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Prospection: Experiencing the Future

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Fig. 6. Two adult male chimpanzees in Kanawara groom. Male chimpanzees participate in a variety of cooperative activities and form close social bonds. [Photograph taken by Ian Gilby]

izations of at least 100 other individuals (*53*); bottlenosed dolphins (*Tursiops aduncus*) form stable multilevel alliances (*54*); and rooks (*Corvus frugilegus*) console their partners after conflicts with other members of their flocks (*55*). For individuals in these species, there may also be important social components of fitness.

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56. My ideas about the adaptive value of social bonds have been profoundly influenced by my collaborations with S. Alberts, J. Altmann, D. Cheney, and R. Seyfarth. This paper has profited from conversations with and comments from them as well as R. Boyd, N. Clayton, T. Clutton-Brock, N. Emery, and K. Langengraber.

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REVIEW

Prospection: Experiencing the Future

Daniel T. Gilbert[1*] **and Timothy D. Wilson**[2]

All animals can predict the hedonic consequences of events they've experienced before. But humans can predict the hedonic consequences of events they've never experienced by simulating those events in their minds. Scientists are beginning to understand how the brain simulates future events, how it uses those simulations to predict an event's hedonic consequences, and why these predictions so often go awry.

All animals are on a voyage through time, navigating toward futures that promote their survival and away from futures that threaten it. Pleasure and pain are the stars by which they steer. When animals experience pleasure they hold a steady course, and when they experience pain they tack. With a bit of practice, most animals learn to associate pleasures and pains with their antecedents—the smell of an approaching predator or the call of a beckoning mate—which enables them to steer toward pleasure and away from pain before they actually experience either. When a mouse hides before a cat enters the room it is responding to an event that has not yet happened, and its ability to do so is one of evolution's most remarkable achievements.

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Humans have this ability too. But they also have another ability that extends their powers of foresight far beyond those of any other animal. Just as retrospection refers to our ability to re-experience the past, prospection refers to our ability to "pre-experience" the future by simulating it in our minds. We know that chocolate pudding would taste better with cinnamon than dill, that it would be painful to go an hour without blinking or a day without sitting, that winning the lottery would be more enjoyable than becoming paraplegic—and we know these things not because they've happened to us in the past, but because we can close our eyes, imagine these events, and pre-experience their hedonic consequences in the here and now. Unfortunately, the conclusions that we draw in this way aren't always right. Trysts are often better contemplated than consummated, and sweetbreads are often better the other way around. In this article we will review what scientists have discovered about how humans mentally simulate future events and how well they can predict their hedonic reactions to them.

Mechanisms of Prospection

The brain combines incoming information with stored information to build "mental representations," or internal models, of the external world. The mental representation of a past event is a memory, the mental representation of a present event is a perception, and the mental representation of a future event is a simulation. One way to predict the hedonic consequences of a future event is to simulate it, and the brain's frontal regions appear to play a critical role in that process (*1*–*3*). Patients with damage to the prefrontal cortex are described as being "bound to present stimuli" (*4*) and "locked into immediate space and time" (*5*). Such patients seem unable to simulate future events and often have difficulty answering simple questions such as "What will you be doing tomorrow?" (*6*–*8*). Neuroimaging studies reveal that both the prefrontal cortex and the medial temporal lobes are strongly activated by prospection (*9*–*11*). Interestingly, these regions are part of the "default network" that is active when people are not specifically engaged in other tasks (*12*), which suggests that when the mind is not busy perceiving the present it tends to simulate the future (*13*). The critical role played by frontal regions suggests that few if any other animals are able to simulate future events, and even our closest relatives in the animal kingdom may be "stuck in time" (*14*, *15*). Although some animals have evolved strategies to solve problems involving future events such as impending food shortages (*16*), it seems unlikely that they achieve these solutions by simulating future events. Indeed, the ability to simulate and pre-experience the future does not appear in human children until the third or fourth year of life, long after other complex intellectual abilities such as language have bloomed (*17*).

People mentally simulate future events, but how do they use those simulations to predict the event's hedonic consequences? As the mere thought of eating a liver popsicle reveals, mental simulations of the future can elicit hedonic reactions in the present (*18*, *19*). People use their immediate hedonic reactions to simulations as predictors of the hedonic reactions they are likely to have when the events they are simulating actually come about (*20*–*22*). People do not imagine feeling anxious while having a colonoscopy so much as they imagine a colonoscopy, feel anxious, and then take this anxiety as an indicator of the feelings they can expect to experience during the procedure itself. Simulations allow people to "preview" events and to "prefeel" the pleasures and pains those events will produce. A great deal has been learned in the past few years about the neural substrates of prefeeling. For example, it appears that the activity of midbrain dopamine neurons encodes information about the magnitude of pleasure that a future event is likely to produce (*23*–*25*). Simulation of pleasurable future events activates subcortical structures such as the nucleus accumbens (*26*) and the anterior regions of the ventral striatum (*27*), whereas simulation of painful future events activates the amygdala (*28*) and/or the posterior ventral striatum (*27*). An extensive body of research shows that prefeeling depends critically on the ventromedial prefrontal cortex and that people with damage to this area find it difficult to predict the hedonic consequences of future events (*29*). Although there is still much to learn about its neural substrates, prefeeling clearly provides a basis for making hedonic predictions.

Errors of Prospection

Prefeelings will be reliable predictors of subsequent hedonic experiences when two conditions are met. As Fig. 1 shows, when we are in the present (T_1) attempting to predict our hedonic reaction to an event in the future (H_2), our present hedonic experience (H_1) is influenced by our simulation of the future event (e_1) as well as by contextual factors ($\bar{e}_1$), such as the events that are occurring in the present, the thoughts we are having in the present, our present bodily states, and so on. We feel better when we imagine going to the theater than to the dentist, but we feel better imagining either event on a sunny day than on a rainy day, or when we are well rather than ill. Similarly, our future hedonic experience (H_2) will be influenced both by our perception of the event (e_2) and by contextual factors ($\bar{e}_2$). Because our hedonic experiences are influenced both by our mental representation of the event and by contextual factors, our present hedonic experience will be a reliable predictor of our future hedonic experience if and only if (i) our simulation of the event at T_1 exerts the same influence on our hedonic experience at T_1 as our perception of the event at T_2 exerts on our hedonic experience at T_2, and (ii) contextual factors at T_1 exert the same influence on our hedonic experience at T_1 as contextual factors at T_2 exert on our hedonic experience at T_2. In other words, $H_1 = H_2$ if and only if $e_1 = e_2$ and $\bar{e}_1 = \bar{e}_2$. Errors in prospection arise from the fact that people use their prefeelings to make hedonic predictions even when one or both of these conditions is not met. These errors are of four kinds.

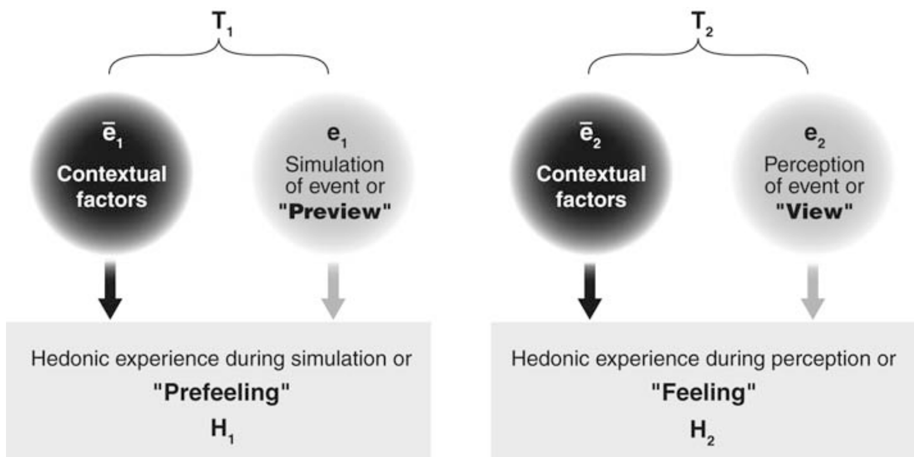

Fig. 1. Hedonic experience is influenced by mental representations (simulations and perceptions) and by contextual factors.

Simulations are unrepresentative. We naturally imagine our next dental appointment by remembering our last one. Memories are the building blocks of simulations (*13*, *30*–*33*), which is why amnesiacs who have trouble with retrospection tend to have trouble with prospection as well (*7*, *8*, *34*). Of course, simulations cannot accurately represent the future if they are constructed from memories that don't accurately represent the

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past, and research suggests that people often use unrepresentative memories as a basis for simulation. For example, when people who have missed trains in the past are asked to imagine missing a train in the future, they tend to remember their worst train-missing experience rather than their typical train-missing experience. They then use this unrepresentative memory to construct a simulation of their next train-missing experience, which leads them to overestimate how painful the next train-missing experience will be (*35*). Similarly, when people experience an unpleasant episode that ends in brief relief—for example, submerging their arms for 90 s in a bath of ice water that is slightly warmed in the final 30 s—they tend to remember the closing moments of the experience rather than the most typical moments. They then use this unrepresentative memory to construct a simulation of the event's recurrence, which leads them to underestimate how painful the recurrence will be (*36*, *37*). It seems that everyone remembers their best day, their worst day, and their yesterday. Because unusual events and recent events are so memorable, people tend to use them when constructing simulations of future events.

Simulations are essentialized. When we imagine "going to the theater next week," we don't imagine every detail of the event, but rather, we imagine the essential features that define it. We imagine seeing a stage filled with actors but we do not imagine parking the car, checking our coat, or finding our seat. The problem with omitting inessential features from simulations is that such features can profoundly influence our subsequent hedonic experience. Most events have a small set of extremely positive or negative essential features that define them, as well as a large set of both mildly positive and mildly negative inessential features that don't. The event's net hedonic effect is a weighted average of these. Because simulations omit inessential features, people tend to predict that good events will be better and bad events will be worse than they actually turn out to be (*38*). The young couple who simulate the joys of parenthood but fail to simulate the drudgery of diapers are unlikely to have the hedonic experience they imagined.

The tendency for simulations to omit inessential features becomes more pronounced as the event being simulated becomes more temporally distant (*39*, *40*). Participants in one study were told that in a year there would be an interesting lecture at an inconvenient location and a boring lecture at a convenient location. Because their simulations of the lecture contained the essential features (e.g., the topic) but lacked the inessential features (e.g., the location), participants predicted that they would attend the more interesting lecture. But participants who were told that the same lecture was taking place tomorrow instead of next year tended to simulate both the essential and inessential features, and thus predicted that they would attend the more convenient lecture (*41*). The fact that simulations of far-future events are especially likely to omit inessential features is one of the reasons why people so often make future commitments that they regret when the time to fulfill them arrives.

Simulations are abbreviated. If we imagined each and every moment of the events we were simulating, our simulations would take as long as the events themselves. Simulations are naturally abbreviated and represent just a few, select moments of a future event. The moments they select tend to be the early ones. When people imagine what their lives would be like if they won the lottery or became paraplegic, they are more likely to imagine the first day than the two-hundred-and-ninety-seventh. The problem with imagining only the early moments of an event is that hedonic reactions to events typically dissipate over time, which means that mental simulations tend to overrepresent the moments that evoke the most intense pleasure or pain. This is one of the reasons why healthy people consistently underestimate how happy they would be in various states of ill-health (*42*–*44*). When people imagine "losing mobility," they expect to be less happy than people who have experienced these events actually are because their simulations over-represent the initial—and typically the worst—moments of these events. The tendency to underestimate how quickly we will adapt to a wide range of pleasurable and painful events is probably the most commonly observed error in research on hedonic prediction (*45*).

Adaptation takes time, and because simulations do not fully "play out" the events they represent, people's hedonic predictions are typically unaffected by those features of an event that will promote or inhibit adaptation over time (*46*–*49*). For example, people adapt to events much more quickly when they understand why those events happened. When students at a university library were approached by a researcher and given a $1 coin, those who received an explanation for the event were less happy 20 min later than those who did not (Fig. 2). But when students were asked to simulate the event, they predicted that they would be happier if they received an explanation (*50*). Participants in another study were more satisfied with a gift when they were not given the opportunity to exchange it because inescapability, like explanation, facilitates adaptation. And yet, participants who merely simulated receiving gifts failed to realize that they would be more satisfied with gifts that they couldn't exchange (*48*). Because simulations tend to represent the early mo-

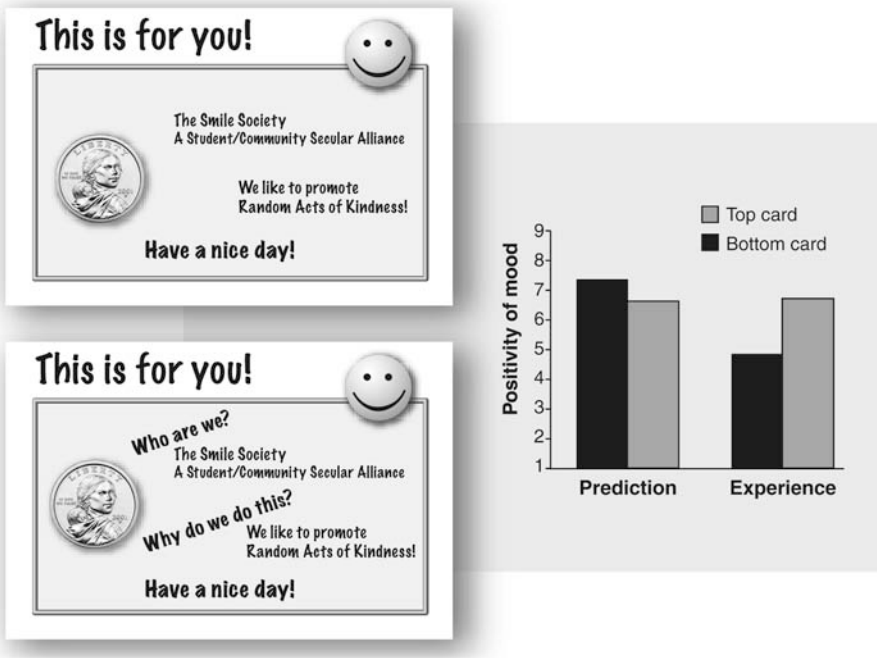

Fig. 2. When students in a library were given a card with a $1 coin attached, they were in better moods 20 min later if they received the top card than the bottom card; however, when asked to simulate this event, students predicted that they would be in better moods if they received the bottom card than the top card (*50*). The bottom card is identical to the top card except that it includes the phrases "Who are we?" and "Why do we do this?" The inclusion of these phrases creates a question-and-answer format that gives people the sense that the event has been explained. The histograms show the average predicted and experienced mood as measured on a series of nine-point Likert-type rating scales.

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ments of future events, predictions based on them tend to ignore things that happen in the later moments.

Simulations are decontextualized. As mentioned earlier, two conditions must be met for a person's present hedonic experience to be a reliable predictor of their future hedonic experience. First, their simulation of an event (e_1) must exert the same influence on their present hedonic state (H_1) as their perception of the event (e_2) will exert on their future hedonic state (H_2). This does not always happen because compared to perceptions, simulations are unrepresentative, essentialized, and abbreviated. The second condition that must be met is that contextual factors ($\bar{e}_1$) must exert the same influence on their present hedonic state (H_1) as contextual factors ($\bar{e}_2$) will exert on their future hedonic state (H_2). Unless T_1 and T_2 are brief and contiguous, this is unlikely to happen because contextual factors—from the temperature in a room to the amount of glucose in a bloodstream—change over time.

Research shows that people often do not consider the potentially significant differences between contextual factors at T_1 and T_2 when using their present hedonic state to predict their future hedonic state (*51*). For example, hungry people mistakenly expect to like eating spaghetti for breakfast the next day, and sated people mistakenly expect to dislike eating it for dinner the next day (*52*). People who have just exercised mistakenly expect to enjoy drinking water the next day more than do people who are about to exercise (*53*). In both cases, people do not seem to realize that their present hunger and thirst are influencing their hedonic reactions to simulated future consumption. They ignore the fact that the contextual factors that are presently exerting an influence at T_1 (i.e., hunger and thirst) will not exert the same influence at T_2. Conversely, people overestimate how unhappy they will be after their team loses a football game (*54*) and how happy they will be after becoming wealthy (*55*) because they do not consider the fact that their hedonic experience after an athletic defeat or a financial victory will be influenced by factors other than scoreboards and bank balances. They ignore the fact that the contextual factors that will exert an influence at T_2 (e.g., weather, traffic, conversation, etc.) are not presently exerting an influence at T_1 (*56*). And indeed, when people are specifically encouraged to consider these contextual factors, their predictions become more accurate (*54*, *57*).

Conclusion

Mental simulation is the means by which the brain discovers what it already knows. When faced with decisions about future events, the cortex generates simulations, briefly tricking subcortical systems into believing that those events are unfolding in the present and then taking note of the feelings these systems produce. The cortex is interested in feelings because they encode the wisdom that our species has acquired over millennia about the adaptive significance of the events we are perceiving. Alas, actually perceiving a bear is a potentially expensive way to learn about its adaptive significance, and thus evolution has provided us with a method for getting this information in advance of the encounter. When we preview the future and prefeel its consequences, we are soliciting advice from our ancestors.

This method is ingenious but imperfect. The cortex attempts to trick the rest of the brain by impersonating a sensory system. It simulates future events to find out what subcortical structures know, but try as it might, the cortex cannot generate simulations that have all the richness and reality of genuine perceptions. Its simulations are deficient because they are based on a small number of memories, they omit large numbers of features, they do not sustain themselves over time, and they lack context. Compared to sensory perceptions, mental simulations are mere cardboard cut-outs of reality. They are convincing enough to elicit brief hedonic reactions from subcortical systems, but because they differ from perceptions in such fundamental ways, the reactions they elicit may differ as well. Although prospection allows us to navigate time in a way that no other animal can, we still see more than we foresaw.

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