Affect is the foundation of value

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I. Introduction

Answering the question of how emotion is integrated into choice necessarily begins with identifying some of the relevant dimensions and processes underlying both. As with any other broad psychological construct (e.g. memory, attention, perception), neither emotion nor decision-making are unitary phenomena that interact in a single way. Instead, each consists of multiple underlying dimensions and component processes that enable multiple specific and selective interactions between emotion and decision-making. Only by taking into account this complexity can we begin to elucidate the roles of emotion in our choices and actions.

For the sake of simplicity, we will focus here on simple decision-making situations in which two or more alternative options are made available to a decision-maker. As part of the choice process, the decision-maker: 1) evaluates the attributes of those options, 2) estimates each option's total subjective value, and 3) chooses the option with higher estimated subjective value. Importantly, different types of option attributes (e.g. delays in time, the probability of reward, social context) can engage distinctive evaluative processes. Thus, the nature of the choice options will determine which processes are used to make the choice. Additionally, in contrast to the view of value as a static association with a choice object that is merely veridically retrieved at the moment of choice, this descriptive model of decision-making proposes that estimates of value are constructed over time for any given decision, interacting with the attributes and context of the decision at hand, and the decision-maker themselves.

Here, we argue that emotion, or what we will call affect, plays several key roles in the construction of subjective value. We use the term "affect" in its overarching sense to encompass a variety of types of responses, including diffuse and long-lasting moods, stress responses, discrete short-term emotional responses, and even basic valenced associations (see Scherer 2005). Specifically, we propose that affect is integrated into decision-making processes in two main ways. First, affect has an incidental role via its influence on the processes underlying attribute perception and evaluation. Second, affect plays an integral role as the foundation for value itself (this conception borrows elements from Loewenstein and Lerner 2003; and Lerner, Li et al. 2015).

II. Affect as an incidental factor in decision-making

Incidental interactions between affect and decision-making parallel and rely upon the known roles of affect in other cognitive domains. In the domain of memory for example, affect modulates the subjective sense of remembering, such that objects that elicit positive or negative arousal are remembered with greater confidence (Poldrack, Wagner et al. 2008). Arousal has also been shown to facilitate the consolidation of newly encoded memories, thereby increasing the chance of successful later retrieval (LaBar and Cabeza 2006). Similarly, in the domain of attention, affect is known to narrow the focus of attention, resulting in better perception at the focus of gaze, but reduced perception in the periphery (Phelps, Ling et al. 2006). Notably, this change in attention has consequences for other cognitive processes. For example, decreased attention to the periphery leads to worse memory for peripheral items (whether physically or conceptually peripheral), and better memory for focal items (Christianson and Loftus 1991). Of course, this particular interaction between affect and memory is best described as a secondary consequence of affect's primary influence on attention. In this manner, the influence of affect in one cognitive domain can alter other, downstream domains.

Similarly, research has highlighted specific modulatory consequences of affect for processes that directly underlie decision-making. One of the main sources of evidence comes from studies manipulating moods, typically defined as relatively low-intensity, diffuse affective states occurring on a timescale of tens of minutes. In these studies, participants may observe film clips that are known to create mood states (like sadness, disgust, or happiness), after which they perform a nominally unrelated choice task. Despite the irrelevance of the film clips to the choices, induced moods can nevertheless change decisions: altering selling and buying prices for goods like office supplies (Lerner, Small et al. 2004), or changing reactions to unfair offers in interpersonal interactions (Harlé and Sanfey 2007; Moretti and di Pellegrino 2010). In these studies, moods are thought to alter decisions by shifting how objects or events are appraised in specific, predictable ways. For example, moods may facilitate retrieval of mood-congruent information from memory that influences unrelated choices (Isen, Shalker et al. 1978), or moods may be appraised as choice-relevant sources of information, thereby altering evaluations (Schwarz and Clore 1983).

Affective states of stress have also been shown to alter how choices are made. The dominant finding in this literature is one of a shift in decision systems. Stress is known, with some neurobiological specificity, to simultaneously impair higher-order cognitive function while potentiating other more reactive systems (Lupien, Maheu et al. 2007). The most robust effect of stress on decision-making is thus a reduction in the use of cognitively complex evaluation systems allowing simpler association-driven systems to dominate behavior, a tradeoff often described in terms of a shift from more goal-directed to more habitual behavior (Dias-Ferreira, Sousa et al. 2009; Schwabe and Wolf 2009; Otto, Raio et al. 2013).

There are therefore two main routes by which affect can incidentally alter decision-making. First, insofar as choice incorporates contributions from other cognitive domains (e.g. memory; attention), affective modulation of processing in those domains will result in changes in decision-making. Second, as the above examples highlighted, affect can also modulate processes at the core of decision-making (e.g. appraisal processes for evaluating option attributes; goal-directed evaluation systems), changing the content and contribution of those particular processes to decisions.

III. Affect as an integral part of decision-making

Beyond scenarios in which external, non-task-related sources of affect (e.g. mood or stress) can alter the processes underlying decision-making, affect can also play a more integral role in the evaluation of choice objects. One recent example linking a specific affective response directly with a defined decision-making process is a series of studies relating arousal responses to loss aversion. An initial study found that individuals who weighted losses greater than gains in their choices (i.e. were loss averse) also had correspondingly greater arousal responses to losses compared to gains (Sokol-Hessner, Hsu et al. 2009). Additionally, the authors found that when people took a broader perspective on their choices, both loss aversion and relative arousal responses decreased. Critically, this pattern of effects was selective to loss aversion, with no other measured decision-making processes showing a relationship with arousal or changing during the perspective shift. Two follow-up studies also supported this proposed link between loss aversion and affect. First, one study linked loss aversion to interoception (the accuracy in perceiving internal states; generally operationalized with the perception of heartbeats), consistent with the idea that loss aversion may result from physiological signals (Sokol-Hessner, Hartley et al. 2014). Second, the medication propranolol, which blunts the neural systems underlying arousal, was found to systematically and selectively reduce loss aversion (Sokol-Hessner, Lackovic et al. in press). Together,

these studies have provided compelling evidence for a causal link between a specific component of affect (the arousal response) and a specific component of decision-making (loss aversion).

An integral role for affect in decision-making has also been established in the domain of interpersonal interactions. A study examining participants' affect during the "Ultimatum Game" (UG) provided one of the earliest demonstrations of a link between objectively-measured components of affect and social decision-making. In the UG, a "proposer" player is given money, which she then splits between herself and a second player, the "responder". The responder can either reject the split, in which case neither player receives any money, or accept it, in which case the proposer's allocations stand. Typically, lopsided offers are perceived as unfair and rejected by the responder, whereas more even offers are accepted. In this early study, the authors measured responders' skin conductance responses as they accepted and rejected offers, finding that greater arousal responses to unfair versus fair offers predicted an increased tendency to reject those unfair offers (van 't Wout, Kahn et al. 2006). Building upon this result, another paper found that interoception mediated the relationship between arousal and decisions to reject, such that arousal was only related to rejections for good interoceptors (Dunn, Evans et al. 2012). These findings provide strong evidence that arousal responses in the social domain may signal specific evaluative information (that is, appraisals of relative unfairness), thus driving similarly specific choice behavior (rejection).

Beyond these externally observable relationships between discrete responses and decision-making, however, we contend that the very idea of something being "preferred," "desired," or "valued" reflects a intrinsic role for affect in choice. That is, affect is required in order for something to be preferred. While some theories of affect have simply assumed this fundamental role as an "axiom" of sorts (Scherer 2005), we propose an underlying, mechanistic explanation. The central idea is that choice stems from a dynamic constructive process, which has been formalized in a class of "integration models" (e.g. drift diffusion models, linear ballistic accumulators). These models propose that observers gradually accumulate noisy samples of information or evidence until they reach an internal threshold (Laming 1968). Integration models have provided successful accounts for behavior in the domain of perception, for example in motion judgment tasks, in which samples consist of the sensory evidence at a given moment for motion in a particular direction (Gold and Shadlen 2000). These models have also been applied to memory retrieval, for example in planning tasks in which future event expectations are generated by sampling memories of relevant past events (Bornstein and Daw 2013). In recent years, integration models have also been extended to value-based choices (Gold and Shadlen 2007; Rangel, Camerer et al. 2008). In this context, we propose that estimation of choice option values occurs through a process of sampling past experiences with the relevant option, including affective associations of positive or negative valence, arousal responses, etc. Thus, the process of constructing subjective value relies upon the sampling of inherently affective information, meaning that even in the absence of a measured affective response, affect is integral to value itself, and therefore choice.

The source of affective samples can vary. Most obviously, consideration of a choice option may invoke the retrieval of mnemonic associations based on our own prior experience. For example, individuals who have consistently enjoyed eating chocolate cake in the past may readily retrieve memories of those pleasurable experiences when considering dessert options after a meal. In a sense, the choice to eat cake results from samples of previous (tasty) cake experiences that lead to a choice to eat cake once again. This does not, however, mean that we are simply slaves to prior direct

experience. If a doctor warns that our cake consumption is leading to serious heart disease, future samplings of associations with cake might include the negatively-valenced memory of that conversation. Thus, this dynamic process of constructing subjective value enables individuals to make choices that integrate information in a manner that is sensitive to their current needs or desires.

It's not always the case that we have direct prior experiences upon which to base an evaluation. In these cases, mental simulation can generate an anticipated experience of a novel choice option. In a recent study (Barron, Dolan et al. 2013), participants were asked to make choices between novel foods made of combinations of familiar food items (e.g. tea-jelly dessert, raspberry avocado smoothie). When simulating their affective experience of the novel item, participants activated neural representations of the items' familiar components. Insofar as this reactivation reflected sampling, the more strongly participants sampled the components, the higher the value they eventually ascribed to the novel item.

The constructed nature of preferences has the important consequence that value depends on which experiences, real or imagined, are sampled. In practice, this leads to a variety of effects on choice. For example, samples can include explicit connections between a decision context, actions, and specific outcome objects, or can simply include contexts and previously rewarding actions, neglecting consideration of outcome objects entirely. The difference is revealed when the outcome value of a choice option suddenly changes (e.g. the doctor says that eating cake carries negative health consequences). The latter approach results in perseverative behavior that fails to take into account new information about the outcome object (as the sample only includes the value of the cake-eating *action*), while the former flexibly adapts by using the new information about the outcome object itself (Dickinson and Dickinson 1985).

Importantly, affective sampling from prior experience is subject to the constraints of memory retrieval processes, making recent experiences more likely to be sampled than remote ones. Because recent outcomes or current expectations serve as reference points for our judgments and decisions, the subjective value of choice options may be assessed as more positive or negative at different timepoints depending on the affective contrast with one's current state. This phenomenon of reference-dependent evaluation has been widely noted in both psychological (Geers and Lassiter 1999) and economic (Post, van den Assem et al. 2008) literatures. For example, a recent study examining the subjective evaluation of happiness during a gambling task found that happiness in any given moment was predicted not by aggregate statistics like wealth, but by recent outcomes, and in particular, how unexpected they were (Rutledge, Skandali et al. 2014). Reference dependence may also play a critical role in affective forecasting errors, in which people systematically mispredict the subjective value of future affective experiences (Gilbert and Wilson 2007). For example, people may overestimate the effect of winning the lottery on happiness because the sampling process will unavoidably feature the relative change between current and future wealth, even though that change will have only a transitory effect on happiness before it is eventually assimilated into the status quo (Brickman, Coates et al. 1978). In other words, because affect is elicited by deviations from the current state, affective sampling may likewise result in a bias toward choice options that yield such relative improvements.

In summary, we propose that the value of a choice option is constructed by sampling our affective associations with the option's attributes. This sampling integrates affective memories of our own prior direct experiences and simulated affective experiences based on relevant knowledge. In this manner, affect is integral to choice as it is the informational foundation of subjective value or utility.

IV. Conclusion

Here, we have argued that affect is deeply intertwined with decision-making, shaping our choices through both incidental and integral mechanisms. Affect is involved in many cognitive processes, and influences the decisions that we make in a multitude of ways, including by changing what we remember, perceive, attend to, or deem to be meaningful. Notably, this means that the manner in which affect is integrated into choice can depend on the choice situation itself, including the attributes of the options under consideration, the current state of the decision-maker, recent choice history, as well as numerous other contextual factors. However, in a manner unlike any other cognitive domain, we believe affect also has a foundational role in decision-making, as affective information constitutes the very basis for every estimate of subjective “value” or “utility”, making affect the fundamental metric upon which choice itself is built.

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