how the value of a gamble is calculated. We modeled the value function according to prospect theory as follows:

$$v(x) = \begin{cases} x^{\alpha} & if\ x = x_{gain} \\ -\lambda(-x)^{\alpha} & if\ x = x_{loss} \end{cases}.$$

We estimated the degree of loss aversion (λ) and the degree of diminishing sensitivity over monetary amounts (α). Generally, prospect theory allows for separate parameters of diminishing sensitive over monetary amounts for the gain versus loss domain. However, we modeled one parameter, α, across both the loss and gain functions as previous research has often found little differences in values (see e.g., Fox & Poldrack, 2014) and introducing another free parameter reduces the ability to robustly estimate the model, particularly considering that all prospect theory parameters are highly interrelated. The value of the gamble (g_1) according to prospect theory thus is

$$V(g_1) = 0.5v(x_{gain}) + 0.5v(x_{loss}).$$

Additionally, we modeled a logit stochastic choice function to account for noise in observed choices (e.g., Stott, 2006):

$$p(V(g_1), V(g_2)) = \frac{1}{1 + e^{-\varepsilon(V(g_1) - V(g_2))}}$$

where $V(g_2) = 0$ is the value of the alternative, i.e. rejecting the gamble, and estimated the degree of stochastic choice (ε). Using a stochastic choice model allowed us to obtain cleaner estimates for the decision parameters. We employed maximum likelihood to estimate the model and allow α and λ to vary across affective stimuli groups but held the error parameter ε fixed across the stimuli conditions (simplifying the model by assuming that the degree of error will be similar across conditions).

Study 1

Methods

Participants. 110 (57 female) University of California, San Diego undergraduates participated in the study. No subjects were excluded from data analysis;

only individual trials with missing accept/reject responses were dropped (6% of trials were dropped, on average, per participant).

Stimuli. This study had 127 trials of a unique picture and gamble, using the paradigm described above (see General Methods). Stimuli chosen for this study were food items (i.e., bat soup (negative), butter slices (neutral), burger (positive)). Stimuli were chosen from the IAPS database (Bradley & Lang, 2007) and from freely available pictures online, selected carefully by lab research assistants. There were 26 negative food pictures, 50 neutral food pictures, and 51 positive food pictures.

Results

Questionnaire Results. After the experiment, participants were asked several questions to judge whether they had predictions regarding the study's objective that might have influenced their behavior. We asked the following 3 questions: "What do you think was the purpose of the experiment?", "Where you suspicious of anything?", and "Did you think there was a relationship between the pictures presented and the gamble? Please describe.". Responses were given in free text, and varied in length. Most participants (68%) believe that the purpose of the experiment had to do with a relationship between the pictures and the gambles. However, out of those that described what that relationship would be, only 10% predicted results that might correspond with our findings. 39% made non-corresponding predictions. Only 39% answered "yes" to the question "Were you suspicious of anything?", and most described suspicion regarding the stimuli used in the experiment, and the structure of the trial. Examples of such responses are:

"I felt like ethnic background was being researched with this food experiment."

"I was suspicious of how many pictures were represented to us."

"Why did the scales keep changing around?" (referring to the 1-4 answer scale)

18% believed that there was an actual relation between the pictures and the gambles that followed. These beliefs varied greatly (as did the predictions regarding our research objectives). These results suggest that beliefs regarding the objective of the study could not explain our findings.

Participants were also asked if they utilized a strategy to make a decision regarding the gamble. 73% claimed to use a strategy. Of those, many mentioned a strategy involving the ratio between gains and losses. These ranged from the least loss averse (accepting anything with a positive expected value), to very loss averse (accepting gambles with a gain/loss ratio of 4), as has been found in other studies examining individual differences in loss aversion.

Acceptance Rate. Affective categories influenced participants' gamble choices, as is demonstrated by the overall test of Stimulus Category, c^2 (2) = 107.85, $p < .001$. Planned contrasts comparing each affective category with the neutral category demonstrate that participants accepted significantly less gambles following negative stimuli (c = -0.088, $p < .001$, CI [-0.108; -0.069]). In contrast, viewing positive stimuli did not lead to a significant change in gamble acceptance (c = 0.012, $p = .16$, CI [-0.005; 0.028]). Figure 2 illustrates these effects.

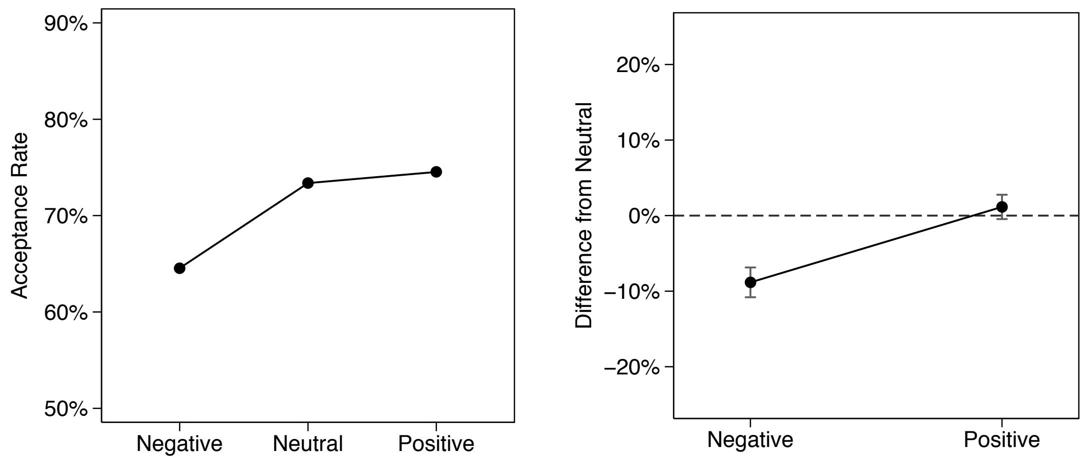

Figure 1.2: Acceptance rate across affective categories (Study 1). This figure shows acceptance rates across affective categories (left) and contrasts in acceptance rate relative to the neutral stimuli (right). Reported are adjusted predictions from a two-level linear model with subject-level random intercepts and gender as covariate.

There was no statistically significant Gender x Stimulus Category effect (c^2 (3) = 3.52, *p* = .32), which is why we report the results collapsed across gender for Study 1.

Valence and Arousal Ratings. According to some theories, affective stimuli need not elicit any affective states in order to produce effects on judgment (e.g., through semantic associations, Bower, 1991). However, we hypothesize that affective reactions are responsible for the effects of stimuli on choice demonstrated above. We therefore expect affect to mediate acceptance rates. As mentioned, participants rated each stimulus on measures of valence and arousal, thus giving us a subjective measure of the affective value of the stimuli. We used these ratings to examine the relationship of affect to the influence of affective stimuli on gamble choice. Ratings were elicited on 9-point scales from 1 (positive valence/high arousal) to 9 (negative valence/low arousal) but were reverse coded for the purposes of presenting the results.

First, we conducted straightforward manipulation checks – to test whether stimuli categories correspond to participants' valence and arousal ratings. Overall, both affective categories were rated differently than neutral (valence: c^2 (2) = 5,487.33, $p < .001$; arousal: c^2 (2) = 754.46, $p < .001$). The results are depicted in Figure 3.

Participants rated negative stimuli more negative than neutral stimuli (c = -2.41, $p < .001$, CI [-2.50; -2.33]) and positive stimuli as more positive than neutral stimuli (c = 0.68, $p < .001$, CI [0.61; 0.74]). Interestingly, the difference between negative and neutral stimuli is not symmetrical to the difference between positive and neutral stimuli. Comparing these differences shows that negative stimuli are rated more extreme than positive stimuli (c^2 (1) = 233.92, $p < .001$), suggesting the null effect of positive stimuli on gamble choice might be due to a weaker reaction to positive stimuli.

Arousal ratings were higher for both negative (c = 0.88, $p < .001$, CI [0.79; 0.97]) and positive stimuli (c = 1.01, $p < .001$, CI [0.94; 1.09]) compared to neutral stimuli, as expected. Interestingly, positive stimuli were rated more arousing (in comparison with neutral stimuli) than negative stimuli (c^2 (1) = 228.92, $p < .001$).

While these results validate that affective stimuli were categorized correctly, they suggest that the positive stimuli chosen were not as effective in eliciting affective reactions as the negative stimuli, which might explain the non-symmetrical effect of these categories on gamble choice.

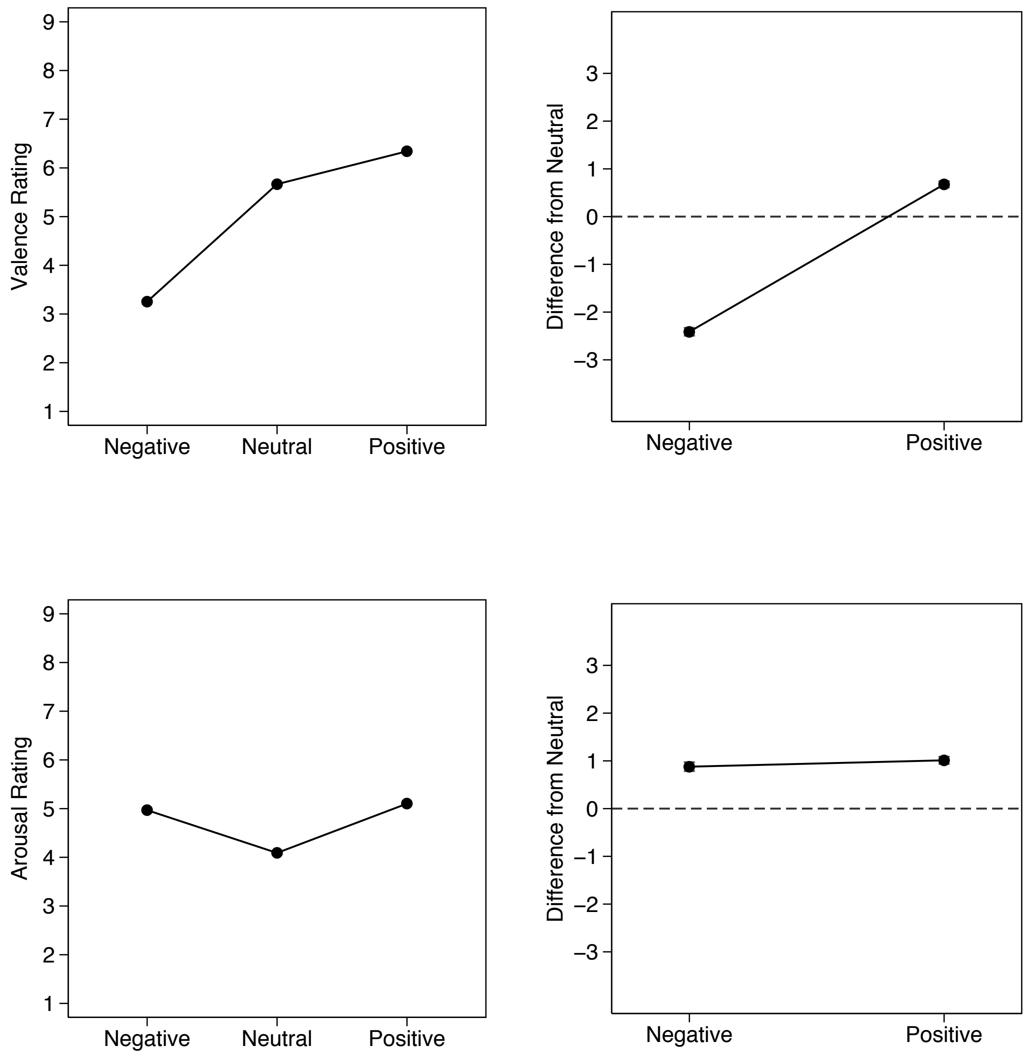

Figure 1.3: Valence and arousal ratings across affective categories (Study 1). This figure shows valence ratings (top panel) and arousal ratings (bottom panel) across affective categories (left) and contrasts in ratings relative to the neutral stimuli (right). Reported are adjusted predictions from a two-level linear model with subject-level random intercepts and gender as covariate.

Finally, we conducted mediation analyses to test whether these ratings mediated changes in gamble choices across stimuli conditions. We used SEM with bootstrap confidence intervals (bias-corrected; 10,000 replications) for the indirect effects to estimate meditational effects, as suggested in Zhao, Lynch Jr., & Chen, 2010. We included both Valence and Arousal as mediators, and examined the mediation separately for the negative stimuli condition and the positive stimuli condition (including Gender as a covariate in all analyses). Testing direct effects first, we find that gambles are less likely to be accepted following negative stimuli, when ratings of Valence and Arousal are held constant (direct effect c' = -0.041, $p = 0.02$, CI [-0.075; -0.007]), while positive stimuli show no such effect on behavior (direct effect c' = -0.006, $p = .59$, CI [-0.026; 0.015]). This result suggests that the influence of negative stimuli on choice is due to other factors beyond affect, as measured by these ratings. Interestingly, we find that Valence mediates the effect of stimuli on gamble choice in the negative stimulus condition, ($a \times b = -0.049$, $p < .001$, CI [-0.060; -0.039]), but also in the positive stimulus condition ($a \times b = 0.014$, $p < .001$, CI [0.011; 0.017]). Arousal also significantly mediated the effect of stimuli on choice in both the negative ($a \times b = 0.004$, $p < .01$, CI [0.001; 0.007]) and positive ($a \times b = 0.004$, $p < .01$, CI [0.001; 0.008]) conditions.

These findings provide evidence that it is the underlying affective reactions to the stimuli that sway gamble choices, and that there is a positive relation between the valence and arousal of these reactions and acceptance rates. In addition, they suggest that although positive stimuli did not demonstrate overall influence on acceptance, it nonetheless influenced choice, as evidenced by the indirect effects of valence and arousal on gamble acceptance.

Probability of Accepting a Gamble. We predicted that affective stimuli would not influence all gambles uniformly, having more influence over those gambles that are more ambiguous in value, e.g. hard decisions or hard gambles. According to prospect theory, these gambles should be those that have a gain/loss ratio that is around 2, because of loss aversion (Kahneman & Tversky, 1984). For this purpose, we used a logit model with gain and loss as independent variables, and acceptance as the dependent variable, for each affective condition and including gender as a covariate, to predict choices across all gain-loss combinations within the range used. These predictions can be visualized as a surface of predicted probabilities of acceptance across the gain-loss matrix (see Figure 4). In order to examine how negative stimuli influenced acceptance across these combinations, we compared predicted acceptance probabilities for the negative condition with the acceptance probabilities predicted for the neutral condition. Figure 4 demonstrates the differences from baseline for each condition as a heat map, where green signifies a increase from the neutral baseline and red denotes an increase. These results should be viewed as purely descriptive and therefore no correction for multiple comparisons was applied. As predicted by *Hypothesis 3*, gambles of ambiguous value were those more likely to be influenced by affect. A decrease in probability of acceptance following negative stimuli took place among gain-loss combinations peaking around 1.8.

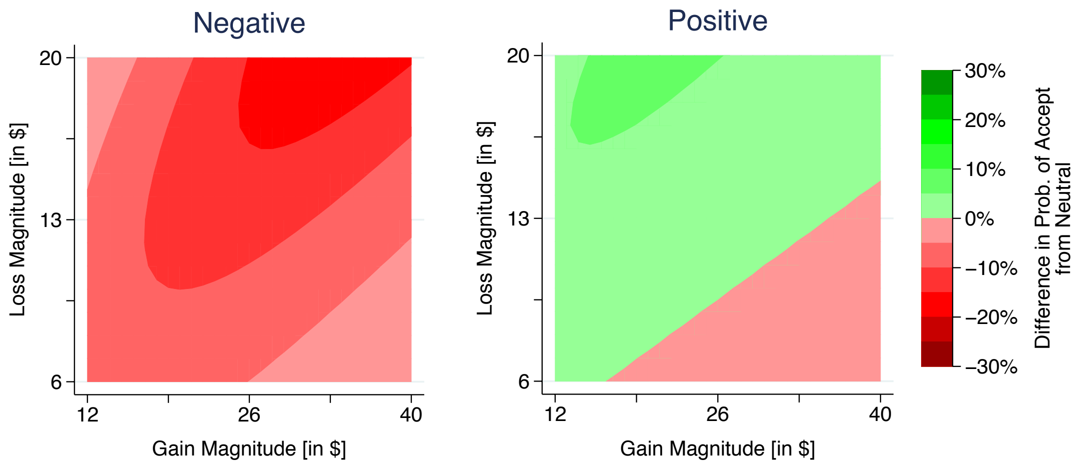

Figure 1.4: Changes in probability of accept across all gambles in affective categories as compared with the neutral category (Study 1). This figure shows contrasts in probabilities of accepting a gamble across affective categories and gain/loss combinations. The coloring indicates statistically significant positive (green) and negative (red) contrasts. Reported are adjusted predictions from a two-level logit model with subject-level random intercepts and gender as covariate.

Another way of examining these changes is comparing interesting features of the gambles accepted at the same predicted probability across conditions. We focused on the gain/loss ratio (GLR) of the gamble, associated with loss aversion, and the expected value (EV – calculated as half of the difference between the gain and the loss), which is a rough estimate of the overall value of the gamble. These two features enable us to roughly quantify the type of gambles accepted in the affective conditions. As with the heatmaps, we present these comparisons descriptive features of our data that aid in the understanding of our statistical results. Using the logit model, we found the predicted probability of the mean GLR (2.28) and EV ($6.50) values in the neutral condition (.83 and .82, respectively), and then found what GLR and EV values generated the same predicted probability in each affective category. These are noted in Figure 5. Mean GLR and EV increased greatly in the negative stimulus condition ($GLR_{negative}$ = 3.02, $EV_{negative}$ = \$9.53), as compared to the mean values. They did not change greatly in the positive stimulus condition ($GLR_{positive}$ = 2.23, $EV_{positive}$ = \$6.40).

These differences mean that, for example, if a gamble has a -$10 loss, participants were willing (on average) to accept it if the gain was at around $22 (GLR of 2.2) or more in the neutral condition, but were only willing to accept it if the gain was around $30 (GLR of 3) or more in the negative condition. An increase in EV of $3 means that participants required gambles to be worth $3 more on average in the negative condition, for them to accept the gamble. Overall, participants seem to require greater gain/loss ratios, and greater returns to accept gambles following negative stimuli.

These analyses show that participants do not simply accept fewer gambles in a random fashion when encountering negative stimuli. Participants accept gambles that have a greater unambiguously high value than in other conditions. These results can be explained by a change in strategy (participants become more selective following negative stimuli), but also by incidental influence on decision parameters (such as increased sensitivity to losses).

A more selective strategy aligns with Mood-as-Information and other theories that propose more calculative processing under low intensity negative moods (Bless, Clore, et al., 1996; Sinclair & Mark, 1992). In order to test this, we ran a logit model with expected value (EV), Stimulus Category, and EV x affective category interaction predicting acceptance, to see whether EV held greater weight in the negative condition. While both EV and Stimulus Category were significant predictors (EV: $F(1,13964) = 1544$, $p < .0001$; Stimulus Category: $F(2,13964) = 16.07$, $p < .0001$), the interaction was not significant ($F(2,13964) = 1.15$, $p = .32$). While participants were selective in which gambles they accepted following negative stimuli, they did not weigh the value of the gamble more heavily in this condition. This evidence suggests that the change in decision strategy was not due to more calculative processing, but to incidental influences on valuation processing under affective state. These findings also rule out global direct effects of affect on choice, since the weight of EV did not differ from neutral in either of the affective categories.

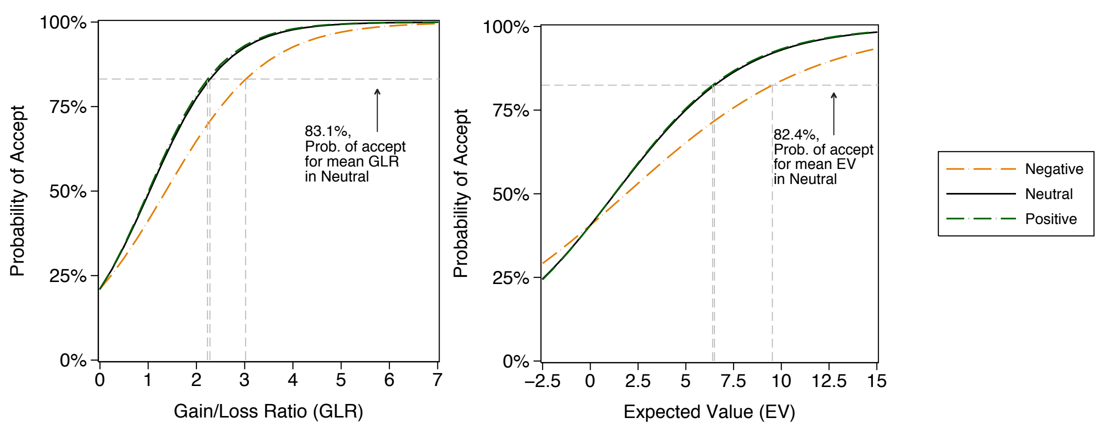

Figure 1.5: Probability of accepting a gamble by gain/loss ratio and expected value, across affective categories (Study 1). Results for gain/loss ratio (left) and expected value (right). This figure shows probabilities of accepting a gamble across affective categories. Reported are adjusted predictions from a two-level linear model with subject-level random intercepts and gender as covariate.

Prospect Theory Parameters. Further examination of decision strategies warranted the use of prospect theory modeling so that we could describe these changes in decision model parameters. As mentioned in the General Methods, we used a maximum likelihood estimation model (MLE) to estimate α and λ simultaneously for each experimental condition, enabling us to examine differences between affective conditions and the neutral condition in curvature and loss aversion. Overall, the model significantly predicted behavior in the negative stimulus condition ($\chi^2 = 9.10$, $p = 0.01$), but not in the positive stimulus condition ($\chi^2 = 2.93$, $p = 0.23$). We predicted that loss aversion would increase in the negative stimulus condition, due to a shift in focus on losses, whereas it would increase in the positive stimulus condition, where participants focus more on gains. In addition, we predicted that curvature would increase for both affective conditions.

λ indeed increased in the negative stimulus condition, c = 0.04, $p = .03$, CI [0.00; 0.07], and marginally decreased in the positive stimulus condition, c = -0.02, $p = .09$, CI [-0.04; 0.00]. Participants exhibited greater loss aversion ($\lambda_{negative} = 1.07$) in the negative stimulus condition, than in the neutral stimulus condition ($\lambda_{neutral} = 1.04$), and less loss aversion in the positive stimulus condition ($\lambda_{positive} = 1.02$). In addition, α decreased significantly in the negative stimulus condition, c = -0.03, $p < .01$, CI [-0.05; -0.01], although no significant difference was found for the positive condition (c = -0.01, $p = .30$, CI [-0.02; 0.01]). This decrease in curvature in both the gain and loss functions ($\alpha_{negative} = 0.21$, vs. $\alpha_{neutral} = 0.24$) can be interpreted as a decrease in sensitivity to scope in this condition. Interestingly, this effect relates to previous findings for choosing between positive affect-rich stimuli, in a riskless context (Hsee & Rottenstreich, 2004). These findings demonstrate that the decrease in gamble acceptance in the negative stimulus condition is associated with a higher degree of loss aversion, and a diminished sensitivity to scope of value.

Discussion

Affective stimuli appear to influence gamble decisions. Specifically, participants are less likely to accept gambles that were preceded by negative pictures. This effect is driven by participants' affective reactions to the unrelated images that alter their decision-making processes. Interestingly, although participants didn't exhibit significant changes in choice following positive stimuli, affective reactions still influenced their decisions, where a more positive reaction led to increased probability of acceptance. Differences in affective response to negative and positive stimuli might explain this asymmetry in effects. Another explanation might relate to the paradigm we utilized for this study. Previous research suggests that effects of incidental affect are moderated by attributions of the cause of the affective state (Schwarz & Clore, 1983). Rating stimuli might have made participants aware of their reactions, prompting them to discount their influence on subsequent decisions. If participants expected greater influence of positive stimuli on their choices, they might have discounted their influence to a greater degree. Nonetheless, our results demonstrate effects of both negative and positive stimuli on choice.

We found that change in decision behavior had monetary consequences: overall, participants accepted gambles that were of higher value following the viewing of unrelated negative imagery. The effect of negative stimuli can be characterized as a change in decision parameters, where participants become more loss averse, and less sensitive to changes in scope. Finally, participants were less likely to accept gambles that they considered ambiguous in value (as modeled by prospect theory value functions).

These findings present evidence for indirect effects of affective reactions on choice, through the altering of decision-making processes. These results support motivational-based theories in which negative affect is associated with increased focus on losses (with some evidence for the complementary effect for positive affect). This made participants' decisions under negative affect more selective, however, they did not demonstrate evidence for more calculative processing. They also didn't demonstrate general effects of arousal, since self-reported arousal was higher for positive stimuli, which demonstrated less influence than negative stimuli. Nonetheless, the limited effects of positive stimuli on choice and underlying parameters warrant further investigation. In order to address this issue and generalize our findings, we replicated this study in Study 2 with an entirely different set of stimuli.

Study 2

The previous study demonstrated that affective stimuli influence gamble choice through changes in underlying affective states. However, these stimuli represent only one type of affective stimuli, namely food. We wished to replicate our findings in another stimuli domain. Furthermore, although we found that negative stimuli significantly decreased acceptance of gambles, we did not find an increase following positive stimuli, as predicted. For these reasons, we conducted another study with the same methods, using a different stimuli domain – people. In addition, we expanded the three valence conditions (positive, neutral and negative) with an additional condition – sexual stimuli. Previous research has shown that these stimuli elicit highly positive reactions (Everaerd, Both, & Laan, 2009; Lang, Bradley, & Cuthbert, 1999), and have a demonstrable effect on decisions – namely more risk taking (Ariely & Loewenstein, 2006; Ditto, Pizarro, Epstein, Jacobson, & MacDonald, 2006; Knutson et al., 2008; Li et al., 2012). For these reasons, we wished to see how such pictures would influence gamble decisions in our paradigm. However, many of the previous experiments with sexual stimuli and decision making were conducted only on male subjects. Female subjects exhibit a more mixed reaction to such stimuli (for a review, see Rupp & Wallen, 2008), implying that they might not influence their behavior in the same way as they do for males. We therefore attempted to acquire sexual stimuli that were previously rated highly by females, and conducted all analyses with gender as a factor.

Methods

Participants. 103 (49 female) University of California, San Diego undergraduates participated in the study. No subjects were excluded from data analysis; only individual trials with missing accept/reject responses were dropped (5% of trials were dropped, on average, per participant).

Stimuli. The task followed the same timeline as that in Study 1. In this study, however, we used a different selection of stimuli. We used the IAPS database for the negative/neutral/positive stimuli conditions, specifically choosing pictures previously rated as most extremely negative or positive for the two affective conditions. Sexual stimuli were borrowed from Heather Rupp from the Kinsey Institute. These stimuli were gathered by her graduate students from online porn sites, and were rated by both males and females in the Kinsey Institute (stimuli used in Rupp & Wallen, 2007). We chose those rated highest by females, in order to get a more positive response from female subjects in our study. Overall, we had 201 unique trials for this experiment with 48 negative, 50 neutral, 53 positive, and 50 sexual pictures.

Results

Questionnaire Results. As in Study 1, participants responded to a questionnaire following the experiment that asked several questions about their beliefs regarding the study they participated in. These were the same 3 questions as those in the Study 1 questionnaire. Results were similar to those of Study 1. Most participants (62%) believed that were testing the effect of the pictures on subsequent gambles. Yet, as before, they did not have a coherent belief regarding what that relationship should be. Of those who describe a relationship, only 11% made correct predictions, while 33% predicted behavior that did not correspond with our findings. Again, 33% answered “yes” to the question “Were you suspicious of anything?”, but mostly of the nature of the pictures and the trial. A few examples of such responses:

“erotic pictures... ‘what the heck?’ was my reaction when I first saw the pictures”

“I was just wondering why were there a lot of family and friends pictures, sexual pictures, bloody pictures and individual random pictures. I don't see the correlation for some reason.”

“Yes. The pictures were very explicit.”

“Why was there a lot of pictures of black people compared to any other minority?”

In this study, only 9% believed that there was a correlation between the picture and the gamble’s value. We believe that these results do not suggest that participants’ beliefs regarding the study would influence their behavior. 65% of participants claimed to use a strategy, where most strategies described were either related to GLR, or to EV.

Acceptance Rate. Overall, affective stimuli influenced gamble choice, c^2 (3) = 196.01, $p < .001$. As in Study 1, a decrease in acceptance rate followed negative stimuli, c = -0.096, $p < .001$, CI [-0.113; -0.079]. Gambles were more likely to be accepted following positive stimuli, though only marginally so, c = 0.016, $p = .05$, CI [0.000; 0.033]. Interestingly, sexual stimuli were followed by a decrease in acceptance rate, c = -0.032, $p < .001$, CI [-0.049; -0.015].

As expected, these effects were influenced by the gender of the participants, as is demonstrated in a Gender x Stimulus Category effect, c^2 (4) = 44.12, $p < .001$ (results can be seen in Figure 6). Specifically, the genders varied in how sexual stimuli influenced their gamble choice compared to the neutral category. Males did not accept more or less gambles following sexual stimuli, c = 0.014, $p = .24$, CI [-0.009; 0.037], while females accepted significantly less gambles after viewing these pictures, c = -0.079, $p < .001$, CI [-0.103; -0.054].

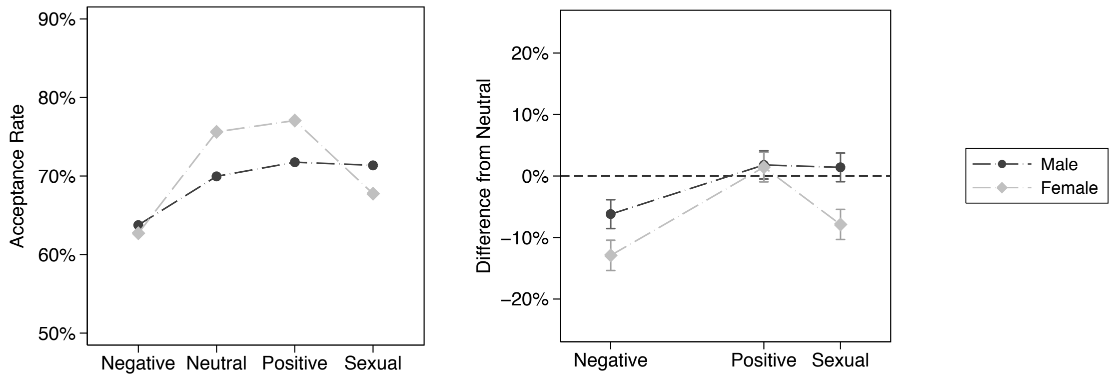

Figure 1.6: Acceptance rate across affective categories (Study 2). This figure shows acceptance rates across stimuli categories (left graph) and contrasts in acceptance rate relative to the neutral stimuli (right graph), split by gender. Reported are adjusted predictions from a two-level linear model with subject-level random intercepts and gender as covariate.

Valence and Arousal Ratings. Again, we examined whether stimuli categories influenced valence and arousal ratings. As expected, participants rated affective pictures differently than neutral pictures (Valence: c^2 (3) = 23,072.55, *p* < .001; Arousal: c^2 (3) = 6,530.80, *p* < .001). Overall, participants rated negative stimuli more negatively than neutral stimuli (c = -3.07, *p* < .001, CI [-3.13; -3.01]), and rated positive and sexual stimuli more positively than neutral stimuli (positive: c = 1.54, *p* < .001, CI [1.48; 1.60]; sexual: c = 0.40, *p* < .001, CI [0.33; 0.46]). All affective stimuli were rated as more arousing than neutral stimuli (negative: c = 1.52, *p* < .001, CI [1.45; 1.59]; positive: c = 0.72, *p* < .001, CI [0.65; 0.79]; sexual: c = 2.81, *p* < .001, CI [2.74; 2.88]).

However, these ratings interacted with gender (Valence x Gender*:* c^2 (4) = 1,713.35, *p* < .001; Arousal x Gender*:* c^2 (4) = 393.58, *p* < .001), see Figure 7. Interestingly, female participants rated sexual stimuli more negatively than neutral stimuli (c = -0.61, *p* < .001, CI [-0.70; -0.52]), while males rated these stimuli as more positive than neutral stimuli (c = -1.41, $p < .001$, CI [1.32; 1.49]). In addition, although both genders rate sexual stimuli as significantly more arousing than neutral, this increase in arousal is significantly greater for males, as compared to the increase for females (contrast comparing the difference between sexual stimuli and neutral stimuli for females vs. males: c = -1.44, $p < .001$, CI [-2.04; -0.85]). These results correspond to earlier research on gender differences in affective reactions to sexual stimuli, where males generally react positively to such stimuli, and women have a more ambiguous and context-sensitive response (Bradley, Codispoti, Sabatinelli, & Lang, 2001; Dekker & Everaerd, 1988; Everaerd, Both, & Laan, 2009; Rupp & Wallen, 2008; Sabatinelli, 2004).

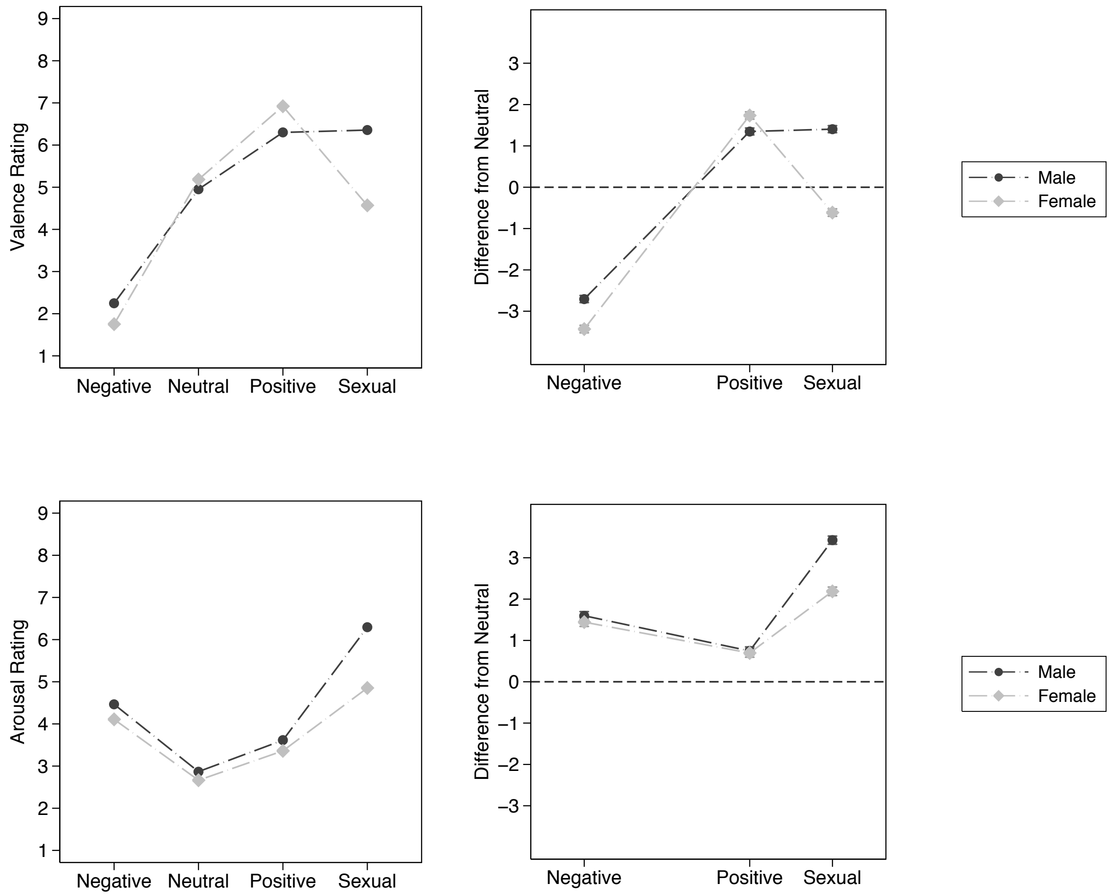

Figure 1.7: Valence and arousal ratings across affective categories (Study 2). This figure shows valence ratings (top panel) and arousal ratings (bottom panel) across affective categories (left) and contrasts in ratings relative to the neutral stimuli (right), split by gender. Reported are adjusted predictions from a two-level linear model with subject-level random intercepts and gender as covariate.

Following our results in Study 1, we conducted mediation analyses to test whether these affective reactions, measured through ratings of Valence and Arousal, might mediate the effect of stimulus category on choice. These analyses were conducted separately for each affective condition, and each gender. Table 1 details the effects across all conditions and genders. When holding Valence and Arousal constant, we find that none of the affective stimuli conditions hold a significant direct affect on acceptance (see

Table 1). However, Valence and Arousal significantly mediate the effects of Stimulus Category on gamble choice in every affective condition, for both genders. Interestingly, we find a marginally significant direct effect of sexual stimuli on gamble choice for females. This finding suggests that for females, there might be more complicated reactions to sexual stimuli, beyond basic affect, that might influence behavior. This certainly corresponds with previous research on female sexual attitudes (Bradley et al., 2001; Janssen, Carpenter, & Graham, 2003; Rupp & Wallen, 2008), and warrants further research. However, on the whole, these findings clearly demonstrate the role affective response plays in guiding gamble acceptance.

Furthermore, sexual stimuli are a particularly interesting type of stimuli. They are considered generally highly rewarding (e.g., Everaerd et al., 2009), however, as evidenced in our findings, can induce negative response. They are also associated with concepts of risk taking and competition (Buss, 1995). Theories of semantic priming (Bower, 1991; Forgas, 1995) would claim that such stimuli would invoke risk-taking behaviors, such as accepting more gambles in our paradigm. However, our findings demonstrate the opposite of this – neither genders accepted more gambles following sexual stimuli, and females even accepted fewer gambles in this condition. On the whole, these findings clearly demonstrate the role affective response plays in guiding gamble acceptance. They corroborate with theories that require changes in underlying affective states to influence behavior, such as affect-as-information (Schwarz & Clore, 1988).

Table 1.1: Affective mediation of the effect of stimulus category on acceptance (Study 2). Coefficient estimates of the direct and indirect effects of stimulus category on acceptance rates, where both valence and arousal are included as mediators in the model. Direct effects demonstrate the effect of stimulus category on acceptance rate holding valence and arousal constant, whereas indirect effects demonstrate the product of the effect of stimulus category on valence/arousal (a), and the effect of valence/arousal on acceptance (b). Bootstrap confidence intervals (bias-corrected; 10,000 replications) for the indirect effects.

		Coefficient	[95% CI]	*p*
Males				
direct effect *c'*	Negative	0.003	[-0.046; 0.053]	0.89
	Positive	-0.009	[-0.036; 0.019]	0.52
	Sexual	-0.002	[-0.048; 0.044]	0.93
Valence indirect effect *a x b*	Negative	-0.058	[-0.068; -0.047]	< 0.001
	Positive	0.029	[0.024; 0.035]	< 0.001
	Sexual	0.031	[0.025; 0.037]	< 0.001
Arousal indirect effect *a x b*	Negative	-0.005	[-0.010; -0.001]	< .05
	Positive	-0.003	[-0.005; -0.000]	< .05
	Sexual	-0.011	[-0.021; -0.002]	< .05
Females				
direct effect *c'*	Negative	-0.050	[-0.118; 0.017]	0.14
	Positive	-0.021	[-0.052; 0.011]	0.20
	Sexual	-0.058	[-0.116; -0.000]	0.05
Valence indirect effect *a x b*	Negative	-0.074	[-0.087; -0.060]	< 0.001
	Positive	0.038	[0.030; 0.045]	< 0.001
	Sexual	-0.013	[-0.017; -0.010]	< 0.001
Arousal indirect effect *a x b*	Negative	-0.005	[-0.009; -0.001]	< .05
	Positive	-0.002	[-0.004; -0.000]	< .05
	Sexual	-0.007	[-0.013; -0.001]	< .05

Probability of Accepting a Gamble. As in Study 1, we used a logit model to generate predicted probabilities of acceptance across the gain-loss matrix. Figure 8 presents the heat map of the differences from a neutral baseline to each affect condition (columns), by gender (rows). The negative condition shows a predicted decrease of acceptance for gain-loss combinations that peak around 1.8. Interestingly, we find a similar pattern for the sexual stimuli condition, in females. It appears that sexual stimuli lead to a negative affective reaction for females, and therefore produced effects similar to negative stimuli on behavior. On the other hand, the positive stimulus condition demonstrates a slight increase in acceptance around that same set of gambles. The results suggest that affect specifically influence gambles whose value is ambiguous to participants.

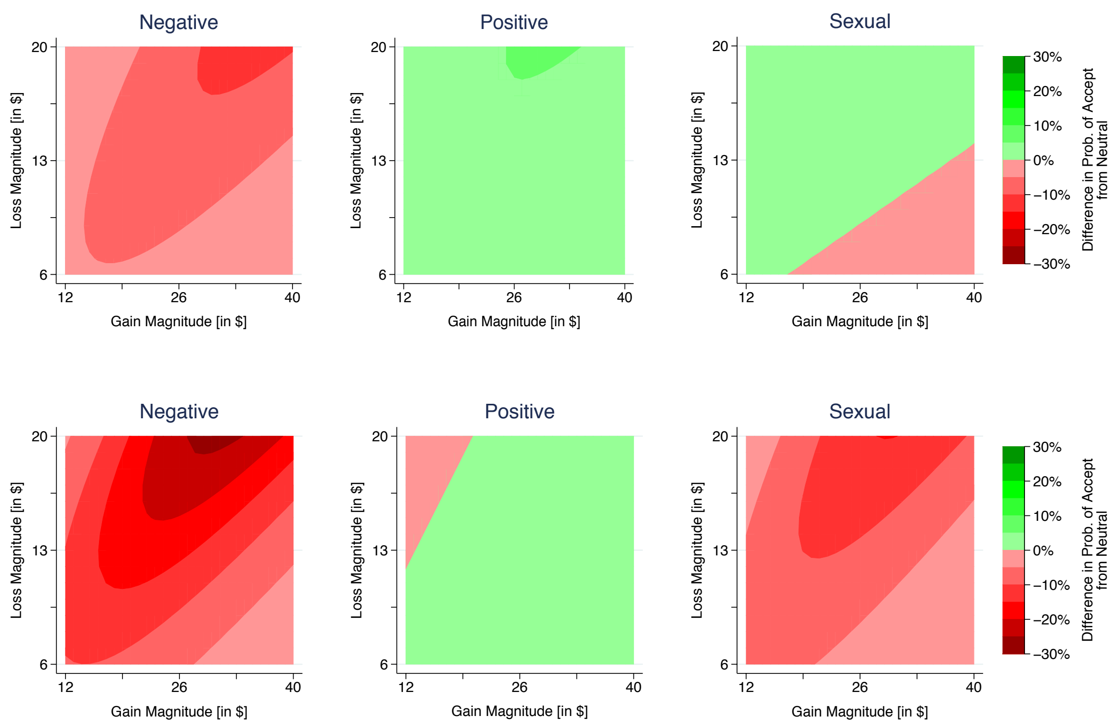

Figure 1.8: Changes in probability of accept across all gambles in affective categories as compared with the neutral category (Study 2). This figure shows contrasts in probabilities of accepting a gamble across affective categories and gain/loss combinations for male (top panel) and female (bottom panel). The coloring indicates statistically significant positive (green) and negative (red) contrasts. Reported are adjusted predictions from a two-level logit model with subject-level random intercepts and gender as covariate.

We again used the predicted probability of mean GLR and EV values in the neutral condition as a point of comparison of GLR and EV across conditions and genders (.79 and .78 for males; .88 and .85 for females). These differences can be seen in Figure

9. This shift is especially prominent in females. GLR of gambles accepted by females increase in both the negative and sexual stimuli conditions ($GLR_{negative}$ = 3.27, $GLR_{positive}$ = 2.16, GLR_{sexual} = 2.87). Females accept gambles that have GLR of 1 more than average in the negative condition, and 0.60 in the sexual condition. EV of gambles in these conditions shift greatly as well: females accept gambles that are worth $4 more in the negative condition, on average, than those they accepted throughout the experiment. EV increased as well for gambles accepted in the sexual stimulus condition – an increase of $2.20 ($EV_{negative}$ = $10.52, $EV_{positive}$ = $5.95, EV_{sexual} = $8.70). For males, GLR increases by 0.50 in the negative stimulus condition, and doesn't change much in the other conditions ($GLR_{negative}$ = 2.76, $GLR_{positive}$ = 2.16, GLR_{sexual} = 2.27). EV of gambles accepted by males increases by $1.60 in the negative condition as well. However, we also find that the EV of gambles decreases, although by a smaller amount, $0.50, in the positive stimulus condition. EV doesn't change greatly for gambles accepted in the sexual stimulus condition ($EV_{negative}$ = $8.08, $EV_{positive}$ = $5.96, EV_{sexual} = $6.40).

These numbers are similar to those found in Study 1, suggesting that the shift in decisions apply specifically to gambles that seem more risky and of a questionable value. However, they also suggest that there may be small shifts in behavior in the positive stimulus condition, in the opposite directions. This corresponds to our findings that valence mediates behavior within the positive stimulus condition, although we didn't see any significant shifts in acceptance. Interestingly, females show greater changes in GLR and EV than males, suggesting they might be more sensitive to these effects. Overall, they demonstrate that affect influences choice in a more strategic manner, targeting decisions that we are more unsure of.

As in Study 1, we ran a logit model with expected value (EV), affective category, EV x affective category interaction predicting acceptance, separately for each gender, to see whether EV held greater weight in the negative condition, or across all affective conditions, as compared with neutral. For both genders we found that both EV and stimulus category were significant predictors (males EV: $F(1,10846) = 1162$, $p < .0001$; stimulus category: $F(3, 10846) = 5.54$, $p < .0001$; females EV: $F(1,9841) = 1228$, $p < .0001$; stimulus category: $F(3, 9841) = 10.05$, $p < .0001$), but the interaction was not significant (males*:* $F(3, 10846) = 0.77$, $p = .51$; females*: :* $F(3, 9841) = 1.75$, $p = .15$). These findings replicate those of Study 1, demonstrating that the change in acceptance is neither due to global effects of affect, nor to indirect influences on processing mode.

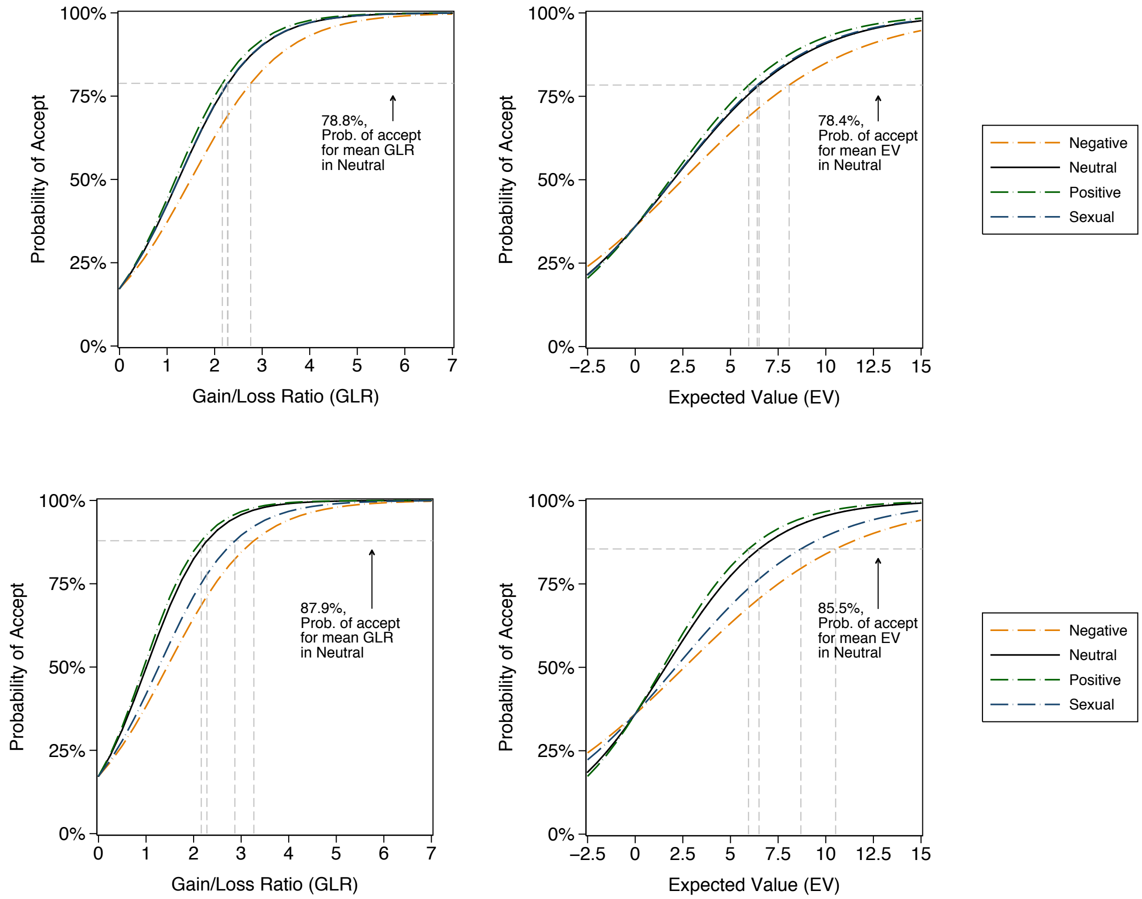

Figure 1.9: Probability of accepting a gamble by gain/loss ratio and expected value, across affective categories (Study 2). Results for gain/loss ratio (left) and expected value (right). This figure shows probabilities of accepting a gamble across affective categories for males (top), and females (bottom). Reported are adjusted predictions from a two-level linear model with subject-level random intercepts and gender as covariate.

Prospect Theory Parameters. As in Study 1, we used an MLE model to estimate prospect theory parameters for each stimulus condition, enabling us to compare estimates of α and λ across affective conditions. Overall, the model significantly predicted choice in the negative stimulus condition ($\chi^2 = 10.18$, $p < .01$), marginally predicted choice in the positive stimulus condition ($\chi^2 = 5.03$, $p = .08$), and did not significantly predict choice in the sexual condition ($\chi^2 = 4.04$, $p = 0.13$). λ estimations differed significantly only for the negative stimulus condition, c = 0.05, p = .01, CI [0.01; 0.09]. Participants were more loss averse in the negative stimulus condition, $\lambda_{negative}$ = 1.10, as compared to the neutral stimulus condition, $\lambda_{neutral}$ = 1.05. This increase in loss aversion can be seen in both genders (males: $\lambda_{negative}$ = 1.09, $\lambda_{neutral}$ = 1.06, c = 0.03, p = .04, CI [0.00; 0.06], females: $\lambda_{negative}$ = 1.11, $\lambda_{neutral}$ = 1.04, c = 0.07, p = .02, CI [0.01; 0.13]). In addition, participants again showed a decrease in α in the negative stimulus condition ($\alpha_{negative}$ = 0.26, $\alpha_{neutral}$ = 0.29, c = -0.02, p = .02, CI [-0.04; -0.00]), as well as in the sexual stimulus condition (α_{sexual} = 0.27, c = -0.02, p = .08, CI [-0.04; 0.00]), although only marginally so. When examining the genders separately, we find that this effect is driven by the female participants, who show a significant decrease in curvature (increase in α) in both the negative and sexual stimuli conditions ($\alpha_{negative}$ = 0.26, $\alpha_{neutral}$ = 0.30, α_{sexual} = 0.27, negative contrast c = -0.03, p = .02, CI [-0.06; -0.01], sexual contrast c = -0.03, p = .05, CI [-0.06; -0.00). No significant changes in α were found for male participants.

Discussion

This study sought to replicate and extend the findings from our previous study. Indeed, we find that negative pictures of people produce the same effect as negative pictures of food – participants accept less gambles after viewing these pictures. Surprisingly, we did not find the opposite effect for this set of sexual pictures, which we hoped would serve as highly positive stimuli. Female participants even accepted less gambles following these pictures. Looking closely at participants' affective ratings, we find that they did not view this particular set of stimuli as highly positive, as expected, and female participants even rated them negatively. So, while these stimuli failed as positive stimuli, they provided another chance to demonstrate the relationship between affective state, uncoupled to the type of stimuli, and gamble decisions. Mediation analyses show just that – affective ratings mediate the effects of stimuli condition on gamble choice, regardless of condition. Further, the effects on decision strategy replicate those in the previous study – in both the negative condition, and sexual stimuli condition specifically for females, we see participants accepting less ambiguously valued gambles, such that overall the expected value of the gambles they do accept is higher in these conditions, than in the neutral condition. Looking at prospect theory parameters, we see that loss aversion increased in these conditions, as expected.

Overall, we find that negative affect leads to a decrease in gamble acceptance. This appears to be associated with a general negative state, and not to specific type of negative stimuli. This effect is associated with an increase in loss aversion, and not simply a decrease in acceptance of any gambles.

Study 3

Both study 1 and 2 present a robust effect of negative stimuli on gamble acceptance. This effect doesn't appear to be associated with a particular type of stimuli, since it occurs with both pictures of humans and food, and even differed across the genders in the case of sexual stimuli. Interestingly, mediation analyses of participants' ratings of these stimuli suggest that emotional pictures influence choice through changes in internal affective states. However, subjective ratings are not always a reliable means of accessing internal states, and can be influenced by other processes. In order to further pursue the connection between changes in internal affective states and gamble choice, we conducted the next study using a different means of measuring affect, facial electromyography (EMG). Facial EMG allows the recording of activity in facial muscles involved in smiling or frowning, and these have been reliably associated with positive and negative affective states, respectively (Cacioppo, Petty, Losch, & Kim, 1986). This method also allows us to measure affective states in a rather implicit manner, since participants are not explicitly made aware of the connection between the electrodes and their own affective states. With the use of this method, we record facial muscle activity while participants view stimuli and make gamble decisions, similar to the task in studies 1 and 2. We predicted that facial muscle activity will demonstrate an affective response to the stimuli, that is, participants will frown but not smile to negative stimuli. In addition, we predict that the EMG response will overlap with the decision portion of the task, demonstrating that incidental affective reactions occur at the same time as affective reactions to the gamble during the decision.

Decisions made in the previous two studies were entirely hypothetical – participants did not receive monetary compensation for participation (they received class credit), and their gambles were not fulfilled. It is unclear if the effect of emotional stimuli on choice is more likely to occur when decisions have no real consequences for the participants. For this reason, we made this experiment incentive compatible. Participants were paid for participation, and were told that we would select a random gamble to honor for real money. That is, if they made a choice to accept that gamble, they will win/lose according to the payoffs. Compensation for participation was such that they could at most lose all of their experiment compensation. However, they could win up to an additional $40.

Methods

Participants. 21 (11 female) University of California, San Diego undergraduates, participated in the study. No subjects were excluded from data analysis; only individual trials with missing accept/reject responses were dropped (4% were dropped, on average, per participant).

Monetary Incentive. Participants were compensated with $20 for participation. Participants were told that one trial would be chosen randomly, and that if they had accepted that gamble, we would play it out and honor the outcome. Due to the range of the gains and losses (described above in General Methods) participants could gain up to $40 and lose up to $20, such that they could either lose their entire compensation, or walk away with $60. Roughly half (11) of the participants accepted the gamble chosen, and out of those who did, the average outcome was -$3.10.

Stimuli. We focused on human stimuli for this experiment as in Study 2. Since we previously did not find a difference between positive and neutral conditions, we only used a negative, neutral and sexual stimuli condition. We selected a smaller set of pictures (35) from the set we had in Study 2 for the negative and neutral affective condition. For sexual stimuli, we selected a set of erotic couples from the IAPS database, to examine whether the effects found might have been associated with a specific set of stimuli. We removed the stimulus rating phase, since we did not want participants to consciously monitor their affective state during the experiment (see Figure 10 for an outline of a trial). However, we did add a shape cue associated with the stimuli category (square for negative, triangle for neutral, circle for sexual stimuli), since previous studies demonstrated that anticipation of affective stimuli can intensify the response (Knutson & Greer, 2008; O'Doherty, Deichmann, Critchley, & Dolan, 2002). These cues were not explained to the participants in order not to raise their awareness to this anticipation phase. We had 105 unique trials (35 each for negative, neutral, and sexual), with the gamble task the same as in the previous two experiments.

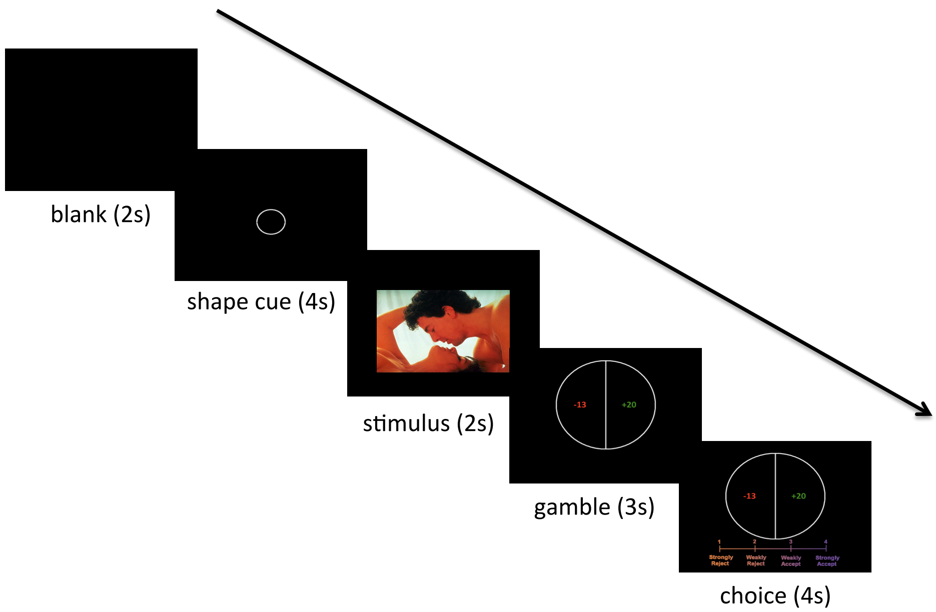

Figure 1.10: Affect gamble task (Study 3). During each task, participants first were shown an anticipatory shape and then viewed a picture. They were then presented with a gamble, and then asked to make a choice on a 4-point scale, ranging from Strongly Reject to Strongly Accept.

EMG and SCR Recording. EMG was measured by pairs of 4-mm electrodes over the regions of zygomaticus major (cheek) and corrugator supercilii (brow), according to EMG processing standards (Tassinary & Cacioppo, 2000). For the zygomaticus major muscle, the first electrode was placed in the middle of an imaginary line between the lip corner at rest, and the point where the jaws meet (approximately near the ear lobe). The second electrode was placed a collar width (approximately 1 cm) posterior to the first. For the corrugator supercilli muscle, the first electrode was placed right above the eyebrow, on an invisible vertical line from the corner of the eye up. The second electrode was placed a collar width posterior to the first (following the eyebrow arch). AcqKnowledge software (Biopac Systems, Goleta, CA) along with Biopac (Biopac Systems, Goleta, CA) were employed to acquire the EMG signal. The amplified EMG signals were filtered online with a low-pass of 500 Hz and a high-pass of 10 Hz, sampled at a rate of 2000 Hz, and then integrated and rectified using Mindware EMG software, version 2.52 (MindWare Technologies Ltd., Ohio, USA). Measurements were averaged in 500 ms intervals, resulting in 30 observations for the 15 seconds duration of each trial.

<u>Results</u>

Acceptance Rate. Affective stimuli significantly influenced gamble choice, c^2 (2) = 15.23, $p < .001$). As in Study 1 and 2, participants accepted significantly less gambles following negative stimuli, c = -0.090, $p < .001$, CI [-0.136; -0.045]. The Gender x Stimulus Category effect was marginally significant, (c^2 (3) = 6.55, $p = .09$), with the smaller sample size muting the statistical significance. Interestingly, the pattern of responses to sexual stimuli is similar to that of Study 2 – females demonstrate a decrease in acceptance (c = -0.089, $p < .01$, CI [-0.152; -0.026]), while males show no change from neutral (c = 0.012, $p = .72$, CI [-0.054; 0.077]). Results can be seen in Figure 11.

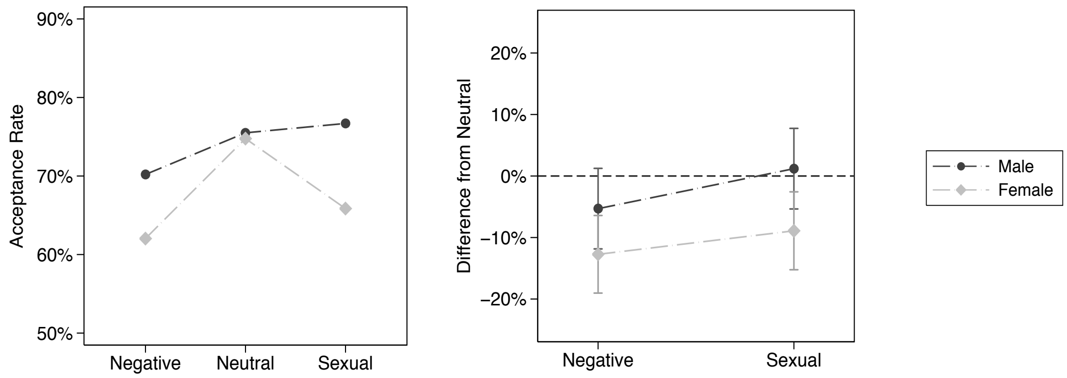

Figure 1.11: Acceptance rates across affective categories (Study 3). This figure shows acceptance rates across stimuli categories (left) and contrasts in acceptance rate relative to the neutral stimuli (right), split by gender. Reported are adjusted predictions from a two-level linear model with subject-level random intercepts and gender as covariate.

EMG and SCR Measures. We report results from two types of analysis. First, we examine the average measurements for the stimulus segment (2s) to inspect whether presenting the stimulus affects EMG responses. SCR responses are slower (in the order of seconds) which is why we did not analyze them isolated for the stimulus segment. Second, we leverage the time series nature of the observations and analyze how EMG and SCR measurements vary over the duration of the post-stimulus phase.

In line with other studies employing EMG and SCR measures, we winsorized the measurements at three times the standard deviation on the trial-level to account for extreme outliers. To further account for differences in baseline activity, we measured the average activity during the pre-stimulus phase (blank slide and shape; see Figure 10) as a baseline on the trial-level, and subtracted it from each datapoint in the following analyses.

EMG Responses to the Stimulus. First, we compared facial EMG (corrugator and zygomaticus) responses to stimulus pictures across the affective categories. We compared the mean of the muscle activity for the two seconds of the stimulus phase. Results are shown in Figure 12.

Corrugator responses differed across affective categories (c^2 (2) = 26.53, $p < .001$). Participants frowned more to negative stimuli than to neutral stimuli, c = 303.36, $p < .001$, CI [176.96; 429.75]. Sexual stimuli did not elicit different corrugator responses (c = 35.06, $p = .59$, CI [-91.63; 161.74]). This effect generalized across the genders – the Gender x Stimulus Category interaction was not significant (c^2 (3) = 1.11, $p = .77$). Zygomaticus activity differed marginally across categories (c^2 (2) = 5.44, $p = .07$), and is mostly due to a decrease in smiling for females in the sexual condition (c = -488.71, $p = .08$, CI [-1034.80; 57.38]).

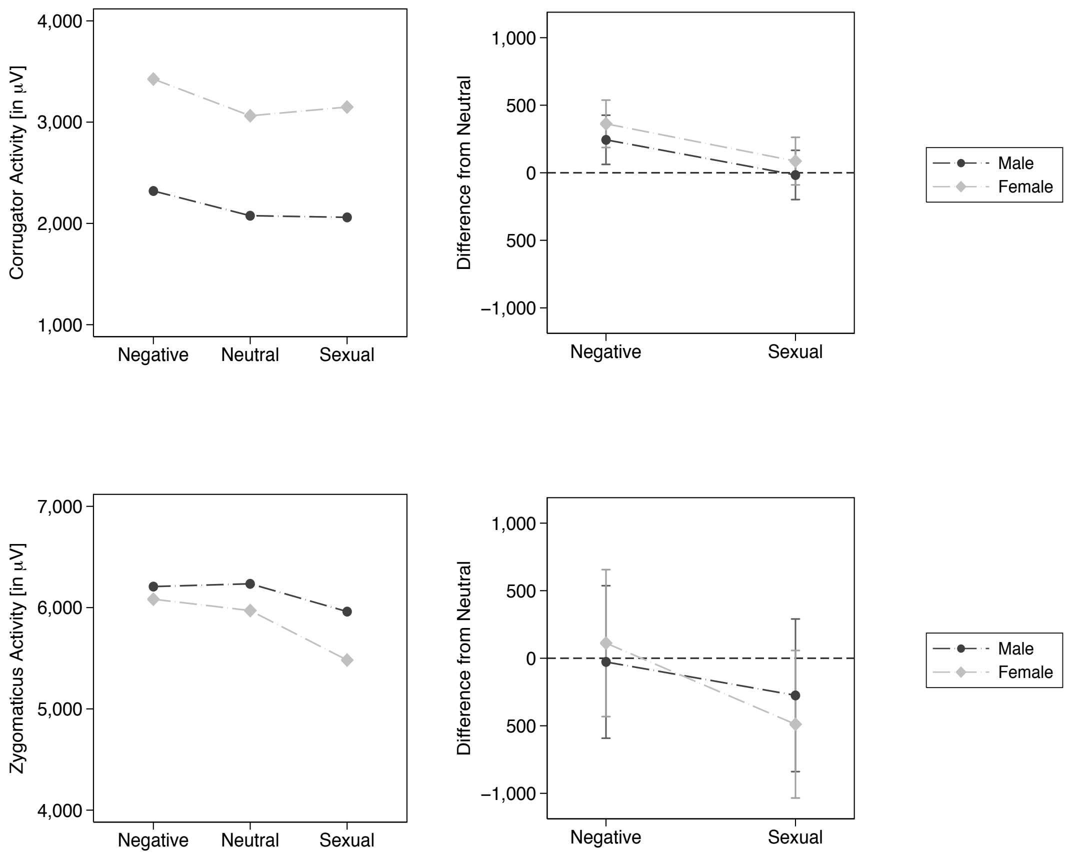

Figure 1.12: Mean EMG corrugator & zygomaticus reactions during stimuli viewing, across affective categories. This figure shows EMG corrugator (top panel) and EMG zygomaticus (bottom panel) measures [in mV] across affective categories (left) and contrasts in measures relative to the neutral stimuli (right), split by gender. Reported are adjusted predictions from a two-level linear model with subject-level random intercepts and gender as covariate.

EMG Responses During the Duration of the Trial. Measuring physiological affective response over the entire trial allows us to determine how long affective responses might last, demonstrating that these long responses might be related to the influences we demonstrate in gamble choice.

We estimated a three-level model with measurements nested in trials and trials nested in subjects. Random intercepts are modeled on the subject-level. To additionally account for the time series nature of the observations, we model the residuals to follow an autoregressive process of order 1 on the trial-level (AR(1)). In line with our main analysis strategy, we wished to compare EMG reactions between affective stimuli conditions and neutral. Therefore, we tested two contrasts comparing each affective condition, negative and sexual, with neutral, for each muscle and gender. These contrasts are plotted across time for each affective condition and muscle in Figure 13.

Both genders frowned more when viewing negative stimuli as compared with neutral stimuli, as is demonstrated by significant positive differences in corrugator activity between these two conditions (males: c = 220.37, $p < .001$, CI [98.84; 341.89], females: c = 330.74, $p < .001$, CI [213.64; 447.85]). However, females also frowned more when viewing sexual stimuli, albeit this effect was only marginally significant (c = 101.64, $p = 0.09$, CI [-15.91; 219.19]).

Activity in the zygomaticus muscle differed across the genders. Zygomaticus activity increased significantly in the negative stimulus condition for females (c = 623.42, $p < .05$, CI [82.98; 1163.86]), but not for males. On the other hand, it decreased significantly for males in the sexual stimulus condition for males (c = -564.87, $p < .05$, CI [-1126.18; -3.57]), but not for females. These findings are intriguing considering that zygomaticus activity is associated with positive affect. However, unlike the corrugator, zygomaticus activity varied greatly over the trial, as can be seen in Figure 13, and doesn't correspond with a change necessarily triggered by the stimulus itself, as is suggested by the above analyses focusing on the stimulus phase. One possibility is that the zygomaticus is sensitive to affective reactions to the *removal* of emotional pictures. That is, females are relieved after the removal of a negative stimulus, and males are less happy about the removal of a sexual stimulus. Indeed, as mentioned above, females show an initial (albeit marginal) decrease in zygomaticus activity in response to sexual stimuli as compared to neutral. However, their zygomaticus activity increases significantly from that phase to the subsequent gamble phase (c = 1207.14, $p < 0.01$, CI [434.26; 1980.02]) in the negative condition, as well as the sexual condition (c = 840.02, $p < .05$, CI [60.80; 16119.25]).

Arousal, as measured with SCR, did not increase significantly for the affective conditions, except for males viewing sexual stimuli (c = 637.23, $p < .05$, CI [8.63; 1265.83]). Not surprisingly, males exhibit an increase in arousal when viewing sexual stimuli.

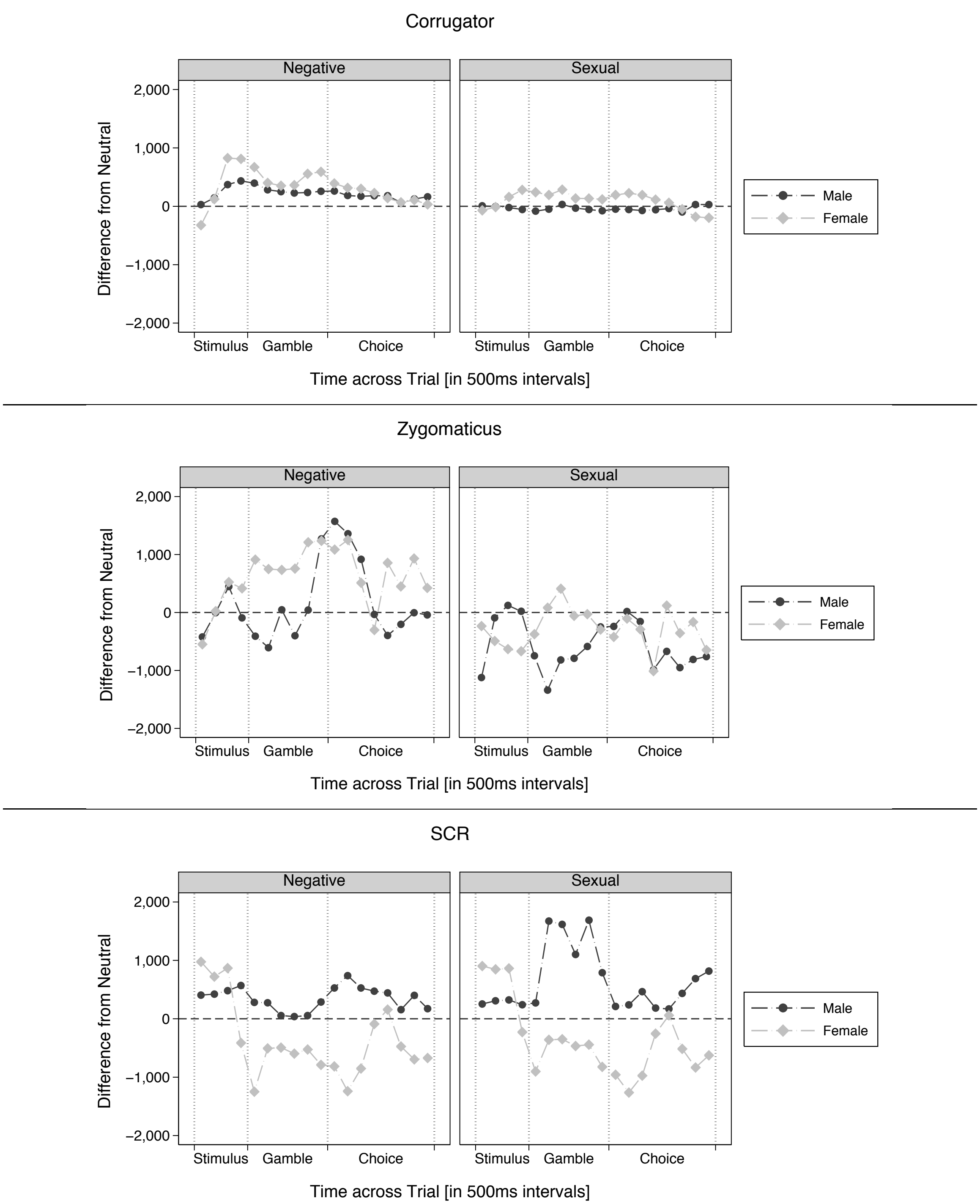

Figure 1.13: EMG and SCR activity across the duration of the trial. This figure shows contrasts in EMG corrugator (top panel) and EMG zygomaticus (middle panel) measures as well as SCR measures (bottom panel) [all in mV] relative to the neutral stimuli. Reported are adjusted predictions from a three-level linear model with subject-level random intercepts, gender as covariate, and an autoregressive process of order 1 on the trial-level (AR(1)).

Probability of Accepting a Gamble. We used a logit model as in the previous studies to examine which decisions are influenced by affective responses. Looking at Figure 14, we find that the decrease in predicted probability of accept is greater for gambles with a gain/loss ratio of around 2. Females show a greater decrease in both affective conditions, while males show a small decrease only in the negative stimulus condition.

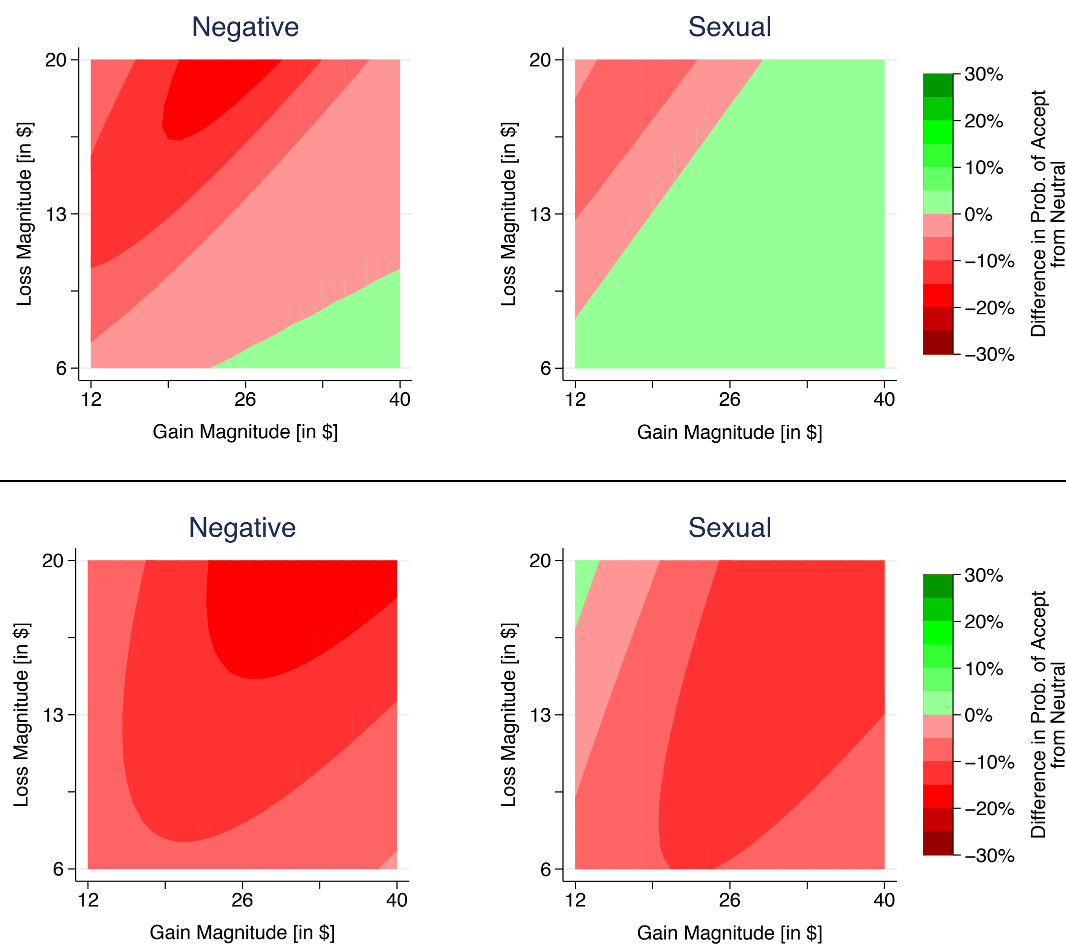

Figure 1.14: Changes in probability of accept across all gambles in affective categories as compared with the neutral category (Study 3). This figure shows contrasts in probabilities of accepting a gamble across stimuli categories and gain/loss combinations for male (top panel) and female (bottom panel). The coloring indicates statistically significant positive (green) and negative (red) contrasts. Reported are adjusted predictions from a two-level logit model with subject-level random intercepts and gender as covariate.

When examining GLR and EV (predicted probabilities .96 and .90 for males; .67 and .75 for females), we find similar numbers to those of the previous studies. Females accept gambles that have a GLR of 1 greater than average, in both the negative and sexual stimulus conditions ($GLR_{negative}$ = 3.38, GLR_{sexual} = 5.89). EV of the gambles chosen by females in these conditions also increases greatly, by around $4 ($EV_{negative}$ = 10.59, EV_{sexual} = 10.29). Males show very small shifts in GLR ($GLR_{negative}$ = 2.54, GLR_{sexual} = 2.23) and EV ($EV_{negative}$ = 7.34, EV_{sexual} = 5.89), although again GLR and EV increase in the negative stimulus condition, and decrease in the sexual stimulus condition. These findings align with their positive affective response to those stimuli, where females demonstrate a negative response. As in Study 1 and 2, we find that affect targets ambiguous decisions, causing a decrease in risk taking after viewing negative stimuli, and potentially an increase in risky behavior following the viewing of positive stimuli.

A logit model including EV, affective category and the interaction was run for each gender. Here we found that EV was significant for both genders (*males*: $F(1,1044) = 181.85$, $p < .0001$; *females*: $F(1,1149) = 108.33$, $p < .0001$), but that affective category was only marginally significant for males (*males:* $F(2,1044) = 2.44$, $p = .08$; *females:* $F(2,1149) = 0.88$, $p = .42$). As in Studies 1 and 2, the interaction of affective category and EV was not significant ((*males:* $F(2,1044) = 0.43$, $p = .65$; *females:* $F(2,1149) = 0.34$, $p = .71$), ruling out both global direct effects and processing mode effects of affect on choice.

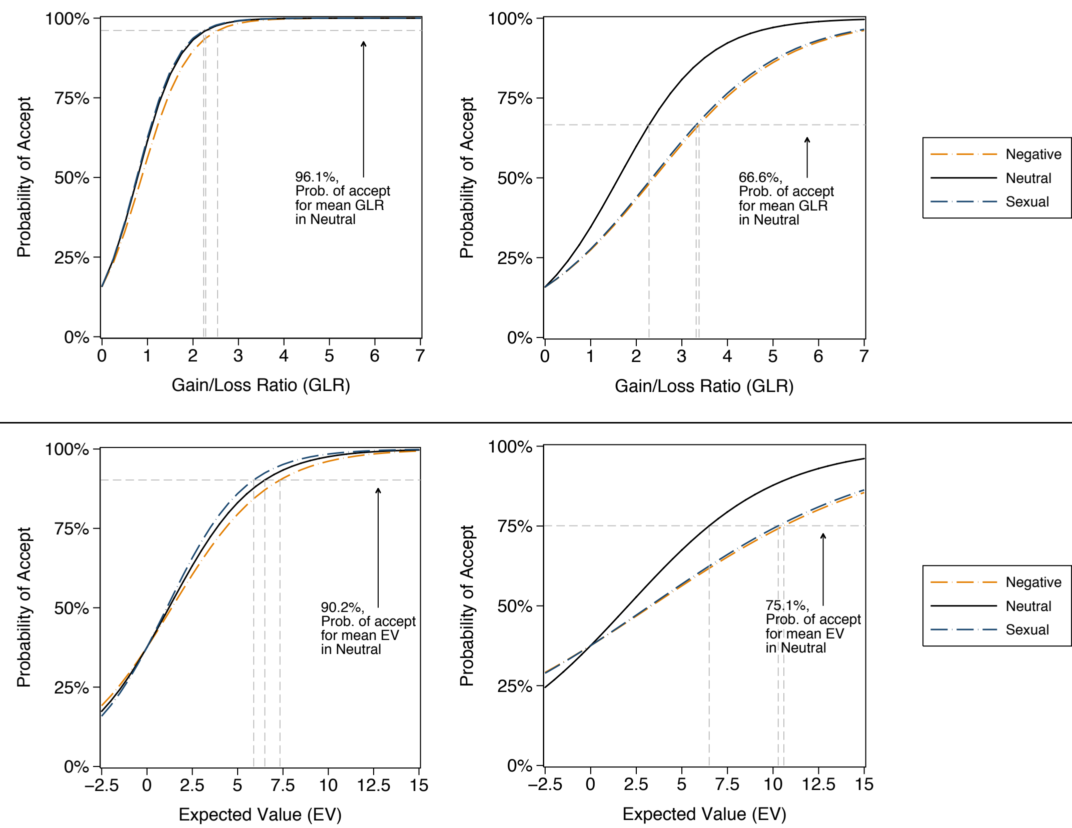

Figure 1.15: Probability of accepting a gamble by gain/loss ratio and expected value, across affective categories (Study 3). Results for gain/loss ratio (right) and expected value (left). This figure shows probabilities of accepting a gamble across affective categories for males (top) and females (bottom). Reported are adjusted predictions from a two-level linear model with subject-level random intercepts and gender as covariate.

Prospect Theory Parameters. We fitted a prospect theory model over the data in each condition, and compared the estimated parameters across affective categories, as before. We found similar effects as in Studies 1 and 2, however they were dampened by the smaller number of participants. The overall fit of the model was not significant for either affective condition ($\chi^2_{negative} = 3.49$, $p = 0.17$, $\chi^2_{sexual} = 1.91$, $p = 0.39$). As expected, λ increased in the negative stimulus condition, c = 0.06, $p = .06$, CI [-0.00; 0.12], although only marginally so, but did not significantly change in the sexual stimulus condition, $\lambda_{sexual} = 1.06$. Participants were more loss averse in the negative stimulus condition, $\lambda_{neutral} = 1.03$, $\lambda_{negative} = 1.09$. When examining the genders separately, we found that this increase was only significant for males, $\lambda_{neutral} = 1.06$, $\lambda_{negative} = 1.12$ c = 0.05, $p = .04$, CI [0.00; 0.10]. However, females demonstrated a marginally significant decrease in α during the negative stimulus condition, $\alpha_{neutral} = 0.25$, $\alpha_{negative} = 0.21$ c = -0.04, $p = .08$, CI = [-0.08; 0.01]. This effect was not significant for males, or overall across genders. Although it is interesting that negative stimuli influenced different decision parameters in the two genders, in light of the results of the previous two studies, these different effects are mostly likely due to the small subject number in this particular study. No changes in parameter estimates were found for the sexual stimulus condition in either gender.

Discussion

This study demonstrated further evidence for the effect of incidental negative stimuli on gamble choice. Participants again accepted less gambles following negative stimuli. However, in this study participants' decisions were not hypothetical – they actually won or lost money based on their decisions. This fact, together with the participants' knowledge that the stimuli have no relation to the gamble decision they are making, suggests that participants are either unaware of this influence, or that they cannot control its effect on their behavior.

Study 1 and 2 demonstrated a possible relationship between participants' affective responses to the stimuli and their decisions. In order to further explore this relationship, we employed a measurement that allows us to examine subtle affective reactions that might not be easily accessed through individual ratings – facial EMG. Facial EMG demonstrated effects of affective stimuli, as expected. However, these psychophysical measurements present a few more interesting findings. First, they are measured in a more implicit manner – participants are not aware that we are measuring their emotional reactions. Therefore, we assume that these reactions are less subject to demand effects and other known influences on subjective ratings. In addition, we were able to measure these reactions across time, enabling us to see the extent in time of such reactions. Looking at Figure 13, we can see that EMG reactions stretch beyond the initial stimulus phase, into the gamble phase and further into the choice phase. This adds further evidence to the meditational analyses for Studies 1 and 2, that affective reactions to the pictures are influencing decisions. They suggest that a transfer of affective response from reactions to the pictures to the gamble decision, through concurrent activation of similar neural systems, might explain the change in gamble acceptance across affective stimuli categories.

General Discussion

Past research has already demonstrated that incidental affect can influence behavior. Yet until now there has not been a systematic demonstration of how affective stimuli influence choice. Across three experiments, we clearly show that affective response to stimuli lead to predictable changes in decision processes and choice. These effects are not specific to a set of stimuli, or specific to one gender, and they can be found in choices that are both hypothetical (Studies 1 and 2) and with monetary consequences

(Study 3). We review our results according to the hypotheses proposed in the introduction.

Hypothesis 1: Participants will accept fewer gambles following negative stimuli, and more gambles following positive stimuli, as compared to neutral.

Overall, we find that participants accept less gambles after viewing negative stimuli. This effect occurred following both pictures of food, and of people. Interestingly, it also occurred for sexual stimuli, particularly for females, even though we initially chose the stimuli to induce a positive response. However, this finding further supports that it is the affective reaction that influenced the change in choice, and not any overall associations with a category of stimuli. Unfortunately we did not find robust effects of positive stimuli, although affective measurements suggest that participants respond less intensely to these stimuli, as compared with negative stimuli. This corresponds to a body of research demonstrating a broad difference in the intensity of response to negative and positive phenomena (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001; Rozin & Royzman, 2001).

Hypothesis 2: Effects of stimuli on decisions are mediated by underlying affective states.

Mediation analyses of affective ratings demonstrate evidence that the affective response to the stimuli is driving the change in acceptance rates. Both valence and arousal significantly mediate the effects of stimuli on acceptance rates. Interestingly, we find these meditational effects across all conditions, regardless of whether there were significant direct effects. This further strengthens the claim that affective response to these unrelated stimuli are those driving the effect on choice. EMG time series analyses demonstrate additional evidence for the affective influence of the stimuli, and also suggest that affective response might last long enough to transfer into decision-making processes. This corresponds with neurological evidence, demonstrating that activation in brain regions associated with affective processing mediate the influence of affective stimuli on choice (Knutson et al., 2008). However, more research on the process through which affective reactions alter decision processes is needed.

Hypothesis 3: The impact of affect will depend on gamble properties.

Although some theories suggest a direct influence of affect, we did not find evidence for this. Participants' decisions were not completely predicted by affect, and the influence of affect specifically targeted decisions of ambiguous value. Further examination demonstrated that participants changed their propensity for gain/loss ratio and expected value, in the affective conditions. Specifically, in order to accept similar proportions of gambles following the viewing of negative stimuli (as compared to neutral), gambles needed to be higher in value and have a greater gain to loss ratio.

Hypothesis 4: Affect will influence choice through changes in valuation parameters, such as loss aversion and scope sensitivity.

We found that loss aversion (λ) increased in response to negative stimuli, and that scope sensitivity to value (α) decreased. These results do not align with theories proposing direct and global influence of affect on choice, nor do they support theories suggesting affect induces a specific mode of processing. Our findings correspond to motivation-based theories that predict that affect influences differential focus on gains and losses.

This research presents evidence for generalized effects of incidental emotional stimuli on decisions. Knowledge of these effects warrants further research on the process through which affective response influences decision parameters. Furthermore, additional examination of positive stimuli is required in light of the weak findings for the effects of positive stimuli. Nonetheless, our findings create a more nuanced model of decision making under risk. This could greatly benefit financial models that would like to incorporate affect into predictions. Importantly, they arm us with the understanding of how our decisions could be swayed in an affectively rich environment. Interestingly, the gambling industry seems to understand these effects, and creates a very intensely affective environment, often involving food, drink and sexual stimuli, to encourage risk taking. Given these findings, amateur gamblers should prefer a quiet poker game at home to a game at a casino.

Chapter 1 is, in part, being prepared for submission for publication of the material. Hofree, Galit; Erner, Carsten; Fox, Craig R.; Knutson, Brian; Winkielman, Piotr. The dissertation author was the primary investigator and author of this material.

Chapter 2:

Food Liking and Wanting:

Motivation and Affective Components of Food Preferences

Introduction

The relationship between affect, motivation and behavior has yet to be fully understood, and is still a focus of much research (for examples: Pessoa, 2009; Schwarz, 1990; Winkielman & Berridge, 2003). A common assumption about this relationship is that our affective reaction to a stimulus is a direct representation of its motivational value to us – we want what we like, and like what we want. However, current research demonstrates that affective response and motivational evaluation are not one and the same (Berridge & Robinson, 2003; Harmon-Jones, Gable, & Price, 2013). This decoupling enables flexibility in behavior, such that an organism can be goal-oriented while maintaining the ability to react to its environment.

Traditional theories of motivation assumed that affective reactions directly reflect motivational evaluation of stimuli. These theories proposed that stimuli are associated with different incentives (through experience and learning), and that organisms respond to these incentives with hedonic reactions and approach/avoidance behaviors (Bindra, 1974). Importantly, they demonstrated that motivational states influence the hedonic reaction to stimuli in the environment, a phenomena commonly known as alliesthesia (Cabanac, 1971), and proposed that motivational states influence behavior by modulating incentive/hedonic evaluation of stimuli (Toates, 1986). For example, sucrose is more palatable when one is hungry (Cabanac, 1971), and water is tastier when thirsty (E. T. Rolls, Rolls, & Rowe, 1983).

Berridge and Robinson's incentive salience model extends these theories by differentiating between 'liking' and 'wanting' evaluations of stimuli (Berridge, 1996; Berridge & Robinson, 1998). 'Liking' is associated with a hedonic or affective response, such as the enjoyment experienced when eating a delicious treat. 'Wanting', on the other hand, is the effort an organism is willing to exert to obtain/avoid an item. For example, how far will you drive to obtain said delicious treat. Importantly, these processes differ from what we colloquially refer to when using the terms liking and wanting. They describe core processes that can function without our awareness, whereas liking and wanting normally refer to conscious attributions (Berridge & Robinson, 2003). For this reason we use quotation marks to denote the core processes of 'liking' and 'wanting'. As mentioned, previous theories assumed that these two concepts were synonymous. Neuroscience research suggests that although these processes are closely related, they can be dissociated (Berridge, 2007, 2009; Berridge & Robinson, 1995; Dai, Miguel, & Ariely, 2010; Winkielman & Berridge, 2003). Separate 'liking' and 'wanting' processes closely interact to maintain goal-directed behavior. Hedonic liking reactions can lead to future wanting, through classical association mechanisms (Berridge, 1996, 2009). If we taste something we liked, we will most likely attempt to eat it again at a later time. Interestingly, habituation/sensitization mechanisms influence these processes differently. A study conducted on addicts demonstrated that sensitization processes will lead addicts to work hard for small doses of a drug, but not to enjoy the effects of these small doses (Lamb et al., 1991). Habituation induced through imagined consumption, leads people to subsequently eat less of the imagined food, although they still find it just as palatable as before (Morewedge, Huh, & Vosgerau, 2010).

One important aspect of motivational processes is their effect on future behavior. One means of assessing this is by measuring indications of action readiness, such as facilitation of specific actions. Early research on motivation demonstrated a general organization of behaviors as approach-oriented or withdrawal-oriented (Brown, 1948; Schneirla, 1965). This organization has also been associated with separate underlying neural systems, even separate hemispheric organization of such systems (Sobotka, Davidson, & Senulis, 1992). Studies show that affective stimuli are associated with either of these actions, through associative learning mechanisms (Lang, Bradley, & Cuthbert, 1997). Positive stimuli facilitate approach while negative stimuli facilitate withdrawal. There is robust evidence for a relationship between affect and approach avoidance tendencies (a meta-analysis of these effects: Phaf, Mohr, Rotteveel, & Wicherts, 2014). Measuring action tendencies can reveal a direction of action (approach vs. avoidance), as well as magnitude of action readiness (through continuous measures of facilitation in reaction times, for example). ‘Wanting’, a measure of motivational effort, is likely to be closely associated with readiness for action, however this has yet to be tested.

Our research focuses on food stimuli, since our interactions with food play a critical role in our survival. Initial evidence for dissociation between ‘liking’ and ‘wanting’ was demonstrated in rats, using food rewards (Berridge, 1996). A large body of research has examined how motivational tendencies might explain some unwanted appetitive phenomena, such as specific food cravings (Kemps, Tiggemann, Martin, & Elliott, 2013), overeating (Brunyé et al., 2013), eating disorders (Seibt, Häfner, &

Deutsch, 2007). Using a novel paradigm, Brunye et al (2013) demonstrate that participants tend to sway towards foods they had previously indicated that they liked, and away from foods they disliked. Kemps et al. (2013) demonstrated that craving is associated with faster approach tendencies. In addition, Gupta and Aron (2011) used an interesting TMS paradigm to demonstrate that viewing highly wanted foods led to heightened motor activity that occurred before knowledge of the action required. Together these demonstrate that food rewards are closely linked to action tendencies. Linking 'liking' and 'wanting' to action tendencies for food might enable us to further our understanding of appetitive behavior in general, as well as the processes that underlie particular eating disorders (Berridge, 2009; Finlayson, King, & Blundell, 2007).

This study aimed to test whether 'liking' and 'wanting' judgments of food stimuli indeed differ in measurable ways. Using a special response apparatus, we measured release reaction times for approach-related arm muscles (flexion) and avoidance-related muscles (extension), while participants made liking and wanting judgments of food stimuli. Additionally, we measured initial hunger ratings. One central question we examined is whether dissociation can be found for explicit liking and wanting judgments, measured through subjective ratings. As mentioned, liking and wanting don't map directly to motivational concepts of 'liking' and 'wanting', yet they are related. It is debated whether liking and wanting ratings can be measured effectively (Finlayson et al., 2007), and evidence for a dissociation in ratings is rare (Zandstra, De Graaf, Mela, & Van Staveren, 2000). Additional indications for their dissociation, beyond different judgments, were tested for in interaction between liking and wanting judgments and key motivational constructs, such as hunger, and action readiness. We predicted that hunger would influence wanting judgments more so than liking judgments. In addition, we predicted that action readiness would differ for liking and wanting judgments. Finally, we tested effects of liking and wanting judgments on unrelated behavior, such as gamble decisions.

Methods

Participants

66 University of California, San Diego undergraduates (44 females, 22 males) participated for class credit. Written consent was obtained according to the UCSD IRB human subjects protocol.

Stimuli

The stimuli chosen for this experiment included 150 pictures of various foods, collected from online sources and from the IAPS (Lang, Bradley, & Cuthbert, 1999, 2008). In order to have a good balance of affective reactions, these pictures included 50 negative foods (e.g., roasted bats), 50 neutral foods (e.g., sticks of butter), and 50 positive foods (e.g., cheesecake). Participants in a separate experiment rated these stimuli as eliciting negative, neutral and positive reactions, respectively.

Response apparatus

Participant response was recorded using a vertical button stand (for more details: Rotteveel & Phaf, 2004, and Figure 1). The button tower was positioned to the right of the participants and so that it would create approximately a 110° angle in their arm at rest. Participants started each trial at rest, by holding down the “home” button (the middle button in the tower), with the back of their hand. When instructed to make a response, they released the home button and pressed either the top or bottom button, without turning their hand.

Responses made on this stand are composed of both a release time (RT), the time until release of the “home” button, and movement time (MT) the time from releasing the “home” button until pressing a response button. Previous studies demonstrated that affective influences are more likely found in RT (Phaf & Rotteveel, 2009; Rotteveel & Phaf, 2004). In addition, RT reflects the part of the response that is associated with non-specific action preparation, which more closely aligns with our theoretical motivations. For these reasons we focused our analyses on the RT measure.

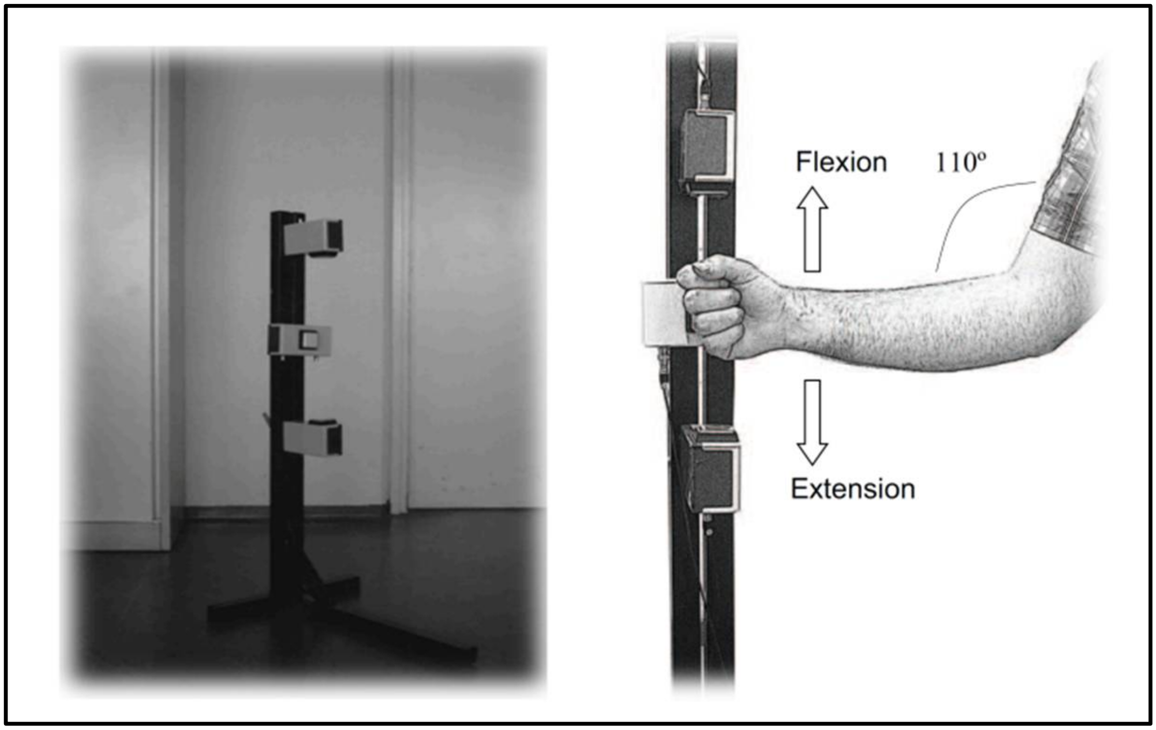

Figure 2.1: Tower apparatus. The apparatus consists of 3 buttons: two response buttons (top or bottom) and one "home" button, on which participants rested the back of their hand between judgments. Participants made judgments by either flexing or extending the arm from the "home" button to press on either the top or bottom button.

Procedure

After signing a consent form, participants sat in front of the computer, and the experimenter helped align their chair to the tower. First, participants answered questions about their current state of hunger, and dietary preferences. Following these ratings, participants read instructions regarding the use of the button tower. They were then instructed on the two types of judgments they were requested to make: Do you find this food tasty? Do you want to eat this food now? Following these instructions, the experiment began. The experimental procedure consisted of 4 blocks in a 2x2 design: 2

Judgment Type (liking/wanting) by 2 Response Action (flexion/extension). These blocks were counterbalanced, but both liking blocks and both wanting blocks were conducted sequentially. Each block began with brief instructions on the type of judgment, and 3 practice trials to familiarize the participant with the judgment and response direction. Participants viewed each picture once for a liking decision, and again for a wanting decision. Each block consisted of 75 trials. Overall there were 12 practice trials and 300 trials throughout the experiment.

Figure 2 presents the time course of a single trial. Each trial began with a 2000 ms fixation, followed by a 500 ms presentation of the food picture. A 5000 ms fixation followed the stimulus, followed by a judgment slide to which participants were asked to respond as quickly as possible by releasing the home button and hitting the appropriate button. A short (100 ms) feedback of their choice was presented before continuing to the next trials. Participants were reminded to keep their hand pressing the home button at the beginning of each trial.

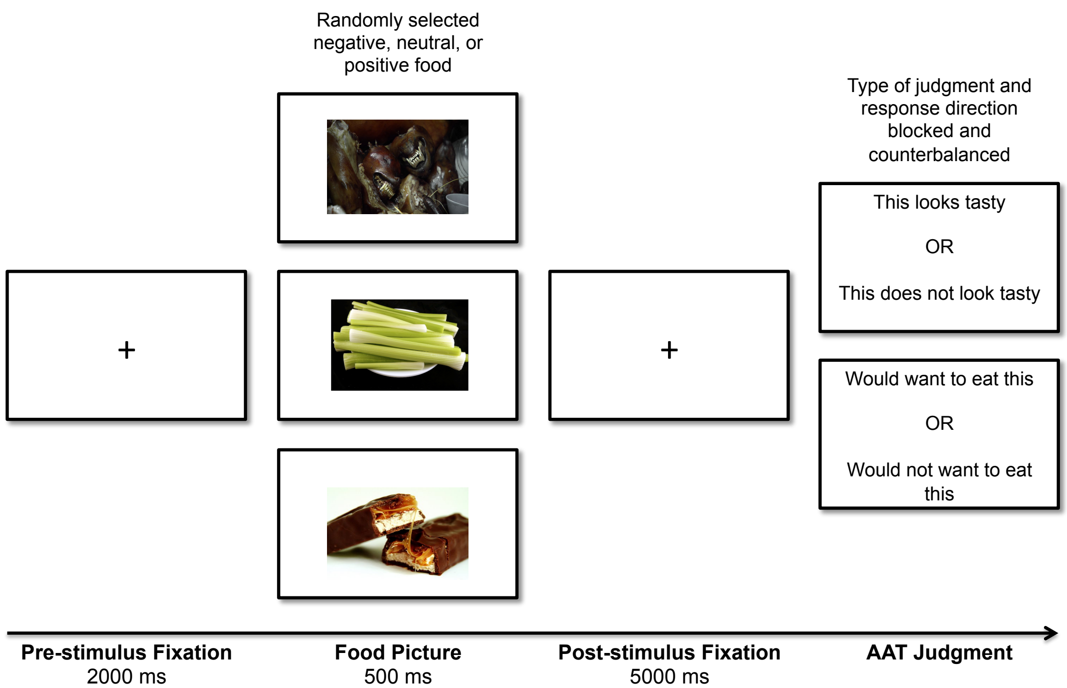

Figure 2.2: Experimental procedure. Participants viewed and judged negative, neutral and positive food pictures in a 2 (Judgment Type) by 2 (Response Action) block procedure. In each trial, participants viewed a random food picture and made a judgment by pressing either up or down on the tower.

Results

Motivational State

Participants were asked to rate how hungry they felt, and how long it's been since they last ate, on a 5 number scale, before the start of the experiment. See Figure 3 for histograms of their responses. These ratings were used as a means to assess the motivational state of the participant, so that we can see how such a state might influence choice. Participants came to the study at various hours in the day, thus their hunger varied across the scale (*median* = 3, *mode* = 4, *IQR* = 2), as well as the time since they last ate (*median* = 2, *mode* = 2, *IQR* = 3). These two measures are highly correlated, $r = .57$, *CI* [.39; .72], $p < .0001$.

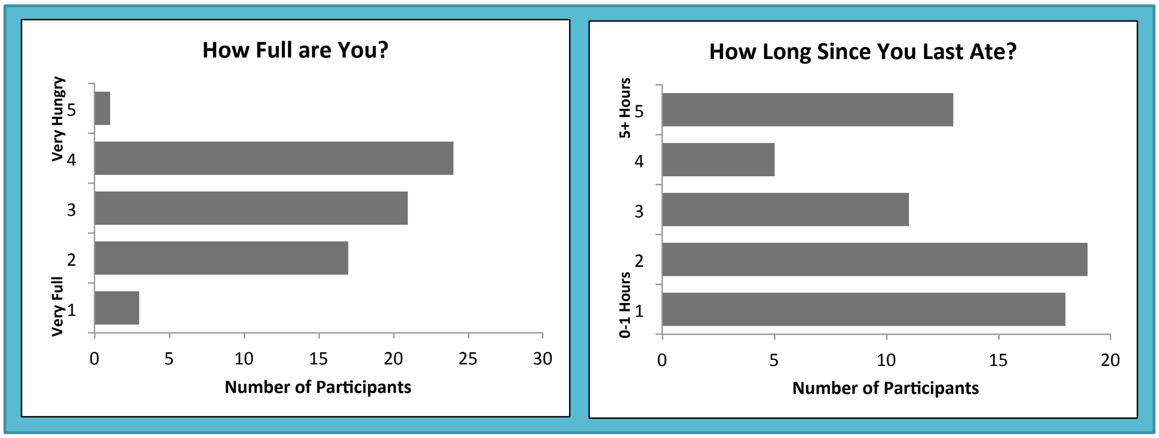

Figure 2.3: Histograms of hunger and eating recency. Participation took place at different hours across the day, such that participants varied on how hungry they were and how much time had passed since they last ate.

Preferences

Stimuli preferences. We examined preferences across the different foods to see if there were any foods that were more likely to be influenced by motivation. See Figure 4 for a scatterplot demonstrating the relationship between liking and wanting ratings for the experimental stimuli. Notice that the Valence categories map well across both types of ratings. As can be expected, neutral foods spread more widely across the ratings, as these are inherently ambiguous stimuli. Liking and rating proportions are highly correlated across stimuli – $r = .98$, p < .0001. However, there are interesting differences between these two conditions. When examining the differences in liking and wanting proportions, we find interesting patterns. Water, for example, is wanted by most participants (mean wanting proportion across 2 pictures: .82), but is not a highly liked food (mean liking proportion across 2 pictures: 0.61). Foods that are highly liked but not as wanted are more likely to be positive foods, like chicken parmesan (proportion liked = 0.95, proportion wanted = 0.73). These results suggest that the ratings indeed tap into different aspects of reward attributions.

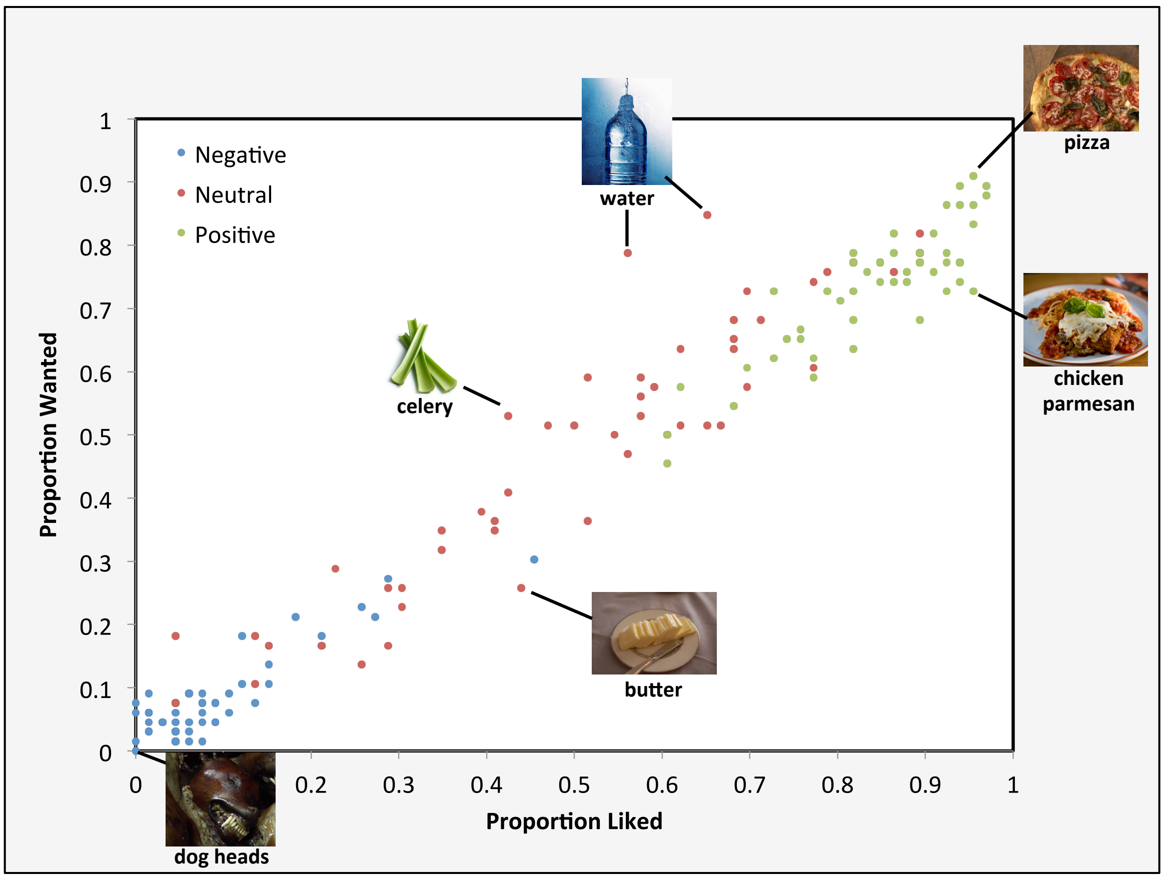

Figure 2.4: From roast dog heads to pizza – liking by wanting ratings across stimuli. Ratings reflect valence categories and are highly correlated, $r = .98$, $p < .001$. However, subtle differences between liking and wanting are clearly demonstrated by pictures liked more than wanted (chicken parmesan), and wanted more than liked (water).

Choices across conditions. We conducted mixed model regressions to examine how participants' preferences changed across conditions. First, we ran a regression with Judgment Type (liking/wanting), Response Action (flexion/extension), Valence (negative/neutral/positive) and Gender, predicting preference (positive choice), where participants were modeled as random effects. As expected, we found a main effect of Valence (F (2,767) = 603.92, $p < .0001$). Participants preferred positive foods to neutral ($M_{\text{positive}} = .80$, $M_{\text{neutral}} = .51$, $t(767) = 14.01$, $p < .0001$), and neutral foods to negative ($M_{\text{negative}} = .09$, $M_{\text{neutral}} = .51$, $t(767) = 20.54$, $p < .0001$). Males preferred more foods than females, as is demonstrated by a main effect of Gender ($M_{\text{males}} = .50$, $M_{\text{females}} = .43$, $F(1,767) = 6.55$, $p < .05$). See Figure 5 for these results.

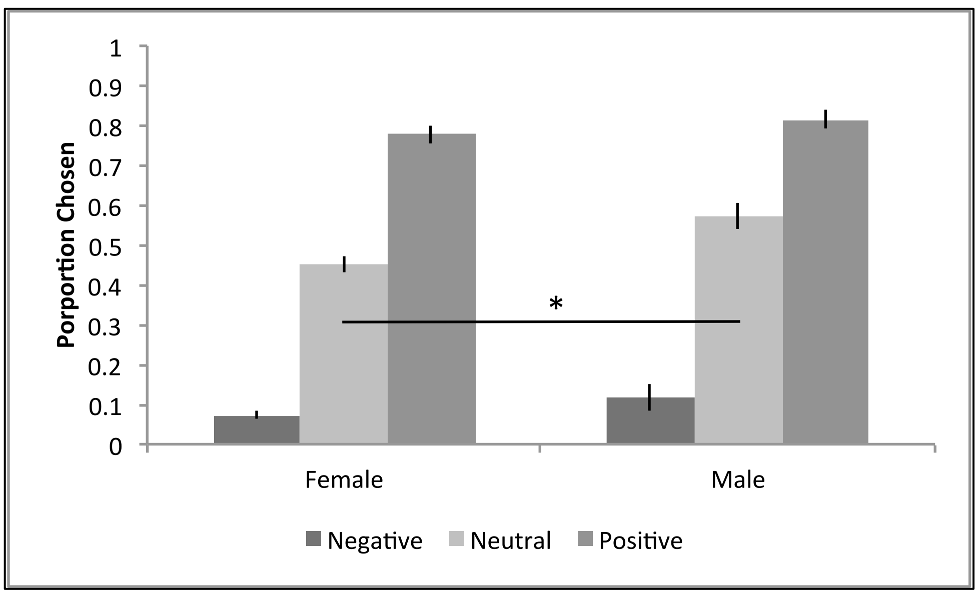

Figure 2.5: Choice across Valence categories, by Gender. Males prefer more foods than females, and this difference is most prominent amongst neutral foods. All comparisons across Valence within each Gender are significant at α = .05. * denotes a significant (at α = .05) comparison across genders.

Overall, participants liked more foods than wanted them (M_{liking} = .49, $M_{wanting}$ = .45, main effect of Judgment Type: $F(1,767) = 15.58$ $p < .0001$). Post-hoc comparisons of Judgment Type for each Valence category demonstrated that they were more likely to like positive foods than want them (Judgment x Valence: $F(2,767) = 12.67$, $p < .0001$, $M_{positive\ liking}$ = .86, $M_{positive\ wanting}$ = .75, t-test comparing positive liking vs. positive wanting: $t(767) = 6.27$, $p < .0001$). This is demonstrated in Figure 6. Interestingly, Response Action influenced preferences, although indirectly. We found a Response Action x Valence interaction, $F(2,767) = 4.49$, $p < .05$, and a Gender x Response Action x Valence interaction, $F(2,767) = 3.19$, $p <.05$. Post-hoc comparisons within Valence categories across Response Action demonstrate that using extension action led to more preferences of positive foods, than using the flexion action, $M_{extension}$ = .81, $M_{flexion}$ = .79, $t(767) = 2.98$, $p < .05$. A follow up analysis to uncover gender effects (separate models for each gender) do not demonstrate any additional differences in judgment using different response actions.

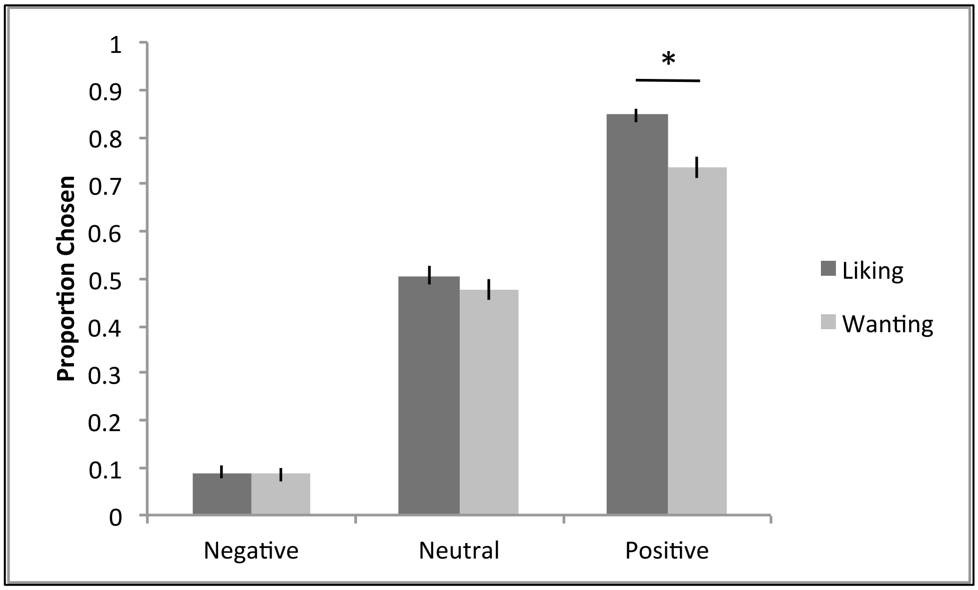

Figure 2.6: Choice across Valence and Judgment Type. Participants liked more foods than wanted them, and this effect was most prominent for positive foods. All comparisons across Valence within each Judgment Type are significant at α = .05. * denotes a significant (at α = .05) comparison across Judgment Type.

Hunger and Eating Recency. Eating Recency marginally correlated with rates of food preferences, $r = .22$, *CI* [-.01; .45], $p = .06$. That is, the longer time has passed since they last ate, the more foods participants preferred. Hunger ratings, on the other hand, did not correlate with food preferences, $r = .13$, $p = .28$. When separating judgments by Judgment Type, we see that Eating Recency significantly correlates specifically with wanting choices, $r = .25$, *CI* [.01; .46], $p < .05$, and not liking choices ($r = .17$, $p = .18$).

In order to further examine the influence of Eating Recency on judgment, we conducted a mixed model regression with Judgment Type, Response Action, Valence and Eating Recency (reduced to a binary factor by a median split) as independent factors predicting choice, with participants modeled as random effects. We found the same effects as in the main regression above, across both genders. However, we found that

Eating Recency interacted with Judgment Type: $F(1,66.13) = 4.19$, $p < .05$ (see Figure 7). Eating recency moderates the difference between liking and wanting, such that the difference grows smaller as time passes since eating (t-test comparing liking and wanting for recent eaters: $M_{liking} = .48$, $M_{wanting} = .42$, $t(743) = 4.32$, $p < .0001$; t-test comparing liking and wanting for non recent reaters: $M_{liking} = .50$, $M_{wanting} = .48$, $t(743) = 3.04$, $p =$ .01). This appears to be due to an increase in wanting as time passes, as was found in the correlation analyses above (t-test comparing recent and non recent wanting: $t(743) = 2.3$, $p = .10$).

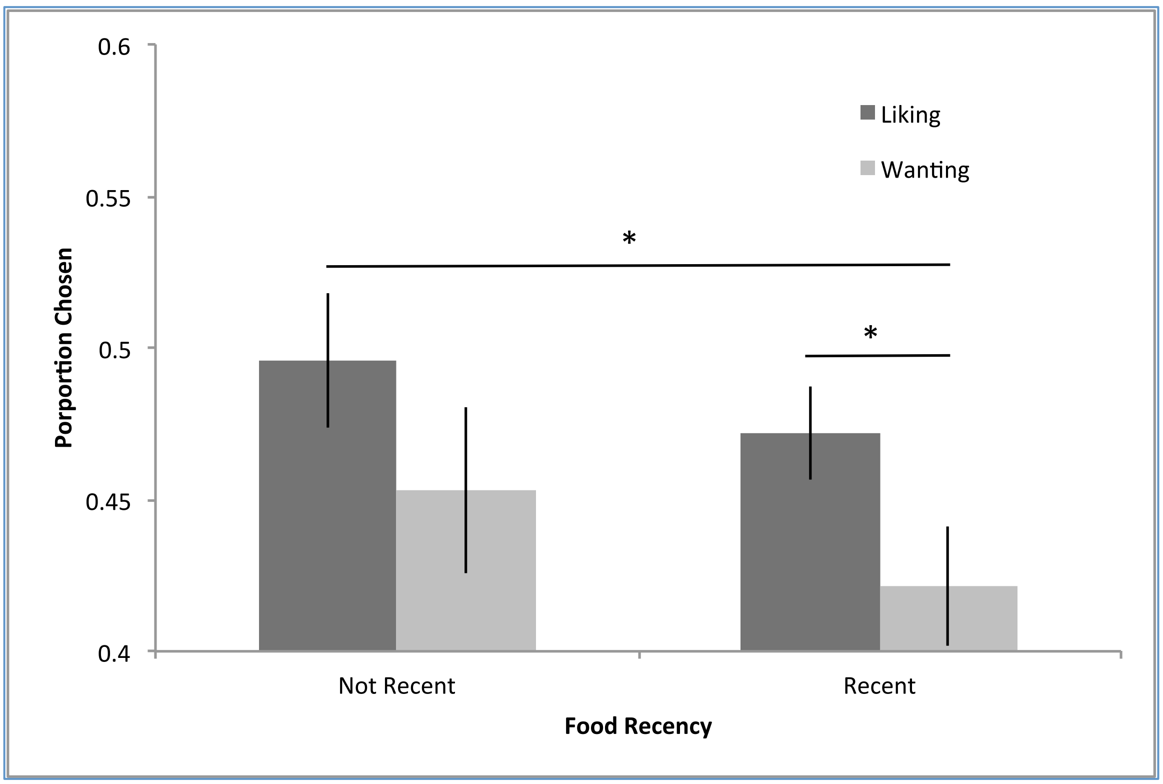

Figure 2.7: The influence of eating recency on liking and wanting food judgments. Time passed since last eating increases wanting for foods, such that the difference between wanting and liking preferences becomes smaller. * denotes a significant (at α = .05) difference.

Judgment Release Time

We also wished to examine the relationship between affective judgment and action tendencies. For this purpose, we examined release time (RT) in preparation for a choice, as detailed in the methods section. We conducted several steps to accommodate the skewed distribution of RT. First, we removed trials in which participants responded under 100ms, or trials that were 3.5 standard deviations above the mean (this removed on average 2% of trials, and at the most 5% of trials, per participant). RTs were then log transformed. In order to examine action tendencies in unambiguous choices, we included only positive and negative valenced trials, in which participants preferred/did not prefer the stimulus respectively (This removed on average 9% of negative trials and 21% of positive trials, per participant). This analysis corresponds to previous research in which analyses are conducted in a negative/positive domain, where responses are labeled correct/incorrect, and incorrect responses are excluded (as in Rotteveel & Phaf, 2004). We used a mixed regression model, in which subjects were modeled as random effects. We report results from a regression with Gender, Judgment Type, Valence and Response Action predicting log RT. We also ran a regression including Eating Recency. Overall, we found that Eating Recency appears to moderate the interaction of Judgment Type, Valence and Response Action differently for each Gender. For brevity these results are reported in the Appendix.

Overall, participants were much quicker to make liking decisions ($M_{\text{liking}} = 6.23$, $M_{\text{wanting}} = 6.29$, main effect of Judgment Type: $F(1,73.5) = 9.44$, $p < .01$). However, we also found a Gender by Judgment Type by Valence by Response Action interaction, F(1,62.15) = 6.70. p < .05. In order to further understand this interaction, we conducted separate regressions for each Gender and for Judgment Type, with Valence and Response Action as independent variables. Broadly, liking and wanting judgments were associated with different effects on response actions (see Figure 8). We found that Valence and Response Action interacted significantly for liking decisions across genders (females: $F(1,3716) = 4.83$, $p < .03$; males: $F(1,1876) = 11.00$, $p < .001$). For wanting decisions, Valence and Response Action interacted significantly for females, $F(1,3516) = 16.68$, $p < .0001$, but not for males. Males' liking decisions exhibited facilitation for congruent actions. Males' liking RTs were faster for negative decisions using extension rather than flexion actions ($M_{extension} = 6.21$, $M_{flexion} = 6.26$, $F(1,51.71) = 3.68$, $p = .06$), whereas the opposite was the case for positive decisions ($M_{extension} = 6.28$, $M_{flexion} = 6.22$, $F(1,54.16) = 5.07$, $p < .05$). Females' wanting RTs demonstrated the same interaction pattern as the male's liking RTs, such that negative extension responses were faster than flexion responses ($M_{extension} = 6.25$, $M_{flexion} = 6.30$, $F(1,100.2) = 7.46$, $p < .01$), and positive flexion responses were faster than extension responses ($M_{extension} = 6.29$, $M_{flexion} = 6.24$, $F(1,100.2) = 7.36$, $p < .01$). However for liking decisions, the extension responses to negative stimuli were slower than both flexion responses to negative stimuli ($M_{extension} = 6.24$, $M_{flexion} = 6.20$, $F(1,216.6) = 7.74$, $p < .01$), and extension stimuli to positive stimuli ($M_{extension} = 6.20$, $F(1,131) = 4.85$, $p < .05$). Overall, it appears that approach avoidance action tendencies differed across types of judgment, and that these differences were influenced by gender.

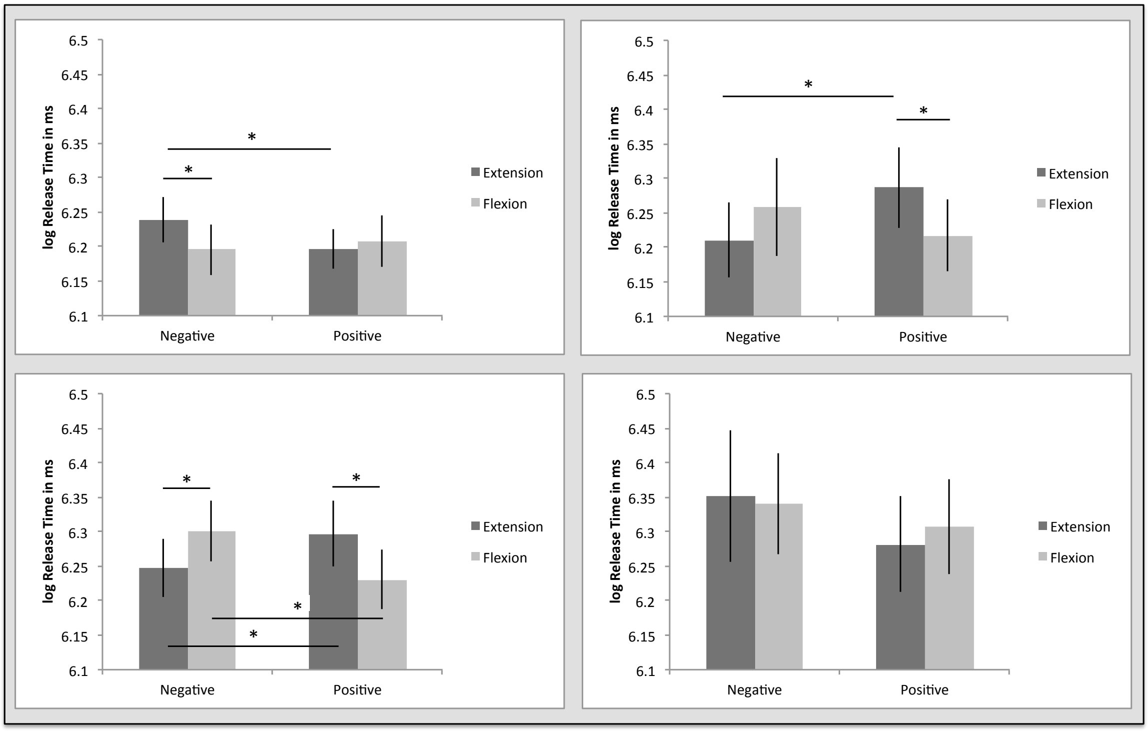

Figure 2.8: Log release time (RT) across Gender and Judgment Type. Log RTs for Liking judgments (top row) and Wanting judgments (bottom row), for Females (right column) and Males (left column). Males show congruent action tendencies when making liking judgments, while females demonstrate the same affect for wanting judgments. * denotes a significant (at α = .05) difference.

Incidental Liking and Wanting Influences Financial Decisions

We conducted analyses using data from Hofree, Erner, Fox, Knutson and Winkielman, in prep, to test the relationship between liking and wanting to an unrelated decision, such as deciding whether to accept a gamble. We calculated a liking rating and a wanting rating for each stimulus, by averaging judgments across participants. Food stimuli used in Hofree et al, in prep, were almost entirely nested in the stimuli set of this study, such that these ratings covered most of the stimuli used in Hofree et al., in prep. We also calculated the proportion of gamble accepted following each picture used in Hofree et al., in prep (see this paper for more details regarding the gamble decision).

Using these two measures, we conducted OLS regressions to explore the relationship between liking judgments, wanting judgments and gamble acceptance across affective categories.

Both liking and wanting of foods were associated with higher probability to accept a gamble viewed after the picture (liking: $r = .62$, *CI* [.49; .72], $p < .0001$, wanting: $r = .62$, *CI* [.50; .72], $p < .0001$). By comparison, subjective valence ratings of the pictures in Hofree et al., in prep, was also highly correlated with rates of acceptance, $r = .73$, *CI* [.64; .80], $p < .0001$, whereas subjective arousal ratings were not ($r = .02$, $p = .83$). To further test the effects of these separate constructs, we ran 2 separate regressions, one with Valence and Liking, and one with Valence and Wanting (separate because Liking and Wanting are highly correlated). As expected, both Liking and Wanting are significant predictors (liking: $\beta = 0.15$, $F(1,1) = 13.56$, $p < 0.001$; wanting: $\beta = 0.14$, $F(1,1) = .8.49$, $p < 0.001$). Interestingly, Liking interacted with Valence, $F(2,2) = 3.29$, $p < .04$. We conducted separate regressions for each Valence condition for Liking, and found that it significantly predicted choice in the negative condition ($\beta = 0.32$, $t = 2.88$, p < .01) and neutral condition ($\beta = .05$, $t = 2.10$, $p < .05$), but not in the positive condition ($\beta = 0.08$, $t = 1.48$, $p = .23$). Wanting appears to be a general predictor of gamble acceptance, while Liking appears to depend on the affective condition.

Discussion

Our results demonstrate a clear distinction between liking and wanting in subjective judgments of food rewards. Participants wanted fewer foods than liked them, and were slower to make wanting judgments, as compared to liking judgments. These differences may reflect a central difference between hedonic and motivation judgments: motivational judgments are associated with a limited resource (energy expenditure), and therefore must be directed towards a limited number of goals, whereas hedonic judgments have no such limitation (Roseman, 2008).

As predicted, hunger had a greater influence on wanting decisions. Whereas other theories suggest that hunger influences hedonic affective judgments (Cabanac, 1971), here we show that hunger increases the amount of foods wanted, whereas the amount of foods liked differs very little across hunger categories. This relationship between motivational state and motivational judgment further corroborates the distinction between liking and wanting decisions, and the different underlying roles they play in motivating behavior.

Liking and wanting judgments interacted differently with action tendencies. Interestingly, we find gender differences in the relationship between judgments and action tendencies. While males show congruency effects on RTs (flexion > extension for positive choices, extension > flexion for negative choices) when making liking judgments, and not wanting judgments, Females showed congruency effects when making wanting and not liking judgments. These findings correspond to previous research on gender differences in response to food rewards. Previous research suggests that males are less likely to restrict their food intake and are more likely to eat to beyond satiety (B. J. Rolls, Fedoroff, & Guthrie, 1991), and overall eat more than females (Cornier, Salzberg, Endly, Bessesen, & Tregellas, 2010). These behaviors suggest that they are more likely to act according to hedonic judgments, that is, liking. On the other hand, Females have been found to be more attuned to internal motivational state, and to cues of hunger and satiety (for example, Stoeckel, Cox, Cook III, & Weller, 2007; Uher, Treasure, Heining, Brammer, & Campbell, 2006). Their actions might be more closely associated with wanting judgments. Overall, these findings present evidence that liking and wanting judgments elicit different effects on action tendencies.

A key question regarding affective reaction is its subsequent effect on behavior. Using data from a study on the effects of incidental affect on financial decisions, we find that wanting judgments of food stimuli are more generally indicative of a subsequent unrelated choice, as opposed to liking judgments. Specifically, a food that is highly wanted, is more likely to be followed by a decision to accept a gamble, regardless of the monetary value of the gamble itself (the opposite is true of unwanted foods). This effect suggests that wanting judgments might have broader influence on behavior. This aligns with previous research suggesting that food promotes general reward approaching behavior (Wadhwa, Shiv, & Nowlis, 2008; Xu, Schwarz, & Wyer, 2015).

Our findings have several limitations. First, it is important to note that this study was conducted on college-age participants who did not disclose any dieting or abnormal eating behavior. These findings therefore do not extend to abnormal behaviors, and may not reflect older (or younger) populations. Second, hunger was not directly manipulated, although we measured a range of responses that correlated between the two measures. Finally, affective judgments were purely hypothetical – participants did not act upon them. While there might be a discrepancy between hypothetical and real affective judgments, our results and those from other similar studies demonstrate that they are indicative of real judgments.

Conclusions

These results demonstrate that different aspects of affective judgments are important in understanding the link between affect and behavior. By teasing apart liking and wanting, we are able to focus on how hedonic experience and incentive evaluation processes each contribute to subsequent behavior. We find that wanting is more to be influenced by motivational state, and are more predictive of future behavior, even in unrelated decisions. Furthermore, we find that wanting and liking judgments differed in their influence on approach/avoidance action tendencies. Together this evidence suggests that explicit liking and wanting judgments can be dissociated, and that separating these constructs can be beneficial in understanding the relationship between affect, motivation and behavior.

Chapter 2 is, in part, being prepared for submission for publication of the material. Hofree, Galit; Rotteveel, Mark; Winkielman, Piotr. The dissertation author was the primary investigator and author of this material.

General Discussion

This dissertation aimed to systematically characterize the effect that incidental stimuli have on financial choices. The first chapter clearly demonstrated how incidental stimuli influence decisions, indirectly, by eliciting affective reactions that influence valuation calculations. The second chapter presented evidence for a possible process by which affect could transfer into decision processes. Together, these two chapters attempted to provide a clear picture of how incidental stimuli can influence decisions, as well as important insights for research on the general relationship between affect and decision making.

In chapter 1, we demonstrated how incidental affective pictures influence the likelihood of accepting a subsequent unrelated gamble. Across three studies with multiple domains of stimuli (food and human pictures), we found a significant decrease in acceptance of gambles, following negative pictures. Affective reactions to the stimuli, as measured through subjective ratings of valence and arousal (Studies 1 and 2) appear to mediate these effects. EMG measures demonstrated that affective reactions to the stimulus continue well into the gamble phase of the trial. These findings demonstrate clear effects of incidental affect on decisions.

Although we did not find a global effect for positive stimuli on choice, we found an indirect mediation of affect for these stimuli, just as we did for negative stimuli. This, along with the finding that participants did not rate positive stimuli as extremely as they did negative stimuli, suggests that positive stimuli can indeed produce a global effect if they elicit strong enough reactions. Evidence for this exists in the literature (Ditto et al., 2006; Hsee & Rottenstreich, 2004; Isen, Nygren, & Ashby, 1988; Knutson et al., 2008).

By parametrically varying the gambles across trials, we were able to also test the type of gambles that participants were likely to accept under different affective conditions. Overall, we found that gambles of ambiguous value, that is, whose value estimated with a prospect theory model was near 0, were particularly likely to be influenced by affect. Gambles with a similar likelihood of acceptance across the affective categories differed in their expected value and gain loss ratio. That is, gambles that were more likely to be accepted following negative stimuli were of higher expected value and had a higher gain loss ratio than those likely to be accepted following neutral stimuli. These findings demonstrate that affect does not produce a global effect on choice, but aids decisions in which we are unsure of the right choice.

Using a prospect theory model of the participants' choices, we found that affect indirectly influenced decisions through changes in valuation parameters. Over all three studies we found that negative stimuli lead to increased loss aversion (with some evidence for a decrease in loss aversion following positive stimuli), and a decrease in curvature. These effects did not appear to be caused by changes in processing methods – participants were not more attuned to the parameters of the gamble (gains and losses) following negative stimuli. These effects were found in both incentive compatible (Study 3) and hypothetical decisions (Studies 1 and 2).

Sexual stimuli provided an interesting unexpected test of our hypotheses. In light of previous studies (Ariely & Loewenstein, 2006; Ditto et al., 2006; Knutson et al., 2008), we included sexual stimuli in our studies to represent extreme positive stimuli. However, our participants reacted negatively to these stimuli. These negative reactions carried over to their decisions in much the same fashion as the negative stimuli did. This suggests that the effect is not associated with certain attributions (such as riskiness associated with sexual activity) regarding the stimuli, or any cultural expectations of affective reactions (positive reactions to sexual stimuli). It is not completely clear why our participants found these stimuli, selected for positive affect in previous experiments, so negative. One difference could be that the participants themselves hold different attitudes regarding sex and sexual stimuli, than those the stimuli were originally gathered for. This might be particularly true for the stimuli used in Study 2, which were originally used in experiments conducted in The Kinsey Institute.

Chapter 2 examined the relationship between affect and valuation, as a more general motivation construct. Through the use of two different types of judgments, we were able to distinguish between two components of affective reactions to food stimuli: 'liking' (hedonic pleasure) and 'wanting' (motivational value) (Berridge, 1996). We demonstrated that although these two types of judgments are highly correlated, 'wanting' judgments are more susceptible to influences of hunger, and are more directly associated with approach/avoidance action tendencies. These findings together suggest that explicit 'wanting' judgments reflect motivational processing associated with incentive valuation. Combining data from this study and that of Study 1 in Chapter 1, we were able to further demonstrate that indeed, 'wanting' judgments (as compared with 'liking' judgments) of stimuli (made by participants in Chapter 2 Study) were more predictive of subsequent gamble decisions (made by participants in Chapter 1 Study 1). These judgments were predictive of gamble acceptance across affective categories, including positive stimuli. This suggests that incidental valuation processing transfers over to gamble decisions.

These findings offer important insights on how affect influences judgments and decisions. Combining findings across the chapters, we find evidence that, specifically, evaluations of incidental stimuli transfer over and become incorporated into subsequent valuation calculations. Although the decisions here were gamble decisions, such a process could easily take place in other decisions and judgments, since valuation processes are critical for decision making in general.

Furthermore, these results suggest ways in in which affect can be incorporated into financial decision-making models. Expanding on existing models to include affective influences can increase predictive power, and allow more flexibility of the model to external affective stimuli in the environment. Knowing how such stimuli influence choices can be a powerful tool for those who design spaces for decisions, as well as individual decision makers.

Certain limitations in our studies should be pointed out. First, as mentioned, we did not find effects for positive stimuli. Affective ratings demonstrated that these stimuli did not produce the affective response that we expected them to have. That is, they were rated significantly less extreme (as compared to neutral stimuli) than negative stimuli. This was true for both positive food stimuli, and positive human stimuli. As mentioned before, we hoped that sexual stimuli would be viewed as highly positive stimuli, but this was not the case. One possible reason for the fact that positive stimuli did not elicit a significant effect might be the context in which they were viewed: randomly, with very negative and neutral stimuli interspersed between them. Affective reactions are relative, and there is an abundance of evidence that negative affect can outweigh positive (Baumeister et al., 2001; Rozin & Royzman, 2001; Taylor, 1991). Nonetheless, we did find indirect effects, through mediation, of positive stimuli. Furthermore, we found that 'wanting' judgments predicted subsequent gamble acceptance, even for positive stimuli. Together, these findings suggest a global effect of positive stimuli on choice, although we didn't measure it directly.

Our research demonstrated the influence incidental *affect* has on decisions. However, the reactions measured were fleeting, and possibly less intense than full-blown emotional reactions, such as sadness or joy. Although affect underlies all emotional reactions, there are other aspects of these reactions that can influence decisions (e.g., Lerner & Keltner, 2000, 2001; Raghunathan & Pham, 1999). Future research on the interplay between basic affective and emotional influences will be important to tease out their different roles.

The findings presented here raise interesting questions for future research. As was already mentioned, it is important to understand how affect and other emotional reactions interact in their influence on decisions. In addition, it would be really interesting to see whether effects on valuation can be measured in other domains, such as financial decisions without risk, or even in non-financial situations. Since there are differences in how people estimate financial and non-financial values (McGraw, Shafir, & Todorov, 2010), affect might influence these decisions differently. Research using financial models is necessary to mathematically estimate the parametric influence of affect on valuation parameters. Although we demonstrate effects on loss aversion, for example, further tests need to be conducted to conclude whether the relationship is additive, or multiplicative. Finally, research on means of mitigating or controlling this effect, on the part of the decision maker, would be of great practical import. This research could take our findings one step further in providing decision makers with some control over the way they make decisions, in a world filled with incidental phenomena.

Appendix

Chapter 2 Supplementary Analyses

We wished to assess the effects of motivational state on response readiness, across the different conditions. Overall, Hunger and Eating Recency don't predict log RT responses. However, when splitting by Gender, we see that Eating Recency correlates marginally with log RTs for females ($r = .28$, *CI* [-.02; .53], $p = .07$), but not for males. That is, the more time has passed since they last ate, the slower they released the home button. When separating by Judgment Type, we see that Eating Recency specifically influences wanting log RTs for females ($r = .29$, *CI* [-.01; .54], $p = .06$).

We ran a model including Eating Recency (using a median split, as before), Gender, Judgment Type, Valence and Response Action on log RT. Participants were modeled as random effects. We found similar effects as before (main effect of Judgment Type: $F(1,31.48) = 9.28$, $p < .01$, and interaction of Gender x Judgment Type x Valence x Response Action: $F(1,60.84) = 5.65$, $p < .05$). However, we also found a marginal Eating Recency x Judgment Type x Valence x Response Action interaction ($F(1,60.84) = 3.81$, $p = .06$), as well as a Gender x Eating Recency x Judgment Type x Valence x Response Action interaction ($F(1,60.84) = 8.14$, $p < .01$). In order to interpret these complicated interactions, we ran separate models for the different judgments, for each gender, as before. See Figure 9 for results. For females, we did not find any significant interactions with Eating Recency. For males, on the other hand, Eating Recency interacted with Valence and Response Action in both liking and wanting judgments (liking: $F(1,19.8) = 6.13$, $p < .05$; wanting: $F(1,15.74) = 5.11$, $p < .05$). Separating again for Eating Recency, we find that liking decisions for recent eaters reflect congruency between judgments and actions, similarly to what we found for males overall ($F(1,1012) = 24.11$, $p < .0001$). However, liking decisions made by males who have not recently eaten did not exhibit such an effect ($F(1,854.6) = 1.66$, $p = .2$). Wanting decisions were influenced differently by Eating Recency (recent: $F(1,948.2) = 8.41$, $p < .01$; non recent: $F(1,746.7) = 3.48$, $p = .06$). Males who have not recently eaten made slow flexion responses when judging negative foods ($M_{extension} = 6.35$) compared to positive flexion ($M_{flexion} = 6.26$), $F(1,17.18) = 4.98$, $p < .05$), where as males who had recently eaten, made slow extension responses when judging negative foods (negative $M_{flexion} = 6.42$) as compared to positive extension ($M_{extension} = 6.30$): $F(1,15.2) = 6.04$, $p < .05$).

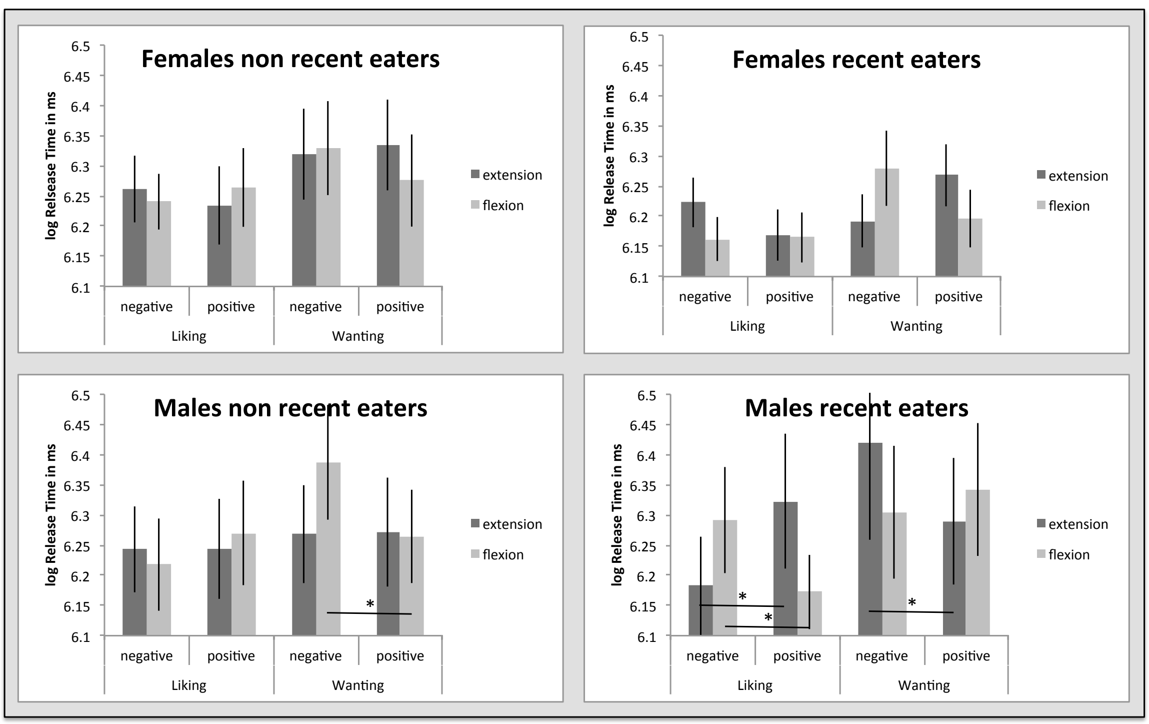

Figure S.1: Log release time (RT) across Gender and Eating Recency. Males who have not eaten recently demonstrate influence of wanting decisions on approach avoidance tendencies, while those who have demonstrate similar effects in liking decisions. Females show no effect of eating recency on the relationship between affective judgment and approach avoidance tendencies.

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