In: Handbook of Psychology of Emotions ISBN: 978-1-62808-053-7
Editors: C. Mohiyeddini, M. Eysenck and S. Bauer © 2013 Nova Science Publishers, Inc.

Chapter 2

EMOTIONAL ACTION: AN IDEOMOTOR MODEL

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ABSTRACT

This chapter presents a new model of emotional action that emphasizes an anticipatory control of emotional actions. It begins by reviewing existing hypotheses about a causal relationship between emotions and action. Then, findings and hypotheses of an ideomotor model are discussed about how an emotional action is learned, represented, activated, selected, and expressed. Finally, the model is applied to an analysis of emotional fight-and-flight behaviors.

Keywords: Emotional action, ideomotor theory, instrumental learning, aggression

INTRODUCTION

Emotion is typically conceptualized as a set of orchestrated responses to a significant event, consisting of (a) a *cognitive response*, corresponding to the evaluation or appraisal of the stimulus, (b) a *motivational response*, corresponding to the activation of a specific action or, at least an inclination to act, (c) a *somatovisceral response*, supporting the preparation and execution of muscular responses, (d) an *expressive response*, consisting of facial and vocal expressions and gross body postures, and (e) a *feeling or experiential response*.

According to contemporary emotion theories, the first stage of an emotion is the affective encoding or emotional appraisal of a stimulus event (Ellsworth and Scherer, 2003). The

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output of this encoding process then generates a motivation to act, which is accompanied by physiological and behavioral changes (Frijda, 1986). A feeling or emotional experience emerges when aspects of the cognitive, motivational, physiological, and motor responses permeate into consciousness (Scherer, 2009).

According to a component model of emotions, emotions are thus intimately related to motivation and action. Some theorists even argue that emotions exist for the sake of action, for dealing with recurrent challenges of the environment (e.g., Tooby and Cosmides, 1990). Yet, the relationship between emotion and action is variable. There is much emotion without action, and much action without obvious emotion (Mauss, Levenson, McCarter, Wilhelm, and Gross, 2005).

Furthermore, the same emotion may lead to different actions depending on the affordances of a situation (Frijda, 2004). Scared to death, you may rush from the building if the fire bell rings, but you may seek shelter under the next desk if an earthquake shakes the building. How to understand these variable relationships?

The present chapter focuses on this question. We first discuss existing hypotheses about a causal relationship between emotion and action. After that, we will present an ideomotor model of emotional action that emphasizes an anticipatory control of emotional behavior.

Then, central hypotheses of this model are described about how an emotional action is learned, represented, activated, selected, and expressed.

Finally, the model is applied to an analysis of fight-or-flight behaviors in aversive emotional situations.

THE RELATIONSHIP BETWEEN EMOTION AND ACTION

Emotion theorists agree that emotions allow a simple interface between sensory inputs and behavior systems (Scherer, 1994). However, they disagree about the flexibility of this interface: While Darwin-evolutionary theory proposes a very rigid link between emotions and a set of hardwired responses, emotional decision theory, by contrast, suggests a highly flexible integration of emotional information in a behavior decision process. In between are emotional motive theories that assume a fixed relation between emotions and motive states but a variable translation of the motive state into a concrete behavior. In the following, we will present each hypothesis in more detail.

The Hard Interface: Evolutionary Theory

Evolutionary theory proposes that emotions are associated with dispositions for actions that have increased the fitness of the species in recurring, challenging situations in the past. In his classic book "The expression of the emotions in man and animals", published in 1872, Charles Darwin was the first who proposed the existence of multiple emotions that differ in their (expressive) response patterns, functions, and evolutionary history. Darwin suggested that a feeling state (corresponding to an emotion) evokes an automatic tendency to perform movements that are associated with this emotional state, as he illustrated elegantly with an anecdote about how he reacted to a snake at the London Zoo as if his life were in danger: "I put my face close to the thick glass-plate in front of a puff adder in the Zoological Gardens, with the firm determination of not starting back if the snake struck at me; but, as soon as the blow was struck, my resolution went for nothing, and I jumped a yard or two backwards with astonishing rapidity. My will and reason were powerless against the interpretation of a danger which had never been experienced." (Darwin, 1872, p. 38).

For evolutionary theorists, emotions are 'problem-solving devices' that have increased the probability of successfully dealing with a few basic, ubiquitous problems in the ancestral past (Ekman, 1992; Levenson, 1999; Plutchik, 2001). Emotional action dispositions are therefore inherited and they were object to natural selection presses in the past.

For example, if withdrawing rapidly from a snake saves an animal from being bitten, this fear reaction surely aids survival of the fearful animal (Öhman and Mineka, 2003). As a consequence, a genetic transmission of the underlying biological structure is more likely. Shaped by natural selection, each emotion is thus associated with a different set of behavior responses that were functional for solving a specific problem in the ancestral past.

Even though an evolutionary analysis of emotional action is intuitively appealing, it is not without problems. One problem is that a functional analysis of emotional reactions is typically a post-hoc enterprise. Given that there are no established principles and procedures for identifying the function of a behavior of our Pleistocene ancestors, one can make many plausible suggestions of adaptations (Gray, Heaney, and Fairhall, 2003). For instance, evolutionary psychologists have related joy and happiness to basic need satisfaction (Frijda, 1994), goal pursuit (Nesse, 2004), resource-building (Fredrickson, 1998), social bonding (Panksepp, 2000), and social facilitation (Buss, 2000). In retrospection, it is difficult to tell apart which adaptive explanation is true and which is not.

A second problem is that most emotional actions are not as uniform as one would expect on the basis of evolutionary theory (Barrett, 2006). According to a strong version of this hypothesis, each kind of emotion should elicit its own pattern of stereotypic responses that is hardwired at birth. However, few emotional actions, at least in mammals, are truly fixed action patterns in the sense that they are not learned and uniform across different situations (Moltz, 1965). For instance, flight is clearly a behavioral response away from a source of danger, but depending on the affordances of a situation there could be very many ways of fleeing from a threat. As noted by Frijda (2004): "Evolutionary psychologists talk too easily about emotions as patterns of stimulus-elicited behaviors […] without wondering about the mechanisms these actions might presuppose" (p. 161). A powerful theory of emotional action thus must additionally specify the processes that adjust a behavioral response to the affordances of an emotional situation.

The Hot Interface: Emotional Motive Theory

Emotional motive theories identify these processes in motivational states that are evoked by emotional events. McDougall (1926) was one of the first emotion theorists who proposed an intimate link between emotions and some motivational concept; he suggested that emotions correspond with the distinctive feeling tone and the bodily changes that are aroused by powerful instincts.

For him, instincts were more than biologically hardwired responses or inherited action dispositions; rather, he assumed that instincts involve mental processes that correspond with "a knowing of some thing or object, a feeling in regard to it, and a striving towards or away from that object" (p. 27). These processes are most aptly described as motivational processes that direct attention, thought, and behavior to a particular class of objects that have significance for the person.

McDougall (1926) suggested that each emotion is linked to a different instinct, and through this motive disposition, to a specific action inclination. For instance, anger was coupled with aggression, fear with an inclination for flight, disgust with a motivation for repulse, and tender with a motivation for parental care. By relating emotions to different instincts, McDougall distinguished seven primary emotions, each of which is characterized by a different action inclination.

Using a different terminology, subsequent theorists refined the basic idea that emotional behavior is directed and aroused by 'central motive states' (e.g., Bindra, 1969; Frijda, 1986; Roseman, 2008). For instance, Frijda proposed that emotional events, as appraised by the individual, elicit changes in motive states that he called states of action readiness. Such states of action readiness may consist "(a) in readiness to go at it or away from it or to shift attention; (b) in sheer excitement, which can be understood as being ready for action but not knowing what action; or (c) in being stopped in one's tracks or in loss of interest" (Frijda, 1988, p. 351). Thus, the idea is that an emotion evokes a readiness to behave in a general way that is functional for dealing with a significant event, rather than being associated with a specific behavior. So, for example, fear might trigger a readiness to flee or hide, but depending on the circumstances there could be very many ways of fleeing and hiding. Accordingly, many different behaviors can be displayed in emotional episodes that have a label in common (anger, fear, and so on), and what behavior is actually produced is determined conjointly by the nature of the motive state, the perceived affordance in the eliciting event, and the individual's action repertoire.

With motivational states as flexible translators between environmental input and behavioral output, motive theories thus can account for the variability and richness of emotional action. Yet, this theoretical approach has several shortcomings. One problem is that little is known about the inner structure of emotional motives and how motive states interact with perceptual systems in the generation of an emotional response. Frijda (2010), for instance, proposed that emotional motives have a specific aim (e.g., the aim to avoid loss and harm), and that an action schema is automatically selected that may be appropriate for fulfilling the aim. However, it is not clear how a motive state comes to select an action schema, and what kind of behavior is actually controlled by an action schema. Just take as an example the simple situation of a caged rat that is frightened by a painful electric shock. By knowing that the rat is motivated to escape from her torture, it is difficult to predict whether the rat will fight (Ulrich and Azrin, 1962), take flight (Blanchard and Blanchard, 1968), or show no activity at all (i.e., freeze; Fanselow, 1980). As a matter of fact, behavior analysts had hard times to account for the appearance of these mutually exclusive fear responses (e.g., Blanchard, and Blanchard, 1990; Gray, 1994), meaning that behavior prediction is poor even with a fair knowledge of the motive state, the action schema, and the environmental situation.

One could of course argue that all these behaviors that occur in threatening situations are "defensive" or suppose the existence of an action readiness to avoid. As noted by Russell (2009), however, doing so creates additional problems.

First, there are counterexamples (e.g., predator inspection and threat-sensitive foraging; Blanchard and Blanchard, 1990). Second, labeling a variety of different behaviors as "defensive" adds nothing to their explanation, because the particular behavior that actually occurs remains to be explained (i.e., fight, flight, or freeze). And, third, one cannot classify an isolated behavioural act as defensive except in the context of an interpretation of the situation as dangerous. For example, to interpret doing nothing as freezing, and not as being startled, disoriented, or disinterested, requires knowledge of the context. Thus, the inference of a defensive reaction to a threatening event is sometimes close to circularity.

Another problem concerns the number of hypothesized motive states and how they are related to different emotions. McDougall (1926) provided an explicit list of seven basic emotions, each of which is characterized by its own distinct motive state (instincts). Modern theorists, however, refrain from making such lists (or they do so more in the secret), and often without assuming a direct correspondence between emotions and motive states. For instance, a readiness to approach has been linked to eleven different emotions, including distinct states such as sorrow, boredom, surprise, and joy (Frijda, Kuipers, ter Schure, 1989).

Thus, at least some emotions may be associated with several, sometimes even conflicting, tendencies to act. Complicating things further, alternative theories proposed that behaviors associated with anger, sadness, fear, and so on are aroused by more fundamental emotional properties such as *valence* and *arousal* (Russell and Barrett, 1999), *positive* and *negative activation* (e.g., Watson, Wiese, Vaidya, and Tellegen, 1999), or *appetitive* and *aversive motivations* (e.g., Lang, 1995). Thus, at present it is not clear what emotional motives are, how many of them exist, what motives are associated with which emotions, and whether motive states can be reduced to more basic properties of emotional episodes.

The Loose Interface: Emotional Decision Theory

These ambiguities caused some theorists to question the assumption that emotions can cause actions directly; instead, they proposed that emotions influence action control indirectly by providing feedback on the consequences of actions and by stimulating retrospective appraisals of behavior decisions.

When making a decision, people anticipate the emotions they might experience as a result of the outcomes of their choices, and they select those actions that they expect will make them feel better rather than worse (Baumeister, Vohs, DeWall, and Zhang, 2007; Mellers and McGraw, 2001; Schwarz, 2012; Slovic, Finucane, Peters, and McGregor, 2007). Thus, an emotion is here the goal, and not the cause of an action.

There is indeed strong evidence that anticipated emotional states can have a powerful influence on action tendencies. For instance, sad people help others more readily when they believe that helping will cheer them up (Manucia, Baumann, and Cialdini, 1984), angry people aggress others more when they hope that acting aggressively reduces their emotional distress (Bushman, Baumeister, and Phillips, 2001), and people anticipating guilt make more generous offers (Nelissen, Leliveld, van Dijk, and Zeelenberg, 2011).

However, for many of these studies it is not clear how emotions become integrated in action decisions.

For instance, some researchers proposed that people weight anticipated feelings by the perceived chances of their occurrence in a rational decision process, choosing the action that maximizes subjective pleasure (e.g., Mellers, Schwartz, and Ritov, 1999), whereas other researchers pointed out that experienced emotions can have a direct hedonic impact on action control without conscious cognitive mediation (e.g., Loewenstein, 1996).

Furthermore, emotions may influence action control via multiple routes, as proposed by dual-process theories that distinguish between an automatic route that is based on associative processes and a controlled route that is based on conscious thinking and reasoning processes (e.g., Clore, and Ortony, 2000; Strack and Deutsch, 2004).

Even though a multiple-route conception is a powerful approach for an explanation of many phenomena, they cannot hide the fact that they are fairly silent about how an action is selected and initiated in the first place.

Summary

To summarize, existing models seem to trade precision for generality in the explanation of emotional behavior. While evolutionary approaches make very specific predictions about a limited set of hardwired emotional responses and their underlying biological circuitry, they are too narrow to account for the richness and complexity of the behavior that is typically displayed in emotional situations.

Emotional motive theory and emotional decision theory, on the other hand, have the potential to account for this behavioral complexity; however, they lack precision of the processes that generate an action when referring to vague and ill-defined constructs like aims, action decisions, and action schemas. What is consequently most needed is a framework that specifies in more detail how complex emotional actions are learned, represented, initiated, and expressed. Such a framework is described next.

An Ideomotor Model of Emotional Action

A distinctive feature of the present framework is that it integrates emotions into an existing theory of action control, which is ideomotor theory. While traditional theories of emotional action often distinguish an emotional system from an action system, with the emotion system adjusting operations of a separate action system, the present approach pursues the idea that affective processes are always part of the mental machinery that generates an action, with ‘emotional actions’ being only particular instantiations of a more general class of affectively motivated actions.

This integrative approach has the advantage that it allows to derive hypotheses about emotional effects on action control processes on the safe ground of an established action theory that is well-supported by many independent strands of evidence.

A central hypothesis of the present model is that an action is initiated, selected, and controlled by an anticipation of sensory action effects, which include affective consequences of actions (ideomotor hypothesis).

From this reference of actions to sensory events, it is hypothesized that perceiving an object and generating an action are represented by codes in a common representational domain (common-coding hypothesis). Affective processes influence the action generation process by a hedonic weighting of the anticipated action effect that primes actions with desired effects (hedonic hypothesis). Furthermore, stimulus events can generate emotional action tendencies by activating emotional outcomes that are associated with a behavioral response (affordance hypothesis).

It should be noted that each of these hypotheses is not new but only their combination and the extension to emotional action is new. In fact, much of the empirical work that is described below tested ideomotor theory and/or instrumental learning theory, while our own work only filled some gaps between both approaches (and certainly not all of them). In the following sections, we will present each hypothesis in detail. First, however, we must additionally clarify the target of our inquiry, which is emotional action.

What Is an "Emotional Action"?

This question must be answered in two parts: First, what is an "action"? Second, what makes an action "emotional"? We want to reserve the term "action" for those body movements that are performed for their effects on the environment. These effects can be many and varied. Some of these effects may be intended, such as the loud honk following a push of my car horn, but other effects may be not, such as the awkward position of my arm joints. Some effects may be desired, such as the cars moving out of my way, and others may be undesired, such as the angry looks of the passengers nearby. Some effects may be achieved through a complex movement sequence, while other effects may require only a single response. The point is that movements make a difference in the perceived world, and that people anticipate making a difference when they perform a movement. They certainly do so when they select an action voluntarily; however, they may also do so when performing an action involuntarily, as we will argue later in this chapter.

Emotional actions are then those movements that make a difference with respect to emotional states of affairs (for a related argument see Averill, 1994). For instance, if a spider phobic is spotting a big, ugly spider on the floor, she may cry for her husband, or suck the spider up with a vacuum cleaner, or smash it with a shoe. All these actions may have the same effect: removing the spider from sight and with it the source of emotional tension.

As our spider example shows, the cause of the emotional action thus may lie not only in the present (i.e., in the spider) but, also, in the future (i.e., in the removal of the spider). Of course, only a spider that is present can be removed. However, removing and avoiding bad and unpleasant things is only one side of emotional actions. The other side is approaching and attaining positive and pleasant objects or states. For example, our spider phobic person may give her husband an affectionate hug after he had bravely removed the spider, expressing gratitude and affection to him. Again, the cause of the emotional action may not only lie in the presence of a stimulus (i.e., in the presence of the husband) but in the anticipated consequence of the action (i.e., the expression of gratitude).

Emotional actions may thus be performed for their consequences, whether these consist in attaining desired consequences (i.e., rewards), such as a praise and a smiling face, or in the avoidance of undesired consequences (i.e., punishments), such as an insult and an angry face.

Following Rolls (2005), it is thus assumed that anticipations of rewarding and punishing consequences, as appraised by an individual, can elicit emotional states, and that different emotional states can be described depending on whether a reward or punishment is obtained, omitted, or terminated (see Figure 1). These emotional states may then motivate actions to attain a positive outcome (i.e., a reward or the omission of a punishment) and to avoid a negative outcome (i.e., a punishment or the omission of a reward) in a given situation.

The present conceptualization of emotional action thus draws a very thin line between emotion and motivation. The very same motivational systems that propel behavior towards desired end-states and away from undesired end-states in more mundane settings may also motivate actions in emotional settings.

While emotions may recruit domain-general motivation systems for controlling actions, this does not mean that a distinction between emotional and motivational states is not meaningful. In fact, the present approach posits that not all emotional states may generate an action inclination, but only those that involve anticipations of behavior outcomes.[1]

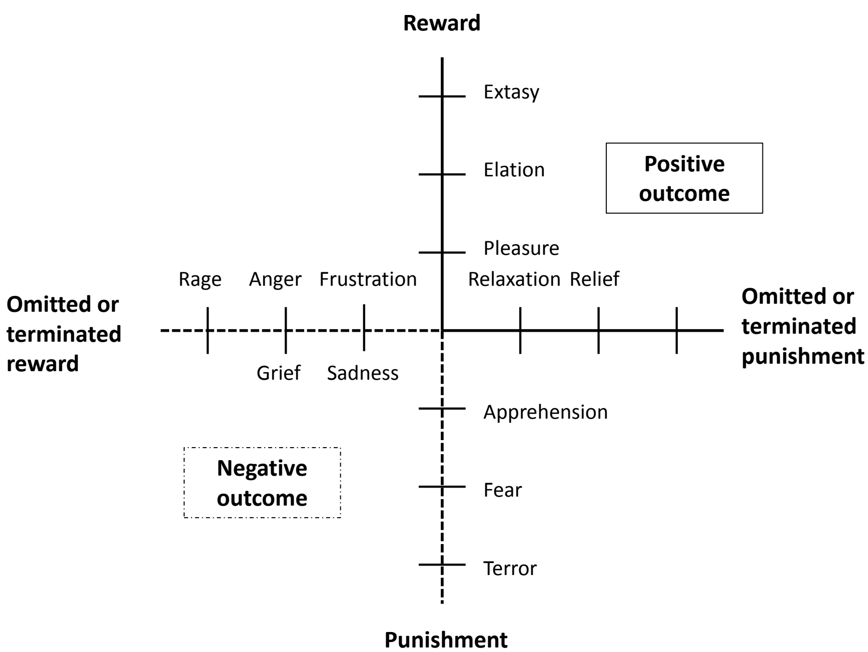

Figure 1. Classification scheme of reward and punishment contingencies, affective outcomes, and some emotions. The vertical axis describes emotions that are typically associated with the expectation or delivery of a reward (up) or a punishment (down). The horizontal axis describes emotions that are typically associated with the omission or termination of an expected reward (left) or punishment (right). Figure taken and adapted from Rolls (2005).

Furthermore, emotional states may elicit more reactions than just a motivational response (see the component model described above). For example, our spider phobic person may spontaneously widen her eyes, frown, and shriek at the sight of the spider (Dimberg, 1986), exhibiting a full set of expressive behaviors that are dissociable from the motivational response (for evidence see e.g., Landis, 1924; Mauss, Wilhelm, and Gross, 2004; Reisenzein

[1] An example emotion is *surprise* that is, by definition, elicited by an unexpected event. Surprise interrupts ongoing action, rather than producing an action (Horstmann, 2006; Reisenzein, Bördgen, Holtbernd, and Matz, 2006), which is in line with the present hypothesis that anticipatory processes are required for the initiation of a specific action.

et al., 2006). Despite intimate links between emotion and motivation, there are thus good reasons to keep both constructs separate.

The Ideomotor Hypothesis

The ideomotor hypothesis proposes that actions are represented in memory by their sensory effects, and that in turn these sensory effects are used to select, initiate, and control a motor activity (Greenwald, 1970; Hommel, Müsseler, Aschersleben, and Prinz, 2001; Kunde, Elsner, and Kiesel, 2007).

William James (1890) has elegantly illustrated the basic principle underlying ideomotor theory more than a century ago (see Figure 2 for a reprint). When a hypothetical motor neuron *M* moves a muscle, either induced externally by sensory stimulation or internally by random motor babbling, the movement produces a kinesthetic feedback that is registered by the neuron *K*. Anticipating Hebb's postulate of "what fires together, wires together", the kinesthetic sensation *K* will then become associated with the active motor neuron *M*, closing a 'motor circle'. On the basis of this cirlce, the motor activity controlled by *M* is then selected by activating *K*—that is, "the idea of the movement M's sensory effects will have become an immediately antecedent condition to the production of the movement itself" (James, 1890, p. 586). After falling in disgrace during the reign of behaviorism (Thorndike, 1913), ideomotor theory was rediscovered by modern cognitive psychology (for an historical review see Stock and Stock, 2004). Since then, numerous studies were conducted that examined assumptions of modern ideomotor theory empirically (for recent reviews see Hommel, 2013; Nattkemper, Ziessler, and Frensch, 2010; Shin, Proctor, and Capaldi, 2010).

Behavioral and neuroimaging studies have shown more specifically (i) that perceptions of action consequences become associated with the producing movements in memory (e.g., Elsner and Hommel, 2001; Elsner et al., 2002), (ii) that knowledge of the sensory effect is automatically retrieved from memory during response selection (e.g., Kunde, 2001; Kühn, Keizer, Rombouts and Hommel, 2011), and (iii) that anticipation of sensory effects is causally involved in the production and control of a motor response (e.g., Greenwald, 2003; Kunde, Koch, and Hoffmann, 2004; Melcher, Weidema, Eenshuistra, Hommel and Gruber, 2008).

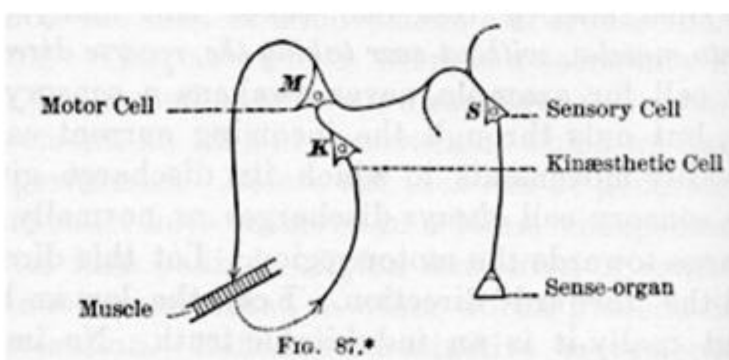

Figure 2. The motor circle underlying ideomotor action as illustrated by William James (1890, p. 582).

Most important for our present concern, ideomotor theory was extended to affective action effects (Eder and Hommel, in press; Eder and Klauer, 2009; Lavender and Hommel, 2007). According to ideomotor theory, a movement should become associated with any consequence that is perceived after its execution. This should also include affective sensations that are registered after a behavioral response.

In support of this idea, several strands of evidence have shown that affective consequences of actions can be learned, consolidated, and retrieved from memory like other, nonaffective sensory effects.

Learning of Affective Action Effects

Most evidence for a learning of affective action consequences comes from the rich animal and human research literature on reinforcement learning.

Since Thorndike's classic formulation of the law of effect (1911), it is well known that 'satisfactory' consequences of a behavior influence the motivation for a behavioral response. While early theories of reinforcement learning proposed that a reinforcer passively "stamps in" an association between a stimulus and a response without being itself included in the associative structure, modern research showed that this early conception is incorrect (Hall, 2002). Instead, it turned out that the consequence becomes an integral part of the cognitive structure that controls the behavioral response.

Evidence for this conclusion comes from devaluation studies in which a pleasant consequence of an action is devalued after sufficient instrumental training. The logic behind these studies is straightforward. If the action outcome merely cements an association between a situation and a response, subsequent changes to the value of that outcome should have no impact on subsequent performance of that action because the relation between the action and the outcome is not represented within the S-R structure. If, however, consequences of actions are learned during instrumental training, any subsequent change in the value of the outcome should be directly manifested in behavior performance. In fact, exactly this result has been observed in studies with animals and humans (e.g., Adams and Dickinson, 1981; Gámez and Rosas, 2007). For instance, Colwill and Rescorla (1985) trained rats to carry out two different responses, each produced a different food reward. After sufficient training, one outcome (but not the other) was paired with a toxin, inducing a negative affective state (nausea). When the animals could freely decide between the two responses in a subsequent extinction test, they no longer showed a preference for the response whose outcome had been devalued. The rats had learned to anticipate specific food rewards after the instrumental training, and they used this knowledge to avoid an outcome that is associated with a negative affective state.

Memory for Affective Action Effects

Devaluation studies clearly show that movements become associated with their rewarding consequences in memory. However, they do not show that the affective value of the effect was memorized. Such evidence is provided by incentive learning studies that show that memories of affective action effects require an updating if the value of the outcome has changed (Dickinson and Balleine, 1994, 2002).

A dramatic example comes from a study of sexual motivation. Everitt and Stacey (1987) trained male rats to press a lever for access to and mating with a sexually receptive female at the end of the session. After sufficient instrumental training, the rats were then castrated. Although the castration produced an immediate reduction in the sexual responsiveness to the female herself, it had no impact on the rate at which the males pressed the lever in the first postoperative session. As argued by Dickinson and Balleine, because the male rats had not been exposed to a female while in the castrated state, their behavioral performance was presumably controlled by the high incentive value assigned to her during training in the intact state. Exposure to the female at the end of the first postoperative session, however, allowed the males to learn about her reduced incentive value, and, indeed, they pressed at a significantly lower rate than controls in all subsequent sessions.

Incentive learning studies suggest that animals develop memories of the affective outcomes of their actions, and that they use these memories to respond advantageously in future situations. Interestingly, a very similar idea was proposed for emotions in human decision making. Damasio (1994) suggested that somatic responses to emotional action outcomes are stored in memory, and that in turn these somatic states (or brain representations thereof) can signal costs and benefits of a response choice when automatically reinstated in a choice situation (the so-called *somatic marker hypothesis*). For a test of this idea, Bechara, Damasio, Damasio, and Anderson (1994) introduced the Iowa Gambling Task to simulate real-life decision-making as affected by uncertain rewards and punishments. In this task, participants could freely select cards from four decks, with each card indicating that the participant has won or lost a specific amount of play money. Unbeknownst to the subject, cards from two decks yield a net gain in the long run (good desks), while drawing cards from the other two decks produces a net loss in the long term (bad decks). Normal participants learn after several trials of selecting from all four decks which are the risky or "bad" decks. Furthermore, before they choose from the risky desk they exhibit an anticipatory emotional reaction (indexed by a change in skin conductance level), and they start to avoid selecting cards from these decks.

In contrast, patients with bilateral damage to the ventromedial prefrontal cortex do not exhibit an anticipatory emotional reaction. They also refrain from picking from the bad decks immediately after a punishment (loss of money), but unlike the healthy controls, they later revert to selecting from the bad decks. The authors concluded that these patients are insensitive to future consequences of their choices because they lack the ability to integrate emotional (somatic) signals about the costs and benefits of their choices (for a thorough review see Dunn, Dagleish, and Lawrence, 2006).

Automatic Retrieval of Affective Action Effects

Several strands of evidence thus converge in the conclusion that affective consequences of actions are encoded in memory structures. Ideomotor theory additionally proposes that this knowledge is retrieved automatically during action selection. Supportive evidence for this claim comes from two studies in which affective action effects were completely irrelevant for the task at hand (Beckers, De Houwer, and Eelen, 2002; Eder, Rothermund, De Houwer, and Hommel, 2012).

In a first learning phase, participants could freely choose between two responses, each response produced a different affective outcome (e.g., the presence or absence of an electric shock or a presentation of pleasant and unpleasant pictures).

In a subsequent test phase, the same actions were emitted in response to a neutral feature of affective stimuli (e.g., whether a picture shows an animal or a person). Responses with affectively congruent effects were emitted faster than responses with affectively incongruent effects, irrespective of whether the produced effect was pleasant or unpleasant. These results support the claims that (a) affective effects become automatically associated with their eliciting movements, and that (b) the affective consequence is automatically retrieved during response selection, even when they are not useful for the task at hand.

Furthermore, given the relative facilitation of a response that produced an unpleasant consequence (e.g., an aversive shock), it is obvious that the process responsible for the affective congruency effect was not hedonically motivated; rather, this finding provides strong evidence for an ideomotor approach, which assumes that the priming of a response effect in memory directly excites the corresponding response (even in the case of an unpleasant effect).

Functional Role of Affective Action Effects

Our review has shown that there is substantial evidence that movements become associated with their affective effects in memory, and that this knowledge is automatically activated during response selection. However, it is possible that this knowledge affects action control only indirectly, so that we need to ask whether an anticipation of affective effects is directly connected with action control. Hence, do we have evidence that anticipatory representations of affective action effects play a causal role in initiating and controlling a behavioral response?

Affirmative evidence comes from an unpublished study that investigated an influence of affective compatibility relations on processing bottlenecks that are related to response selection (Van der Goten, Caessens, Lammertyn, De Vooght, and Hommel, 2001; cited in Hommel et al., 2001). A typical finding in dual-task performance is that latencies in a secondary task (Task 2) increase dramatically when the secondary task overlaps in time with the selection of a response in a primary task (Task 1) (see Pashler, 1994, for a review). This latency increase is typically explained with capacity restrictions of a serial S-R translation stage that can translate only one stimulus into its corresponding response at a time—a processing bottleneck that all other translations have to await (Pashler, 1984; Welford, 1952).

Van der Goten and colleagues however showed that selection of a neutral response to a stimulus in Task 1 is facilitated if the stimulus (e.g., the word ‘grave’) is affectively compatible with the response that is selected for Task 2 (e.g., a response that produced a grumpy on the screen). This backward compatibility effect suggests that affective features of the response in Task 2 were activated before the selection of a response in Task 1 was completed—a finding that is problematic for the assumption of a serial S-R translation stage (see also Ellenbogen and Meiran, 2011; Hommel, 1998; Watter and Logan, 2006).

Instead, this study shows that the affective effect of a response may play a role when selecting the response for execution, which means that response selection considers codes that represent and, thus, predict these consequences.

The Common Coding Hypothesis

If one agrees with ideomotor theory that connections between actions and sensory effects are mutually formed by a Hebb-like mechanism, one has to face the problem that sensory and motor parameters have to be represented in a way that allows the system to “wire” together different types of representations. This problem is addressed by the common-coding hypothesis that proposes that representations of perceived events and planned actions have a common format (Prinz, 1990, 1997). According to Prinz (1992), a commensurate coding of action and perception originates in a common reference to events in the distal environment—events that are registered as a given state in the case of perception and events that are anticipated as a future state in the case of action planning. “Perceiving and action planning are functionally equivalent, inasmuch as they are merely alternative ways of doing the same thing: internally representing external events” (Hommel et al., 2001, p. 860).

Given a commensurate format, representations of actions and perceptions may mutually influence each other on the basis of their overlap in a common-coding domain. Consistent with this assumption, numerous studies have shown that stimuli can prime the execution of ‘compatible’ responses (i.e., responses that share one or more features with stimuli) and that responses can prime the perception of ‘compatible’ stimuli (for reviews see Hommel, 2009; Thomaschke, Hopkins, and Miall, 2012; see also Kornblum, Hasbroucq, and Osman, 1990). More important for the present discussion, such compatibility effects were also observed between affective stimuli and responses. Eder and Rothermund (2008), for instance, showed that the cognitive representation of a pushing or pulling lever movement becomes associated with a different affective meaning depending on how the movement was instructed by the experimenter. When a lever pull was instructed as a movement ‘towards the body’, for example, the lever was pulled faster in response to positive than to negative stimuli; in contrast, exactly the reverse pattern of facilitation was observed when pulling the lever was instructed as a movement in a ‘downward’ direction. Presumably, the cognitive representation of the lever movement became associated with the positive implication of moving something towards oneself (Neumann and Strack, 2000) or with the negative implication of moving something downwards (Meier and Robinson, 2004). The affective ‘response code’ then interacted with the affective ‘stimulus code’ in a shared representational domain.[2]

A commensurate event coding can also create confusion, especially if a feature is shared by different events. For an illustration of this problem, take as an example a social situation in which several persons are smiling simultaneously. In order to distinguish the smiles pertaining to different persons, the perceiver’s brain must relate perceptual features encoding a smile to feature bundles that represent different persons. This ‘binding problem’ is solved by a feature integration process that binds the information to the relevant events and that distinguishes it from features pertaining to other events (Treisman, 1996). Given a commensurate coding of perception and action, a need for feature integration should thus apply to action planning and sensorimotor processing as well (Hommel, 2004).

An interesting hypothesis about the feature binding process is that access to integrated action features is temporarily blocked for other representational purposes after completed action planning, so that other cognitive processes cannot interfere with action control (for a thorough discussion of this assumption see Thomaschke et al., 2012). Binding a code to an action plan should hence impair both planning another action and perceptions requiring that code, which was indeed observed (e.g., Müsseler and Hommel, 1997; Stoet and Hommel, 1999). Conclusive evidence for an analogous occupation of affective codes through action planning was provided by Eder and Klauer (2009). They had participants prepare an

[2] Following Schyns, Goldstone, Thibaut (1998), a feature code is defined as “any elementary property of a distal stimulus that is an element of cognition, an atom of psychological processing” (p. 1). Given that positive and negative affect is “a fundamental, psychologically irreducible property of the human mind” (Barrett, and Bliss-Moreau, 2009, p. 167), properties of distal events that have the capacity to elicit affective states thus meet all criteria for a “code”.

approach-related lever pull (assumed to be coded as positive) or avoidance-related lever push (assumed to be coded as negative) in every trial and asked them to indicate whenever they were ready by pressing a button. The button press triggered the presentation of a briefly flashed positive or negative stimulus, which participants were to identify. Hence, the stimulus appeared after the planning of the lever action was completed but before it was carried out. If the planning would involve integrating a positive or negative code, participants would be expected to have difficulties identifying a stimulus that shares this particular code. In other words, planning a "positive" action should impair the identification of positive stimuli, while planning a "negative" action should impair the identification of negative stimuli. Indeed, Eder and Klauer consistently observed this outcome pattern in several experiments: identifying affectively response-compatible stimuli was more difficult than identifying response-incompatible stimuli. Analogous interference effects were observed with responses that were affectively neutral originally but became extrinsically associated with a positive or negative meaning through task procedures (Eder and Klauer, 2007), or if an evaluative response is selected during the preparation of another evaluative response (Eder, Müsseler, and Hommel, 2012).

As these studies show, perceiving an affective event and planning an affective action (or more precisely, an action that produces an affective event) thus seem to make use of the same type of affective codes, at least to some degree.

The Hedonic Hypothesis

The ideomotor hypothesis suggests that affective action consequences become associated with the producing movements in memory just like other, nonaffective effects. People associate positive and negative action outcomes with the producing movements, and thinking of the consequence automatically reinstates the associated behavior.

The intriguing implication is that the cognitive anticipation of a negative outcome, once learned as a behavioral effect, should prime the associated behavior that generates this outcome (Beckers et al., 2002; Eder et al., 2012). It is clear that this priming process is highly dysfunctional for an action control system that is aimed at an avoidance of undesired outcomes. Thus, for a motivational control of behavior, ideomotor action must be constrained by an additional process that is sensitive to the needs and desires of the person.

In the present framework, this motivational process is covered by the hedonic hypothesis: the anticipation of a positive action effect potentiates an evoked response tendency, while the retrieval of an unwanted, negative effect inhibits an associated action.

Motivational evaluations of anticipated action effects are thus hypothesized to constrain behavioral impulses induced by ideomotor processes, enhancing responses that result in desired effects while suppressing those that generate undesired effects.

Suggestive evidence for the existence of such a motivational process comes from a study of Beckers and colleagues (2002). In their experiment, a movement that generated an aversive shock was executed faster in response to negative stimuli than to positive stimuli, suggesting that the negative stimulus has primed the response via activation of the aversive outcome (indexing an ideomotor process). However, in addition to this priming effect, the shock-generating movement was also initiated more slowly than the alternative movement that was not followed by a shock. The relative suppression of the response that produced an aversive effect suggests that the hedonic implication of the response effect had an additional motivational effect on action control.

The study design of Beckers and colleagues (2002) can however not rule out the possibility that the participants have postponed the experience of the aversive shock strategically (see e.g., Hineline, 1970). More conclusive evidence for an automatic response suppression comes from an experiment of Eder and colleagues (2012) that measured a response preference in a free-choice test situation. Participants first learned to associate one response with pleasant visual effects and another response with unpleasant visual effects. In a subsequent test phase, affective stimuli were presented as go stimuli for a free decision between both responses. In support of the hedonic hypothesis, responses associated with pleasant effects were preferred over responses producing unpleasant effects. This motivating effect was observed in addition to, and independently of, an affective congruency effect between stimuli and response effects. More important for our present concern, a preference for the response associated with a pleasant effect was observed even when no response-effects were presented in the test (i.e., in extinction) and when participants were unable to verbalize the action-outcome contingency. Latter finding suggests that the hedonic implication of a behavioral effect can influence action selection automatically, even in the absence of a conscious expectation and evaluation of the affective consequence.

The Affordance Hypothesis

Our review has shown so far that the cause of an emotional action may not lie so much in the present situation but, rather, in the anticipated consequences of the behavior. However, this model would be insufficient if it would fail to take motivational properties of stimuli into account. In fact, one reason why researchers feel so compelled of emotional action tendencies is that voluntary behavior is often so difficult to control in the presence of emotional stimuli—just take the examples of being afraid to approach a snarling dog or a harmless spider. Without doubt, stimuli can have a powerful influence on action control in these situations, which must be accounted for. The present model accounts for these action tendencies by the assumption that representations of outcomes are not only aroused by internal processes (during action planning) but also by associations with external stimuli.

This idea is based on a standard model of associatve learning that describes classical conditioning processes as learning about predictive relations between an originally neutral event (the conditioned stimulus; CS) and a biologically significant event (the unconditioned stimulus; US) (Rescorla, 1988). Numerous studies have convincingly demonstrated that after several pairings a CS comes to activate a detailed representation of the US that encodes sensory and affective properties of the outcome (Delamater, 2012).

Furthermore, a Pavlovian priming of an internal outcome representation has been shown to trigger a specific action tendency—a phenomenon that is known as outcome-specific Pavlovian-to-instrumental transfer of control (specific PIT; Trapold and Overmier, 1972).[3]

[3] There is also a second form of transfer, termed “general PIT,” in which a Pavlovian cue increases the vigor of an ongoing operant response when both contingencies involve appetitive or aversive stimuli, whereas it decreases the response strength when one of the contingencies is aversive and the other is appetitive (Rescorla and Solomon, 1967). Thus, general PIT affects the strength of an ongoing response, but not the selection of a response.

In a typical demonstration of specific PIT, relations between stimuli and differential outcomes (Pavlovian learning: S1-O1, S2-O2) and relations between responses and outcomes (instrumental learning: R1-O1, R2-O2) are established in separate training sessions. In a transfer test, both responses are then made available in extinction (i.e., without a presentation of outcomes), and the preference for a specific response is measured in the presence of each conditioned stimulus (i.e., S1: R1 vs. R2; S2: R1 vs. R2). The typical result is a preference for the response whose outcome is signaled by the Pavlovian cue (for a review see Urcuioli, 2005).

Overmier, Bull, and Trapold (1971) showed in an early study with dogs that PIT processes may play an important role for emotional action selection. In their study, one stimulus warned of a shock delivered to one leg, while a second stimulus warned the dogs of a shock to the other leg (Pavlovian learning). The dogs could however avoid the shock by pressing different pressure plates in response to each stimulus (avoidance learning). Results showed that the dogs learned faster to avoid the shocks in this condition relative to a control condition in which the warning stimuli were followed by shocks to either leg. The dogs have obviously learned to predict which leg will be shocked in the presence of which stimulus, and they used this knowledge to figure out more quickly which action is necessary to avoid a shock.

Another example for action tendencies induced by PIT comes from a study on human drug seeking (Hogarth, Dickinson Wright, Kouvaraki, and Duka, 2007). In this study, regular smokers first learned to discriminate between a stimulus that signaled a tobacco reward and another stimulus that signaled a money reward (Pavlovian learning). In a subsequent training session, they learned which of two different motor responses earned which outcome (instrumental learning). Finally, they had the opportunity of making either of the two instrumental responses in the presence of either stimulus (transfer phase). Results showed a preference for the response that shared an outcome with the current stimulus: The tobacco-seeking response was selected more frequently in the presence of the tobacco cue, while the money-seeking response was produced more often in the presence of the monetary cue. Given that the Pavlovian and instrumental associations were established in separate sessions, it is clear that this finding cannot be explained with habitual responding to the reward cues (i.e., stimulus-response associations). Furthermore, the preference for a specific reward in the transfer phase cannot be explained with a general priming of affective outcomes that should prime all appetitive responses indifferently (i.e., general PIT). Rather, the specific influence on action selection suggests that a Pavlovian cue can evoke a motor response by priming the representation of the outcome that is associated with this response.

Stimuli thus may trigger a behavioral reaction by activating the representation of an outcome, which then promotes, via ideomotor processes, the selection and initiation of the response that operates on this outcome.

Affective properties of the outcome should then influence the motivational strength of the evoked response in line with the hedonic hypothesis, which was indeed observed (Eder and Dignath, 2012; see also Allman, DeLeon, Cataldo, Holland, and Johnston, 2010). Tasting the flavor of drinks, participants first learned in separate training sessions to associate particular ingredients and responses with two different drinks (lemonades). In a first transfer test, participants worked harder for a lemonade when the picture of an associated ingredient was shown (i.e., they exhibited specific PIT). Before a second transfer test, the taste of one drink was devalued using bad-tasting Tween20.

Importantly, the outcome devaluation treatment selectively reduced working for the devalued drink in the presence of stimuli that were associated this lemonade, eliminating the specific PIT effect. Responding for the non-devalued drink was however not affected by the devaluation treatment. This finding shows that both the outcome and its value were represented during the transfer test, and that the capacity of a stimulus cue to motivate a specific response depended on the current value of the shared outcome.

SOLVING THE PUZZLE: FIGHT OR FLIGHT?

In the following, we will apply our framework to a discussion of fight-or-flight responses that are involved in fear and anger episodes. Several eminent emotion theorists have related fear to an action inclination to escape or avoid and anger to an inclination to attack (e.g., Cannon, 1929; Frijda, 1986; McDougall, 1926; Izard, 1977; Plutchik, 2001; Roseman, 2008). Although there is little doubt that people often flee in a fearful state and respond aggressively in an angry state, it has also been repeatedly observed that frightened people 'fight' and that angry people take 'flight' (see Berkowitz, 2012; Berkowitz and Harmon-Jones, 2004). How to understand this variable relationship?

In their search for an answer, experimental psychologists have analyzed the antecedent conditions, the behavioral characteristics, and the outcomes of aggressive actions in fear and anger situations (Berkowitz, 1988; Hutchinson, 1983). These studies soon made clear that there is no simple answer. As a matter of fact, aggressive behaviors were observed in response to a variety of different aversive events, such as physical blows, electric shocks, loud noises, or intense heat, exposure to foul odors, irritable cigarette smoke, unpleasantly high room temperatures, immersion in cold water, and viewing disgusting or frightening scenes. Furthermore, it was observed that intense aversive stimuli elicit intraspecific attack, interspecific attack, and attack of inaminate objects. In short, studies failed to identify distinct sets of environmental cues that can account for the occurrence of fight or flight responses in aversive situations.

Looking beyond objective situation characteristics, appraisal theorists proposed that aggressive behavior is caused by the cognitive appraisal of a negative event or outcome as "frustrative" (Dollard, Miller, Doob, Mowrer, and Sears, 1939), as "illegitimate" (Averill, 1982), or as being due to someone else "blameworthy" actions (Ortony, Clore, and Collins, 1989). Furthermore, it was suggested that in addition to these appraisals a person must see some potential for coping with the frustrative event (Ellsworth and Smith, 1988).

However, it is not clear which appraisals are necessary or sufficient for aggressive behavior in anger situations (Kuppens, Van Mechelen, Smits, and DeBoeck, 2003). For example, several experiments found that even supposedly "legitimate" frustrations can give rise to aggressive tendencies, and if someone else is not blamed for an unpleasant outcome (for a review see Berkowitz, 1989, 2010).

Viewing different appraisal-patterns as causes of fight and flight tendencies thus does not receive much support.

The by far most important predictor of aggressive action tendencies is instead the learning history of an individual. Numerous studies showed that humans and animals can learn to respond aggressively in aversive situations (Bandura, 1973).

For instance, when shocked rats learned that their attacks terminate the shocks, they attack more frequently (Knutson, Fordyce, and Anderson, 1980); in contrast, if shocks increase after an attack, subsequent attack become less probable (Azrin, 1970; Follick and Knutson, 1978). Terminating an aversive shock thus enhances aggression, whereas producing an aversive shock reduces aggression, showing that the motivation for a fight response is controlled by its consequence. A negative reinforcement of aggressive behavior should of course be also effective if a person views another person as a source of their uncomfortable feelings.

In line with the hedonic hypothesis, it is thus hypothesized that people respond aggressively if they believe that aggressive behavior improves their situation. Several strands of evidence are in line with this hypothesis. For instance, Bushman and colleagues (2001) showed that provoked people do not exhibit increased aggression when they believed that venting their anger has no effect on their feeling state. Thus, at least some aggressive behaviors may aim at a mood-repair.

Other studies showed that outcomes of aggressive actions have reinforcing properties, suggesting a more subtle influence. One study examined whether mouse killing can reinforce key pressing by rats that habitually kill mice. Offered a choice between a key that granted access to mice and one that did not, the rats preferred the key that yielded mice (Van Hemel, 1972).

Sebastian (1978) reported that human participants who were provoked by a confederate experienced greater pleasure the more intense the suffering they supposedly had inflicted on their provocateur. Latter finding is also in line with a modern brain imaging study showing that punishing defectors in a social trust game activates reward circuits in the brain (de Quervain et al., 2004).

A reinforcing role of aggressive action consequences is also suggested by a study of Verona and Sullivan (2008). They observed that aggressive behavior reduced physiological tension (indexed by a heart rate decrease), and that lowered physiological tension actually strengthened the angered participants' urge to attack another person. In contradiction to the catharsis-hypothesis (Feshbach, 1984), acting aggressively thus seems to enhance an aggressive action inclination rather than reducing it.

To summarize, there is substantial evidence that many aggressive actions of angered people are instrumental in the sense that they are being performed because of their consequences.[4]

In the current framework, an instrumental control of aggressive behavior does however neither presuppose a conscious decision to act nor a rational weighting of costs and benefits of aggressive actions. Rather, it is proposed that thinking of the consequences of inflicting injury on another person may automatically instigate a tendency to perform this action (ideomotor hypothesis), and that external cues may do the same if they activate these thoughts (affordance hypothesis).

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[4] Note that the present conception of an "instrumental" aggressive response is different from that proposed in dichotomies between affective (hostile) and instrumental aggression, in which instrumental aggression is typically defined as an intentional action that inflicts injury to some person or object but which, nonetheless is "directed towards the achievement of nonaggressive goals" (i.e., whose primary aim is not to do harm) (Feshbach, 1964, p. 258). Let aside the fact that this dichotomy is difficult to maintain for a number of reasons (for which see Bushman and Anderson, 2001), we define instrumental acts as those movements that are controlled by their consequences, which may (or may not) consist in the aggressive destruction of an aversive source of stimulation.

Consistent with this theorizing, many studies showed that aggressive action inclinations are indeed enhanced in the presence of situational aggression cues (e.g., Berkowitz, 1974; Berkowitz and LePage, 1967; for a meta-analysis see Carlson, Marcus-Newhall, and Miller, 1990). In one particular study (Swart and Berkowitz, 1976), participants were first tormented by a confederate. Then, they learned that their tormenter suffers if a light was turned on (Pavlovian learning). Finally, they were given the opportunity to aggress against another confederate, with whom they have not interacted before, in the presence of the previously conditioned light. Participants responded with more aggression in the presence of the light that was associated with their tormentor's pain relative to a condition in which the light was paired with an affectively neutral event. Cues of a victim's suffering thus seem to have the capacity of eliciting impulsive aggressive reactions under special circumstances. Even though there exist several explanations for the effect of situational aggression cues on aggressive inclinations (for which see Carlson et al., 1990), this sort of aggression transfer is remarkably similar to the specific transfer effects that were described above in the discussion of the affordance hypothesis.

An ideomotor analysis of aggressive behavior thus proposes that people learn to anticipate attractive outcomes of aggressive behaviors, and that situational cues can elicit a spontaneous aggressive response by activating its controlling outcome. With this emphasis on learning and cognitive priming processes, the present approach has much in common with the cognitive-neo-associationist model of aggressive behaviors (Berkowitz, 2012; Berkowitz and Harmon-Jones, 2004), while there are also some notable differences (e.g., the idea of emotion networks vs. the present idea of affectively infused response-outcome associations). Rigorous hypothesis testing will show whether the present analysis has some merits above and beyond these approaches.

CONCLUSION

Many emotional action theories are based on the idea that emotions prime cognitive action structures, which in turn activate body movements. The present ideomotor approach lends credibility to this idea. Thinking about the consequences of a movement may indeed produce the movement itself, and emotions may prime thoughts of particular consequences of actions. Many of these consequences may be functional for coping with an emotional event, but others may be not, or even be outright dysfunctional. In either case, having a closer look at the consequences of actions, rather than at their antecedents, may be the key for a better prediction of how people will respond in an emotional situation.

However, it is also clear that the range of possible action outcomes is constrained by the characteristics of the emotional situation. A frightened person may anticipate very different outcomes depending on whether she feels threatened by making contact with a dental drill, by the neighbors' aggressive dog, or by the diagnosis of a cancer disease. As a consequence, she may prepare very different actions to cope with each threat. Furthermore, not all situations are controllable to the same degree, and context cues are used to estimate which action outcomes can be achieved in a given situation (Kiesel and Hoffmann, 2004). Analyzing the characteristics of an emotional situation thus provides important clues about what people hope, fear, and aspire for their immediate future, and how they will act in this situation.

The present approach also has some limitations. One limitation is that all behaviors are treated equally. At least in lower animals, however, avoidance responses that are closer to species-specific defense reactions (SSDRs) are learned faster than arbitrary responses (Bolles, 1970; Crawford and Masterson, 1982), suggesting that characteristics of the behavioral response may play a role as well. Another limitation is that the present model does not clarify the impact of emotional arousal on action control. One possibility is that emotional arousal intensifies the motivational response that is evoked by anticipatory processes. Another possibility is that emotional arousal affects the generation of a motivational response directly, by influencing the processes that encode the value of an outcome (see e.g., Eder and Rothermund, 2010). Further research is necessary that evaluates these possibilities.

Perhaps the biggest challenge is however the question of how emotional actions are connected to and influenced by other emotional response components (i.e., cognitive, physiological, expressive, and experiential responses). It should have become clear from our review that emotional actions involve more than just "doing" something and require complex cognitive, affective, and physiological preparations. According to the present approach, emotion may not be the crucial element that binds together multiple response systems but, rather, the action that is afforded by an emotional situation. Analyzing emotional actions may then not only enhance our understanding of how emotions make us behave, but also how they make us feel in the way they do.

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AUTHOR NOTE: Preparation of this chapter was supported by a German Research Foundation Grant ED 201/2-1 to Andreas Eder.