Title

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Authors
Barnes, Allison
Thagard, Paul

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Allison Barnes and **Paul Thagard**
Philosophy Department
University of Waterloo
Waterloo, Ontario, N2L 3G1, Canada
{albarnes, pthagard}@watarts.uwaterloo.ca

Abstract

Recent research has yielded an explosion of literature that establishes a strong connection between emotional and cognitive processes. Most notably, Antonio Damasio draws an intimate connection between emotion and cognition in practical decision making. Damasio presents a "somatic marker" hypothesis which explains how emotions are biologically indispensable to decisions. His research on patients with frontal lobe damage indicates that feelings normally accompany response options and operate as a biasing device to dictate choice. What Damasio's hypothesis lacks is a theoretical model of decision making which can advance the conceptual connection between emotional and cognitive decision making processes. In this paper we combine Damasio's somatic marker hypothesis with the coherence theory of decision put forward by Thagard and Millgram. The juxtaposition of Damasio's hypothesis with a cognitive theory of decision making leads to a new and better theory of emotional decisions.

Introduction

Emotions are ordinarily conceived as irrational occurrences that cloud judgment and distort reasoning. This view is well entrenched, despite work in both philosophy and psychology that establishes a strong connection between emotion and cognition. During recent years there has been an explosion of research which indicates that rather than being natural adversaries, rational and emotional processes function together. Barnes and Thagard (in press) argue that emotions and inferences are both necessary when we empathize with other people. Social psychologists have explored the function of emotions in social perception and judgment (Forgas, 1991). But the interdependence of emotional and cognitive processes is perhaps most powerfully presented in recent neurobiological studies which establish that emotion is indispensable in rational decision making.

Most notably, in *Descartes' Error: Reason, Emotion and the Human Brain,* neurobiologist Antonio Damasio (1994) provides a "somatic marker hypothesis" which explains how emotions make decision making possible. Damasio's somatic marker hypothesis suggests that the role of emotions in decision making is biologically extensive and complex. What Damasio's somatic marker hypothesis lacks, we maintain, is a theoretical or computational model of decision making which can advance the conceptual connection between emotional and cognitive decision-making processes. We propose that Damasio's work is best understood and developed by the coherence theory of decision put forward by Thagard and Millgram. Conversely, Damasio's somatic marker hypothesis suggests ways that the coherence theory of decision can be enhanced. After briefly describing Damasio's hypothesis and the coherence theory of decision, we will outline how both projects can merge to form a new and better account of decision making. Our juxtaposition of Damasio's neurobiological hypothesis with a cognitive theory of decision making is preliminary to a possible theory of emotional decision making.

Emotions and the Brain

Damasio re-examines the case of Phineas Gage, the victim of an 1848 mine explosion that hurled an iron rod through his skull and brain. Strangely, Gage recovered except for a severe deficiency in practical and social decision making. According to Damasio, the case of Gage and other patients with similar frontal lobe damage offer convincing evidence that the human brain's regions for making decisions are strongly connected to emotional centers.

Damasio maintains that Gage and other frontal lobe patients with faulty decision making skills have all the information required to make decisions. According to neurological studies by Saver and Damasio (1991), social knowledge in these patients remains intact. Their experimental subject, EVR, could provide response options to social situations, consider the consequences of these options and perform moral reasoning at an advanced level. EVR had normal or better intelligence and memory. Detailed studies by Saver and Damasio suggest that even with all the necessary information, such patients are unable to implement a choice in everyday life.[1] For example, EVR would take hours deciding where to dine by obsessing about each restaurant's seating plan, menu and atmosphere. Even then, he could not reach a final decision.

These neurological studies show that what is damaged in these patients is not memory or intelligence, but the neural connections between the emotional and cognitive centers of the brain. More specifically, the ventromedial frontal region

[1]The deficiency is typically confined to practical decision making. Like other patients, EVR had no trouble with hypothetical decision making.

is reported to be responsible for emotional processing and social cognition through connections with the amygdala and hypothalamus. After a series of tests, Saver and Damasio conclude that in the absence of emotional input, EVR's decision making process was overwhelmed by trivial information. With additional studies, the researchers conclude that EVR had no internal goal representation. In order for goals to remain stable for EVR, they had to be represented externally and repeatedly. Otherwise, "...it was as if he forgot to remember short- and intermediate- term goals.... He couldn't keep a problem in perspective in relation to other goals."(1985, p.1737).

The somatic marker hypothesis is presented by Damasio to explain these experimental findings. The hypothesis is that bodily feelings normally accompany our representations of the anticipated outcomes of options. In other words, feelings *mark* response options to real or simulated decisions. Somatic markers serve as an automatic device to speed one to select biologically advantageous options. Those options that are left unmarked are omitted in the decision-making process.[2] Damasio suggests that patients with frontal lobe damage fail to activate these somatic markers which are directly linked to punishment and reward, and originate in previously experienced social situations. EVR's decision making defect is explained by an inability to activate somatic states when ordinary decisions arise; by an inability to mark the implications of a social situation with a signal that would separate good and bad options.[3] EVR was therefore trapped in a never-ending cost-benefit analysis of numerous and conflicting options. In the absence of emotional markers, decision making is virtually impossible.

A Coherence Theory of Decision

Damasio's hypothesis invites a description of how decisions are ordinarily made. According to the coherence theory of decision (Millgram and Thagard, in press; Thagard & Millgram 1995), people make decisions by assessing and ordering various competing actions and goals. For example, someone may want both to get lots of research done and to relax and have fun with his or her friends. Learning how to accomplish both these tasks will take place in the context of goals that cannot be fully realized together. The rational decision maker chooses complex plans that are *most coherent* with currently held goals. Decisions arise from principles of coherence that govern the relations among actions and goals. In this sense, a decision can be described as an inference to the best plan where the desirability of goals is determined by deliberative coherence. Since goals compete for limited resources, goals that hang together and which produce overlapping plans of action tend to be more easily jointly satisfied. Put simply, actions and plans which best satisfy existing goals are the best options.

Consider Howard, an academic who must decide whether or not to accept a teaching position at another institution. Why are such decisions so difficult? Important life choices such as this one involve many different and sometimes intensely conflicting goals. Perhaps Howard is attracted by the new position because it offers increased salary and prestige, but is concerned that moving would involve considerable dislocation and loss of established relations with colleagues. Moreover, he may have a family with roots in his current community. He thus has to deal with a plethora of interconnected and possibly ill-specified goals that are relevant to what choice he will make.

Thagard and Millgram propose a set of principles designed to specify the kinds of relations that exist among actions and goals and that give rise to coherence estimations that determine not only choices of actions to perform but also adoption of complex plans and revisions of goals. They make no sharp distinction between actions and goals, since what in one context is best described as an action may be best described in another context as a goal. For example, if my main goal is to travel from Waterloo to San Diego, I will set myself the subgoal of getting to Toronto airport, but this subgoal is itself an action to be performed. Actions and goals are referred to as *factors* in decision making. Factors are actions and goals that cohere with each other according to the following six principles.

1. Symmetry. Coherence and incoherence are symmetrical relations: If a factor (action or goal) F_1 coheres with a factor F_2, then F_2 coheres with F_1.

2. Facilitation. Consider actions $A_1 \ldots A_n$ that together facilitate the accomplishment of goal G. Then

(a) each A_i coheres with G,

(b) each A_i coheres with each other A_j, and

(c) the greater the number of actions required, the less the coherence among actions and goals.

3 . Incompatibility.

(a) If two factors cannot both be performed or achieved, then they are strongly incoherent.

(b) If two factors are difficult to perform or achieve together, then they are weakly incoherent.

4. Goal priority. Some goals are desirable for intrinsic or other non-coherence reasons.

5. Judgment. Facilitation and competition relations can depend on coherence with judgments about the acceptability of factual beliefs.

6. Decision. Decisions are made on the basis of an assessment of the overall coherence of a set of actions and goals.

DECO is a computer program that incorporates these principles and makes excellent decisions. DECO constructs

[2]The somatic marker hypothesis originates with Walle Nauta (1971), 183-184: "The normal individual decides upon a particular course of action by a thought process in which a larger or smaller number of strategic alternatives is compared. It could be suggested- admittedly on introspective grounds- that the comparison in the final analysis is one between the affective responses evoked by each of the various alternatives....If this were indeed the case, it would be readily understandable that loss of the frontal cortex as a major mediator of information exchange between the cerebral cortex and the limbic system is followed not only by an impairment of strategic choice making, but also by a tendency of projected or current action systems to 'fade out' or become over-ridden by interfering influences. "

[3]Damasio, Tranel and Damasio (1990) also speculate that the sociopath's inability to avoid punishment is related to a failure to emotionally anticipate the consequences of behavior.

a connectionist network which represents goals and actions by a network node called a unit. Competing actions are evaluated on the basis of how well they cohere with each other and with goals whose acceptance may be affected both by coherence considerations and intrinsic desirability. When two units cohere, DECO places an excitatory link (with weight greater than 0) between the units that represent them. Whenever two factors incohere, DECO places an inhibitory link (with weight less than 0) between them. Intrinsic desirability of some goals is easily implemented by linking a special unit, which is always active, to each unit representing an intrinsic goal. There can be different weights on the links representing different degrees of coherence and desirability. Finally, with activation spreading from the special unit to the goals and then out to the subgoals and the actions, the network will update activation of the various units in parallel until all units achieve stable activation. The final activation of the units represents either the choice of particular actions or the posterior value of particular goals. Just as some actions are rejected in favor of better ones with which they compete, some goals are rejected or downplayed as part of the overall judgment of deliberative coherence. All links in this system are symmetrical, reflecting their implementation of considerations of coherence and incoherence. But the links from some of the goal units to the always-active special unit introduces an asymmetry of processing: goal units may much more of an effect on action units than vice versa, since activation can flow directly from the special unit to the units representing goals with inherent priority, and only then to units representing actions.[4] DECO provides a means of testing out whether the principles of deliberative coherence can fruitfully be applied to understand real cases of complex decision making. For a more complete description of DECO and a comparison with classical decision theory, see Thagard and Millgram (1995).

Emotional Decisions

We are now in a position to merge Damasio's hypothesis with components of the coherence theory of decision. This junction requires that both Damasio's hypothesis and the coherence theory of decision be modified. These modifications produce a much richer outline of emotional decisions.

The most obvious way to modify Damasio's hypothesis is to link somatic markers to goal priority. Recall that Damasio maintains that somatic states mark *response options*. If decision-making is a matter of evaluating goals, it makes more sense to link somatic states with the representation of *goals*. Under this modified hypothesis, our most important or meaningful goals are accompanied by somatic markers, the most salient having stronger emotional tags. In this way, EVR's deficiency could be redescribed as a failure to deal with numerous and conflicting goals. We can surmise that EVR's goals were not prioritized because they were not accompanied by emotional states. That is, none of EVR's goals were more important than the others. It was impossible for him to choose where to dine, we suggest, precisely because goals such as saving money and being healthy could not be weighed in the absence of emotional markers.

Damasio claims that un-marked options are not considered by the decision maker. This biasing function of somatic markers is really what makes decision making possible. In the absence of markers, the decision maker has too much information to deal with. The computations involved are so cumbersome that they cannot yield a final decision. In short, emotions dictate and constrain which bits of information are used. Following Damasio, we also propose that un-marked goals are overridden in the decision-making process and do not factor into coherence calculations. This biasing function of emotion has been underlined by various emotion theorists including de Sousa (1990), Frijda (1986) and Oatley (1992).

From the opposite direction, the coherence theory of decision gains much from Damasio's somatic marker hypothesis. Somatic markers explain how goals can be efficiently prioritized by a cognitive system, without having to evaluate the propositional content of existing goals. After somatic markers are incorporated, what is compared by the deliberator is not the goal as such, but its emotional tag. The biasing function of somatic markers explains how irrelevant information can be excluded from coherence considerations. With Damasio's thesis, choice activation can be seen as involving emotion at the most basic computational level. Inferences to the best plan are not only goal- relevant, directed or determined; they are also emotion-relevant, directed or determined.

In conclusion, the combination of somatic markers with DECO provides the following sketch of a possible theory of emotional decisions:

1. Decisions arise when new information is inconsistent with one or more currently held goals. The mismatch yields a negative emotion which produces a rupture in ordinary activity.[5]
2. The decision juncture causes a simulation to occur, in which goals are reevaluated on the basis of new information. This evaluation of goals elicits somatic markers.
3. Once the goals are prioritized by somatic markers, new options are simulated and evaluated.
4. Coherence calculations produce the best option and equilibrium is restored between the present situation and existing goals.

This sketch shows how emotions help to prevent our decision calculations from becoming so complex and cumbersome that decisions would be impossible. Emotions function to reduce and limit our reasoning, and thereby make reasoning possible.

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[4]For a more complete description of DECO and a comparison with classical decision theory see Thagard & Millgram, "Inference to the Best Plan: A Coherence Theory of Decision" (in press).

[5]This section draws heavily on Frijda's (1986) theory of emotion. Frijda defines an emotion as a change in action readiness. Emotions are always elicited and result from the interaction of an event with our goals or concerns. Emotions are tendencies to establish, maintain or disrupt a relationship with the environment.

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