Deciding Advantageously Before Knowing the Advantageous Strategy

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Deciding advantageously in a complex situation is thought to require overt reasoning on declarative knowledge, namely, on facts pertaining to premises, options for action, and outcomes of actions that embody the pertinent previous experience. An alternative possibility was investigated: that overt reasoning is preceded by a nonconscious biasing step that uses neural systems other than those that support declarative knowledge. Normal participants and patients with prefrontal damage and decision-making defects performed a gambling task in which behavioral, psychophysiological, and self-account measures were obtained in parallel. Normals began to choose advantageously before they realized which strategy worked best, whereas prefrontal patients continued to choose disadvantageously even after they knew the correct strategy. Moreover, normals began to generate anticipatory skin conductance responses (SCRs) whenever they pondered a choice that turned out to be risky, before they knew explicitly that it was a risky choice, whereas patients never developed anticipatory SCRs, although some eventually realized which choices were risky. The results suggest that, in normal individuals, nonconscious biases guide behavior before conscious knowledge does. Without the help of such biases, overt knowledge may be insufficient to ensure advantageous behavior.

In a gambling task that simulates real-life decision-making in the way it factors uncertainty, rewards, and penalties, the players are given four decks of cards, a loan of $2000 facsimile U.S. bills, and asked to play so that they can lose the least amount of money and win the most (1). Turning each card carries an immediate reward ($100 in decks A and B and $50 in decks C and D). Unpredictably, however, the turning of some cards also carries a penalty (which is large in decks A and B and small in decks C and D). Playing mostly from the disadvantageous decks (A and B) leads to an overall loss. Playing from the advantageous decks (C and D) leads to an overall gain. The players have no way of predicting when a penalty will arise in a given deck, no way to calculate with precision the net gain or loss from each deck, and no knowledge of how many cards they must turn to end the game (the game is stopped after 100 card selections). After encountering a few losses, normal participants begin to generate anticipatory skin conductance responses (SCRs) whenever they pondered a choice that turned out to be risky, before they knew explicitly that it was a risky choice, whereas patients never developed anticipatory SCRs, although some eventually realized which choices were risky. The results suggest that, in normal individuals, nonconscious biases guide behavior before conscious knowledge does. Without the help of such biases, overt knowledge may be insufficient to ensure advantageous behavior.

REFERENCES AND NOTES

27. We thank D. Hill and J. Lowenstein for helpful reviews. M.M.M. is grateful to the National Science Foundation for the postdoctoral fellowship under which part of this work was carried out.

27 September 1996; accepted 11 December 1996
tonomic responses and continued to select cards from the bad decks. The patients failed to act according to their correct conceptual knowledge.

On the basis of these results, we suggest that the sensory representation of a situation that requires a decision leads to two largely parallel but interacting chains of events (Fig. 2). In one, either the sensory representation of the situation or of the facts evoked by it activate neural systems that hold nondeclarative dispositional knowledge related to the individual’s previous emotional experience of similar situations (5). The ventromedial frontal cortices are among the structures that we suspect hold such dispositional knowledge, the activation of which, in turn, activates autonomic and neurotransmitter nuclei (such as those that deliver dopamine to selected cortical and subcortical forebrain regions), among other regions. The ensuing nonconscious signals then act as covert biases on the circuits that support processes of cognitive evaluation and reasoning (6). In the other chain of events, the representation of the situation generates (i) the overt recall of pertinent facts, for example, various response options and future outcomes pertaining to a given course of action; and (ii) the application of reasoning strategies to facts and options. Our experiment indicates that in normal participants, the activation of covert biases preceded overt reasoning on the available facts. Subsequently, the covert biases may have assisted the reasoning process in cooperative manner, that is, biases would not decide per se, but rather facilitate the efficient processing of knowledge and logic necessary for conscious decisions (7). We suspect that the autonomic responses we detected are evidence for a complex process of nonconscious signaling, which reflects access to records of previous individual experience—specifically, of records shaped by reward, punishment, and the emotional state that attends them. In this light, damage to ventromedial cortices acts by precluding access to a particular kind of record of previous and related individual experience.

REFERENCES AND NOTES

3. The patients who participated in the experiment were drawn from the Division of Cognitive Neuroscience’s Patient Registry and have been described previously (1, 2). Three are female (ages 53, 63, and 64), and three are male (ages 51, 52, and 63). All have stable focal lesions. Years of education: 13 ± 2 (mean ± SEM); verbal IQ: 111 ± 8 (mean ± SEM); performance IQ: 102 ± 8 (mean ± SEM).
4. The results in this group of normal participants are similar to the results described previously in other normal participants (2).
6. We envision these biases to act as markers or qualifiers in the manner suggested by A. Damasio [in (5), chap. 8] and by A. R. Damasio, D. Tranel, and H. Damasio [in...
Single Molecule Force Spectroscopy on Polysaccharides by Atomic Force Microscopy

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Recent developments in piconewton instrumentation allow the manipulation of single molecules and measurements of intermolecular as well as intramolecular forces. Dextran filaments linked to a gold surface were probed with the atomic force microscopy tip by vertical stretching. At low forces the deformation of dextran was found to be dominated by entropic forces and can be described by the Langevin function with a 6 angstrom Kuhn length. At elevated forces the strand elongation was governed by a twist of bond angles. At higher forces the dextran filaments underwent a distinct conformational change. The polymer stiffened and the segment elasticity was dominated by the bending of atomic bonds. The conformational change was found to be reversible and was corroborated by molecular dynamics calculations.

http://www.sciencemag.org  •  SCIENCE  •  VOL. 275  •  28 FEBRUARY 1997