A closer look at choice

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We often look back and forth between options before deciding which one to choose, even if we have seen them both before. A new study suggests that people are biased to choose things they look at more, providing new insight into how the subjective values of options are constructed.

Why are the most expensive liquors displayed on the top shelf? Why are familiar brands clothed in eye-catching packaging? Such ubiquitous marketing maneuvers must not be accidental, but, according to a simple notion of economic choice, they are nevertheless mysterious. Surely, you know what a candy bar is worth to you regardless of its wrapper or its position on a shelf and surely your purchasing choices are driven by this knowledge?

Or perhaps not entirely. A study by Krajbich and colleagues[1] sheds some light on these issues by looking at economic valuation in the context of perception. The experimenters asked subjects to rate a set of familiar snack foods to obtain an independent estimate of their subjective values for the items. Krajbich and colleagues[1] then monitored subjects' eye movements and reaction times while they made choices between pairs of these items, depicted on a screen. This gave the investigators a behavioral window on the unfolding decision process and how it was reflected and supported by vision.

It is widely assumed that such choices are driven by comparing the subjective values of the outcomes (here, the different snack foods)[2]. However, although much work has considered the manner in which subjective valuations are built up over multiple experiences with an outcome[3–5] (I might learn from experience that I like dark chocolate better than white), very little is known about how these values are computed, constructed or compared over the course of a single decision. Indeed, if you know what a candy bar is worth to you, it's not even obvious that there's anything left to compute.

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In contrast with economic decisions, a great deal is known about the dynamic process by which the brain tackles an apparently quite different sort of choice: the analysis of noisy sensory inputs. For instance, in monkeys trained to indicate with an eye movement whether a staticky field of dots is moving left or right, neurons in eye movement control areas, such as the lateral intraparietal area, appear to determine the choice by ramping their firing up to a threshold[6]. Several other aspects of the choice behavior in this and many similar tasks, including reaction times and error rates, are also well explained by assuming that the choice is determined by just such a ramping process, which is known as a diffusion-to-bound model[7].

One aspect in which choosing a snack resembles making perceptual judgments is that figuring out what the options are involves analyzing visual information. Although the sensory inputs were not noisy in their study (thus, the problem of valuation was not simply one of identifying the options visually), Krajbich and colleagues[1] reasoned that the process of constructing and comparing internal subjective value representations might also be described by a diffusion-to-bound model, albeit with a twist. Motivated by the idea that updating the relative decision value (the value attributed to choosing one outcome over another) requires contemplating the two items' subjective values separately, Krajbich and colleagues[1] extended the model with a parameter that affects the drift rate. The Krajbich model posits that the decision variable guiding the choice drifts to favor one option or the other with a temporary bias in the direction of the choice threshold for the item currently being looked at (presumably, the one being analyzed; **Fig. 1**).

Although this idea seems sensible at first glance and is consistent with a number of features of Krajbich and colleagues' data[1], it has one unsettling consequence. If simply looking at an item tends to drive the diffusing choice process toward selecting it, then peoples' choices will be systematically biased according to wherever they happen to look. And under this model, this would be the case even if (as appears to be true in the data) the amount of time spent looking at items did not depend on how much the items were valued, but was instead random. Accordingly, Krajbich's subjects were more likely to choose the item they looked at last or the item they spent more time looking at overall. Indeed, all things being equal, an option looked at for a half-second longer than its alternative was chosen ~70% of the time. And if subjects happened to look last at an item they had previously claimed to like a bit less, they were equally likely to choose it despite their stated preference.

That people's choices were not always consistent with their previously stated valuations need not mean they were irrationally biased; perhaps, for instance, their subjective values changed over the course of the experiment. But some effects remain that are difficult to rationalize. This brings us back to the top-shelf liquor. Krajbich's subjects live in a country where they read from left-to-right and top-to-bottom. Because of this, perhaps they tended to examine the leftmost item first 74% of the time. This looking bias, in turn, led to a bias in favor of choosing whichever item happened to have been displayed on the left; an effect that is hard to explain as anything other than irrational. However, although this study suggests that marketing strategies, such as placing expensive items where you are most likely to look, may be able to sway our choices, it also offers some consolation in the finding that the looking time bias had the most effect for items with similar subjective value ratings. So if you walk into a bar with a strong preference for cheap alcohol, you are unlikely to be swayed by the tempters on the top left shelf.

The idea that we value the things that we look at, rather than looking at the things we value,

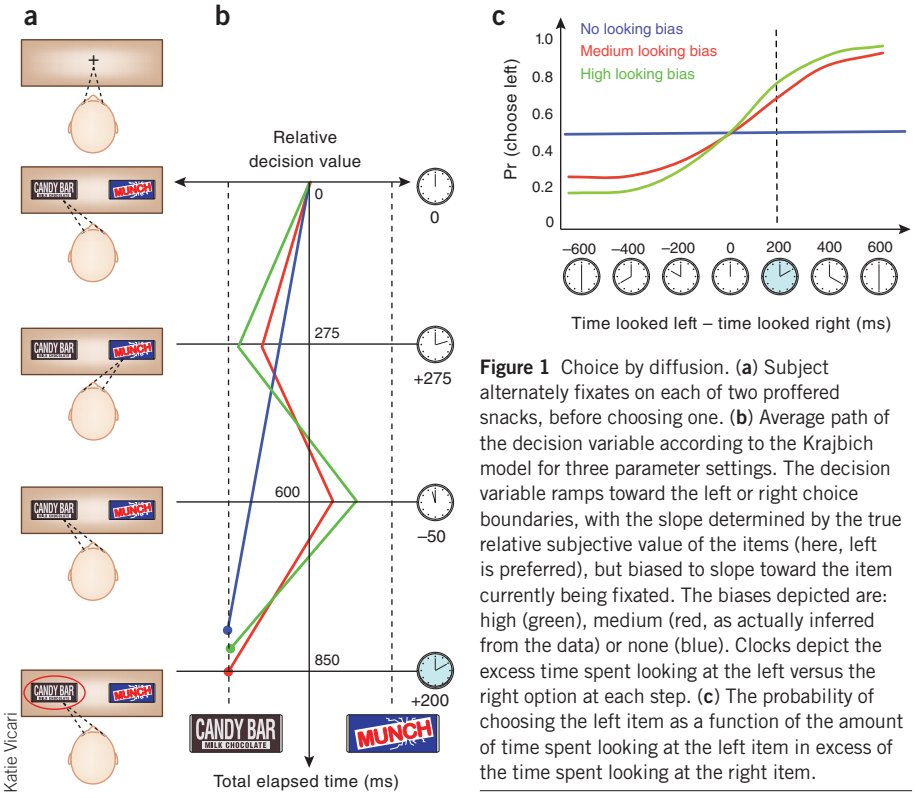

Figure 1 Choice by diffusion. (**a**) Subject alternately fixates on each of two proffered snacks, before choosing one. (**b**) Average path of the decision variable according to the Krajbich model for three parameter settings. The decision variable ramps toward the left or right choice boundaries, with the slope determined by the true relative subjective value of the items (here, left is preferred), but biased to slope toward the item currently being fixated. The biases depicted are: high (green), medium (red, as actually inferred from the data) or none (blue). Clocks depict the excess time spent looking at the left versus the right option at each step. (**c**) The probability of choosing the left item as a function of the amount of time spent looking at the left item in excess of the time spent looking at the right item.

somewhat inverts a standard view. It has long been known that shifts in gaze are influenced by the activity of the aforementioned neurons in eye movement centers, such as the lateral intraparietal area[8]. In experiments in which monkeys are rewarded with juice for looking at particular targets, these neurons are also modulated by the value of those targets[4,5], suggesting a mechanism by which value drives gaze. Such an effect is unlikely to account for Krajbich's results. For one thing, in another experiment, the same group directly manipulated the length of time subjects were allowed to view an option and found that this had a causal effect on subjects' choices[9]. Nevertheless, as it is likely true both that value drives viewing and that viewing drives value, it remains for future studies to examine these dynamics in greater detail.

Furthermore, although the choice data are well characterized by the diffusion model, an important direction in which Krajbich and colleagues[1] only hint is what, exactly, the brain is computing while gazing at an option. When analyzing a staticky motion display, the ramping diffusion process can be viewed as gradually accumulating the average signal from many fuzzy frames of movement; indeed, these theories implement a statistically optimal approach to sequential averaging[6]. Applying the same model to contemplating the value of potato chips, it is unclear what, analogous to the noisy visual samples, needs accumulating.

It may be the case that the brain constructs values by averaging over many noisy bits of evidence about features of the items being considered, such as by retrieving possibly relevant past experiences at random[10,11]. An alternative is that the apparently noisy diffusion is standing in for some more directed analysis whose properties have yet to be discovered. For instance, subjective value may be constructed progressively by considering different aspects of the outcome (such as its saltiness or sweetness) in light of current appetites or motivational states. Indeed, the fact that the subjective values of many options are dynamic and contextually dependent (am I hungry or thirsty or do I have time for a snack) has been taken to explain why it might need to be computed anew for each choice[12]. This is also why simply playing back preferences previously learned by mechanisms for memorizing experienced values, such as those associated with the midbrain dopamine system, are insufficient for explaining some of the more dynamic aspects of human and animal choice preferences[13,14].

In short, although it has been indirectly inferred that choice involves such valuation computations[13,15], Krajbich and colleagues[1] provide some of the first evidence of how they actually unfold. In the future, understanding more clearly what these computations are doing, at the level of what information is being processed at each step, beyond the more mechanistic description of the diffusing decision variable, may help to clarify what it is about them that produces the unfortunate bias toward choosing what you look at most. In the meantime, just keep your eyes on the bottom shelf.

COMPETING FINANCIAL INTERESTS
The authors declare no competing financial interests.

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