Emotion as a Motivated Behavior

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Abstract

Emotions are conventionally treated as automatic processes that flow reflexively from assessments of reality. The assumption that future reward is discounted in standard percent-per-unit-time (exponential) discount curves has prevented recognition that emotions are at most quasi-automatic, and might be reward-dependent even when subjectively involuntary Substantial evidence that the basic discount curve is not exponential but hyperbolic makes possible a model in which even involuntary, negative emotions compete in a single internal marketplace of reward. A crude mechanical illustration of this model is described.

1 Introduction

Emotions are widely recognized to be motivating (Ortony *et.al*., 1988)—The name comes from the same Latin root, *movere*, the verb to move, the past participle of which is *motus*. However, they are thought of as being themselves unmotivated, rather as being imposed by the same process of classical conditioning to which most involuntary behaviors are attributed.

Certainly the major emotions have invariant features, are known to have specific brain circuits using specific neurotransmitters (Panksepp, 2000), and can even be induced by electrical brain stimulation (Delgado, 1969). In the original behaviorist model of emotion it was evoked as a conditioned response to innately determined stimuli (Watson, 1924). However, it proved to be hard to trace the emotional impact of a stimulus to a conditioning event. Even in the laboratory fear is the only emotion that has been conditioned; actual phobias are rarely a consequence of trauma involving the object feared, and trauma rarely leads to phobia (Rachman, 1977). The belief that an emotion is determined by a distant releasing stimulus linked to the immediate occasion by a chain of associations was a reasonable guess, but with little evidence behind it.

Later ideas of what induces emotion have been less specific, but still imply that it is driven by external givens that a person encounters—if not innately determined releasing stimuli, then belief that she faces a condition that contains these stimuli. Emotion is still a reflex of sorts, albeit usually a cognitively triggered reflex, a passive response to events outside of her control—hence "passion" as opposed to "action." In reviewing current cognitive theory, Frijda notes that the trigger may be as nonspecific as "whether and how the subject has appraised the relevance of events to concerns, and how he or she has appraised the eliciting contingency (2000, p. 68);" but this and the other theories of induction that he covers still involve an automatic response to the motivational consequences of the event, not a choice based on the motivational consequences of the emotion itself. Even though emotions all have such consequences, "the individual does not produce feelings of pleasure or pain at will, except by submitting to selected stimulus events (*ibid.,* p. 63)." That is, all emotions reward or punish, but they are said not to be chosen because of this consequence. In every current theory they are not chosen at all, but evoked.

2 Emotions can be shaped…

The widespread agreement that emotions are automatic ignores both common experience and a fair amount of data. Granted that emotions are usually *occasioned* by events outside of your voluntary control; the theory that they are *governed* by such events runs afoul of the widespread acknowledgment that they are trainable: You can "swallow" your anger or "nurse" it, learn to inhibit your phobic anxiety (Marks & Tobena, 1990) or panic (Clum *et.al*., 1993; Kilic *et.al*., 1997) instead of "surrendering to it," limit your grief (Ramsay, 1997) instead of "wallowing in it," refrain from rejoicing or "give yourself over to it." Techniques to foster or inhibit emotions in everyday life have been described (Parrott, 1991), as has their use in preparing yourself for particular tasks (Parrott, 1993). Many schools of acting teach an ability to summon emotion deliberately (e.g. McGaw, 1966; Strasberg, 1988), because even in actors actual emotion is more convincing than feigned emotion (Gosselin *et.al*., 1998). The frequent philosophical assertion that emotions have a moral quality—good or bad (e.g. Hume as presented by Baier, 1991)—implies motivated participation; some philosophers have gone so far as to call the passions voluntary (e.g. Sartre, 1939/1948). In sum, emotions show signs of being goal-directed processes that are ultimately selected by their consequences, not their antecedents. That is, they are at least partially in the realm of reward-governed behaviors, not conditioned responses; they are pulled by incentives rather than pushed by stimuli. Even "negative" emotions like fear and grief seem to be urges that lure you into participating in them, rather than automatically imposed states. Conversely, the fact that emotions are usually involuntary does not mean that they are not selected by reward; after all, reward can even shape behavior during sleep (Granda & Hammack, 1961).

Examples of producing emotions deliberately are usually dismissed as examples of self-conditioning. Actors, for instance, use rehearsal of significant emotional memories to learn the necessary control, and psychotherapists often use guided imagery to influence emotions. According to conditioning theories you find the right conditioned stimulus and provoke your own reflex with it, like hitting your own knee with a rubber hammer to produce a jerk. It is true that in a given instance the goal-directed, or *operant*,[1] sequence of

cue→ response→ reward

can always be interpreted as the classically conditioned sequence of

conditioned stimulus→ conditioned response→ unconditioned or lower-order conditioned stimulus

and vice versa. However, if the conditioning stimulus is not repeated on successive trials, a true conditioned response will extinguish.[2] The memory or image will stop evoking the emotion. If the response grows and comes more readily, like the actor's emotion as she learns to summon it, it must have come under the control of a different selection agent, which probably means that it has been learned as an operant behavior. Learning to induce an emotion follows the same course as a bulimic's learning to vomit at will—the gagging stimulus of a spoon or finger becomes less and less necessary, and eventually can be dispensed with altogether.

2.1 …but how if by reward?

However, theoretical problems implicit in the concept of reward have been an obstacle to building an operant model of emotion. These theoretical problems follow from the conventional utility-based model of motivation. If you could produce "feelings of pleasure or pain at will," why not overdose on the pleasure and skip the pain, without regard to the outside world? If an emotion is aversive and avoidable, what induces people to entertain it? If an emotion is pleasurable and readily accessible, what keeps people from indulging in it *ad lib*?

3 Hyperbolic discounting supplies a mechanism

A solution has been unavailable because of a universal but almost certainly false assumption about how we evaluate future incentives. It is now well documented that both people and nonhuman animals have a robust tendency to devalue expected incentives in a hyperbolic curve. Such a curve represents a radical departure from the exponential curve that has been the explicit assumption of behavioral psychology and classical economics, and is implied by the "rational choice theory" that has become the norm in all behavioral sciences that depend on utility theory (Sugden, 1991; Cooter & Ulen, 2000).

[1] "Operant" is the favored term in behavioral psychology for "governed by differential reward and/or punishment."

[2] I have argued elsewhere that all "conditioned" responses can be understood as operant instead (1992, pp. 39-48; 2001, pp. 19-22), but I am not assuming that here. "Conditioned appetite" as a mechanism of preference reversal is analyzed in Ainslie, 2005.

3.1 Evidence that discounting is hyperbolic

Four kinds of experiment have demonstrated this phenomenon:

3.1.1 Goodness of fit

Given choices between rewards of varying sizes at varying delays, both human and nonhuman subjects express preferences that fit curves of the form,

$$V = A / (1 + kD)$$

a hyperbola, better than the form,

$$V = A\ e^{kD}$$

an exponential curve (where V is motivational value, A is amount of reward, D is delay of reward from the moment of choice, and k is a constant expressing impatience; Green, Fry & Myerson, 1994;Grace, 1996; Kirby, 1997; Mazur 2001). It has also been observed that the incentive value of small series of rewards is the sum of hyperbolic discount curves from those rewards (Mazur, 1986; Brunner & Gibbon, 1995).

3.1.2 Preference reversal

Given choices between smaller-sooner (SS) rewards and larger-later (LL) ones available at a constant lag after the SS ones, subjects prefer the LL reward when the delay before both rewards is long, but switch to the SS reward as it becomes imminent, a pattern that would not be seen if the discount curves were exponential (Ainslie & Herrnstein, 1981; Green *et.al*., 1981;Ainslie & Haendel, 1983; Kirby & Herrnstein, 1995). Where anticipatory dread is not a factor (with nonhumans or with minor pains in humans), subjects switch from choosing SS aversive stimuli to LL ones as the SS ones draw near (Solnick *et.al.*, 1980; Novarick, 1982; Dinsmoor, 1998).

3.1.3 Precommitment

Given choices between SS rewards and LL ones, nonhuman subjects will sometimes choose an option available in advance that prevents the SS alternative from becoming available (Ainslie, 1974; Hayes *et.al*., 1981). The converse is true of punishments (Deluty *et.al*., 1983). This design has not been run with human subjects, but it has been argued that illiquid savings plans and other choice-reducing devices serve this purpose (Laibson, 1997). Such a pattern is predicted by hyperbolic discount curves, while conventional utility theory holds that a subject has no incentive to reduce her future range of choices (Becker & Murphy, 1988).

3.1.4 Stabilization by bundling

When a whole series of LL rewards and SS alternatives must be chosen all at once, both human (Kirby & Guastello, 2001) and nonhuman (Ainslie & Monterosso, 2003a) subjects choose the LL rewards more than when each SS vs. LL choice can be made individually. The effect of such *bundling* of choices is predicted by hyperbolic but not exponential curves.

4 Overvaluation of immediate reward structures the emotions

The hyperbolic shape of the discount curve from delayed rewards makes possible an answer to the question raised above: What would make organisms entertain painful experiences, or limit their indulgence in pleasurable ones?

4.1 ”Negative” emotions

The argument for how negative emotions could be motivated behaviors involves the commonalities of aversive emotions and addictive rewards (Ainslie, 2001, pp. 90-104). Although both are usually avoided from a distance, both are seductive when they might occur in the near future. That is, however much you know that a binge will cost more than it is worth or that a fear is unfounded, it is sometimes hard not to participate in them.

Addictive behaviors can be well explained by imminent highs that, because of hyperbolic discounting, are valued temporarily above the more delayed rewards of sobriety (Vuchinich & Simpson, 1998; Mitchell, 1999). How the opposite rewarding and unrewarding incentives for negative emotions are compounded to attract attention but deter approach in general is still unclear. The similarity to addictive behaviors suggests that the urge to succumb to panic, anger, anguish, and even physical pain might be based on a rapidly recurring but very brief reward, lasting long enough to command attention but not deliberate choice, and fused in perception with longer, unrewarding consequences to form an experience both vivid and aversive (Ainslie, 1992, pp. 100-114). Thus people who often encounter fearful situations—or who have a low fear threshold—sometimes learn to resist the urge to panic (Clum *et.al*., 1993), but find it hard to do so despite an awareness that if they do not, panic will quickly prove to be the more aversive response.

4.2 "Positive" emotions

Although emotions are physically available, something makes them less intense in proportion as the occasion for them is arbitrary. To the extent that someone learns to access them at will, doing so makes them pale, mere daydreams. Even an actor needs to focus on appropriate occasions to bring them out with force. But what properties must an event have in order to serve as an occasion for emotion? The fact that there's no physical barrier opposing free access to emotions raises the question of how emotional experiences become the objects of often arduous striving, goods that seem to be in limited supply. That is, how do you come to feel as if you have them passively, as implied by their synonym, "passions?"

With the positive emotions, the basic question is, how does your own behavior become scarce? I'll divide it into two parts: Why would you want a behavior of yours to become scarce, that is, to limit your free access to it? And given that this is your wish, how can you make it scarce without making it physically unavailable?

All kinds of reward depend on a readiness for it that's used up as reward occurs and that can't be deliberately renewed. This readiness is the potential for appetite. The properties of appetites are often such that rapid consumption brings an earlier peak of reward but reduces the total amount of reward that the appetite makes possible, so that we have an amount-vs.-delay problem. Where people-- or, presumably, any reward-governed organisms-- have free access to a reward that's more intense the faster it's consumed, they will tend to consume it faster than they should if they were going to get the most reward over time from that appetite. In a conflict of consumption patterns between the long and pleasant versus the brief but even slightly more intense, an organism that discounts the future hyperbolically is primed to choose brief but intense. Accordingly, emotional reward, indulged in *ad lib*, becomes unsatisfactory for that reason itself. To get the most out of any kind of reward, we must have-- or develop-- limited access to it.

With emotional rewards, the only way to stop your mind from rushing ahead is to avoid approaches that can be too well learned. Thus the most valuable occasions will be those that are either 1. uncertain to occur or 2. mysterious-- too complex or subtle to be fully anticipated, arguably the goal of art. To get the most out of emotional reward, you have to either gamble on uncertainty or find routes that are certain but that won't become too efficient. In short, your occasions have to stay surprising-- a property that has also been reported as necessary for activity in brain reward centers (e.g. Hollerman *et.al*., 1998; Berns *et.al*., 2001). Accordingly, surprise is sometimes said to be the basis of aesthetic value (Berlyne, 1974; Scitovsky, 1976). In modalities where you can mentally reward yourself, surprise is the only commodity that can be scarce.

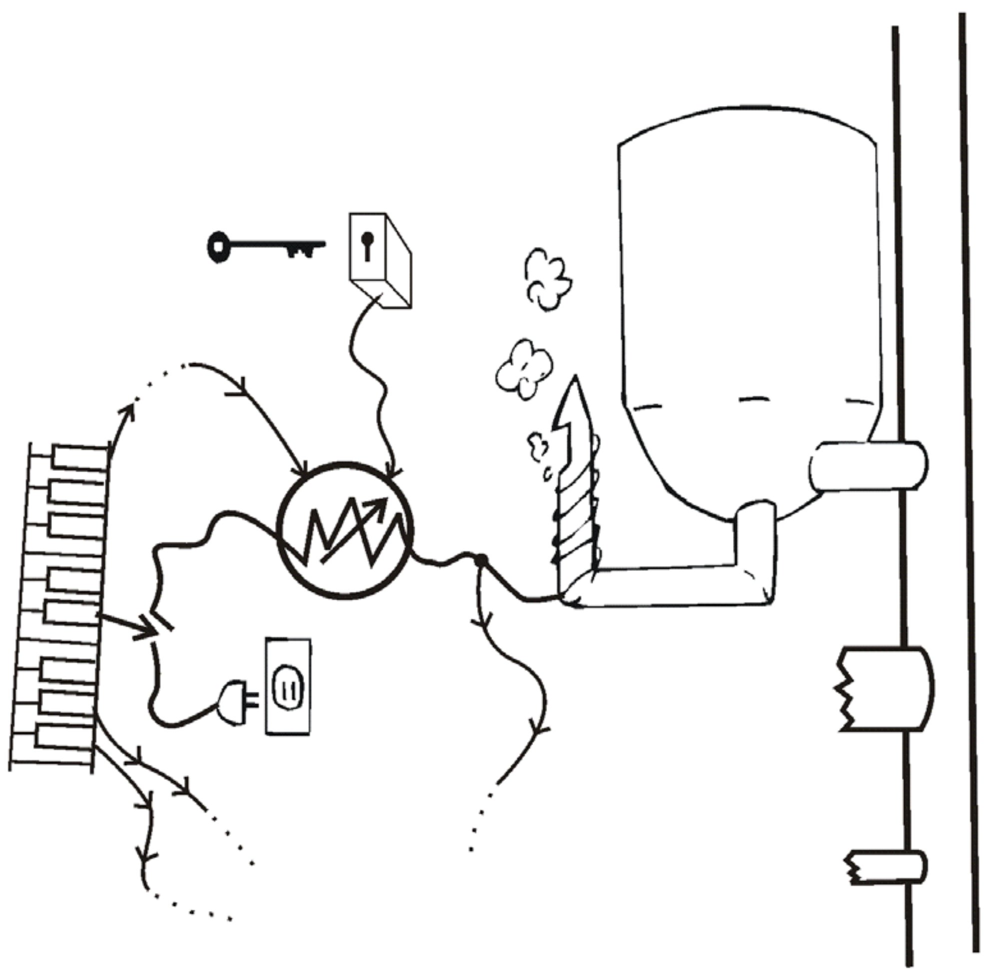
People-- and presumably nonhuman animals-- wind up experiencing as emotion only those patterns that have escaped the habituation of voluntary access, by a selective process analogous to that described by Robert Frank for the social recognition of "authentic" emotions (1988): Expressions that are known to be intentionally controllable are disregarded, as with the false smile of the hypocrite. By this process of selection, emotion is left with its familiar guise as passion, something that has to come over you.

5 A motivational model of emotions

Hyperbolic discounting greatly simplifies the problem of modeling the emotions. With conventional, exponential curves, a person should be able to estimate what emotions will be most rewarding for what durations, and plan accordingly. To correct this picture to match the real world, a modeler has to impose negative emotions on the subject, and limit her access to positive emotions, by a combination of hardwired and conditioned reflexes. By contrast, hyperbolic discounting lets emotions be behaviors that compete in the common market of motivation. In such a model, emotions differ from deliberate but volatile behaviors like paying attention only in producing significant intrinsic reward. The patterns of this reward determine both emotions' quasi-involuntary property and the motive to limit their occurrence—the negative emotions by an admixture of obligatory nonreward that overbalances their reward at all but very short distances, the positive emotions by the premature satiation that will occur unless the subject limits what occasions their occurrence.

5.1 The Demon at the Calliope

This situation can be portrayed by an automated model, and even a mechanical one. I will describe the latter for better illustration (cf. Ainslie, 1992, pp. 274-291). The individual is divided into a motivating part and a behaving part. The motivating part is the brain function that generates reward, modeled by the whistles of steam organ (circus calliope). The calliope has individual steam boilers heated by their own circuits—one for each separately satiable modality of emotion, such as anger, sexual arousal, laughter, and even grief and panic (figure). Other boilers exist for nonemotional options such as muscle movements. The behaving part is a demon who presses the calliope keys according to a strict instruction: "Choose the option that promises the greatest aggregate of loudness x duration, discounted hyperbolically to the present moment."



A single boiler heated by current that is controlled by one key of the calliope. The whistle can blow as long as it has heat and water; the water is replaced in the boiler at a rate determined by the diameter of the intake pipe. A rheostat governed by hardwired factors including turnkey stimuli and current flow in other boilers can modify current flow, and current flow can affect rheostats on other boilers. The loudness of the whistle is not a linear function of the amount of steam produced; it is disproportionately less at very low and very high values.

5.1.1 Properties of the calliope

Pressing a key sends electric current through heating coils around its boiler, causing release of steam through the whistle at a delay and over a time course determined by several factors:

- The shape of the boiler. Narrow necks limit loudness, and bigger tanks hold more water, modeling the potential intensity and duration of the emotion.
- The density of wiring around the boiler neck relative to its diameter. This models the speed of arousal.
- The amount of water in the boiler. This models physiological readiness for the emotion (something like "drive").
- The rate at which the demon presses the key. Pressing too slowly wastes the effort, too fast exceeds the whistle's sound-producing capacity and wastes steam.
- The diameter of intake pipe to the boiler, modeling the rate at which readiness regenerates
- The presence of turnkeys to the rheostat (variable resistor) in the heating wire, modeling the extent to which hardwired stimuli (e.g. pain) facilitate the emotion. Emotions vary in their readiness to occur without hardwired turnkey ("unconditioned") stimuli, and a given process varies among individuals, as in the traits of fear- or fantasy-proneness. This readiness is modeled by what is the lowest setting of the rheostat.
- Activity in the heating coils of other boilers that are hardwired to raise or lower this rheostat. For instance, pain might augment sexual arousal or decrease laughter.

5.1.2 The behavior of the model

The demon has whatever estimating ability the whole individual has, which I do not model further. Emotions are all wired for fast partial payoffs, although their long run payoffs are variable. Because of their fast payoffs they have a great ability to compete with other choices on the demon's keyboard. Because hyperbolic discounting makes curves from imminent payoffs disproportionately high, the demon will often be lured into negative emotions—those that do not have enduring payoffs and that lower the rheostat on other boilers—when a turnkey stimulus is present and/or readiness is high. For the same reason he will press wastefully and not get the most steam from the available water in positive emotions if he presses keys *ad lib.* Thus he will be motivated to tie his pressing to the appearance of adequately rare external cues.

5.2 The value of the model

A quantitatively accurate model would reflect the time course of neuronal processes, of course, most of which are still unknown. Even the sites of interaction of the components that I have illustrated are merely the simplest that will relate the dynamic of hyperbolic discounting to the known properties of drive and emotion. I do not pretend to fit the promising but still sketchy single neuron physiology and fMRI data that are beginning to emerge.

The point of this crude model is to add flesh to the bare mathematical fact that hyperbolic valuation curves describe the temporary dominance of some SS outcomes over some LL ones. That property makes possible a model that uses only one selective process (reward) instead of the conventional two (classical conditioning and reward), and that requires all learnable processes, even emotions, to compete in the single internal marketplace of motivation. A one-process model is not only more parsimonious than the conventional one, but also better fits the phenomenon of mixed emotions—the strangely addictive quality shown often by anger and sometimes even by grief and fear. Beyond that, as I have argued elsewhere (2001, pp. 175-186), a model of emotions that has stimuli serve as occasions for them rather than rather than control them makes possible dynamic theories of the psychological/social construction of facts and of empathy as a primary (not instrumental) good.

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