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A Common-Coding Account of the Bidirectional Evaluation–Behavior Link

Andreas B. Eder
Friedrich-Schiller-University of Jena

Karl Christoph Klauer
Albert-Ludwigs-University of Freiburg

Three experiments tested the influence of approach- and avoidance-related lever movements on the perception of masked affectively positive and negative stimuli. A motivational account of the bidirectional evaluation–behavior link predicted an enhanced detection of response-compatible stimuli, whereas a common-coding model predicted a reduced evaluative sensitivity toward such stimuli due to feature binding conflicts. The results consistently supported the common-coding explanation. In Experiment 1, detection (d') of positive and negative stimuli was selectively impaired by the generation of congruent approach- and avoidance-related lever movements, respectively. This effect, referred to as action-valence blindness, was replicated in Experiment 2 and shown to depend on the evaluative meaning of the generated movement rather than on the movement per se. Experiment 3 revealed that action-valence blindness depends on a temporal overlap between movement generation and stimulus evaluation. A common-coding link between evaluation and motor behavior is discussed.

Keywords: bidirectional evaluation–behavior link, approach and avoidance, common-coding, action-induced blindness

Research on the relationship between stimulus evaluation and motor behavior has accumulated much evidence that evaluative processing is *bidirectionally* coupled to action dispositions: On the one hand, stimulus evaluations have been shown to influence the speed and accuracy of the preparation of specific motor actions, with positive evaluations activating a behavioral set of approach and negative evaluations preparing a behavioral set of avoidance (e.g., Chen & Bargh, 1999; Lang, Bradley, & Cuthbert, 1990; Schneirla, 1959). On the other hand, motor behaviors of approach and avoidance influence evaluative judgments about environmental objects, with more positive evaluations during the generation of approach behavior and more negative evaluations during the execution of avoidance behavior (e.g., Cacioppo, Priester, & Berntson, 1993; Neumann & Strack, 2000). As a general rule, approach behavior has been shown to be compatible with positive object evaluations and avoidance behavior has been shown to be compatible with negative object evaluations.

In explaining this reciprocal connection between stimulus evaluations and motor actions, the following two questions are of primary interest: (a) How are stimulus evaluations translated into motor reactions and motor behaviors into evaluations (*bidirectional translation problem*)? (b) Why is this translation process more effective with some particular evaluation–behavior combinations than with others (*evaluation–behavior compatibility problem*)? In this article, we evaluate two competing accounts by means of the answers to these questions. First, a *motivational account* is described that proposes motivational orientations of approach and avoidance as mediating structures between evaluations and behaviors. Second, a *common-coding account* is introduced as an alternative that proposes that evaluations and behaviors overlap in their mental representations in a common-coding domain.

In the following article, we first summarize empirical evidence that corroborates the claim of a bidirectional relationship between evaluation and motor behavior. Then we describe the dual motivational account and the common-coding account, which offer different solutions to the translation and compatibility problems. Finally, we report a set of experiments that pit predictions of both accounts against each other.

Empirical Evidence for a Bidirectional Evaluation–Behavior Link

Empirical evidence for a bidirectional relationship between stimulus evaluations and motor behaviors stems primarily from paradigms that assign motor reactions of approach and avoidance to affective stimuli in a congruent or incongruent fashion. A typical finding is a facilitation of motor responses (stimulus–response or S–R influence) and evaluative judgments (response–stimulus or R–S influence) in the congruent assignment condition (positive–approach, negative–avoid) relative to the incongruent condition (positive–avoid, negative–approach), revealing an overall compatibility advantage in the processing of "matching" pieces of perceptual information and in the preparation of "matching" motor reactions.

Influence of Stimulus Evaluations on Approach and Avoidance Behavior

Many studies have investigated the speed and accuracy of simple push (avoidance) and pull (approach) reactions to affective

Andreas B. Eder, Department of Psychology, Friedrich-Schiller-University of Jena, Jena, Germany; Karl Christoph Klauer, Department of Psychology, Albert-Ludwigs-University of Freiburg, Freiburg, Germany.

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Correspondence concerning this article should be addressed to Andreas B. Eder, Institut für Psychologie, Am Steiger 3/Haus 1, Friedrich-Schiller-Universität Jena, D-07743 Jena, Germany. E-mail: andreas.eder@uni-jena.de

stimuli.[1] In a seminal study by Solarz (1960), participants classified the evaluative meaning of words presented on a moveable stage using push and pull movements. They were faster to pull favorably evaluated words toward them and to push negatively evaluated words away from them than vice versa. Follow-up studies revealed that push and pull movements of a lever are sufficient: Participants were consistently faster to move a lever toward them in positive evaluations and to move the lever away from them in negative evaluations than vice versa (e.g., Chen & Bargh, 1999; Duckworth, Bargh, Garcia, & Chaiken, 2002; Fishbach & Shah, 2006; Marsh, Ambady, & Kleck, 2005; Rinck & Becker, 2007). The evaluative implications of lever reactions are a function of their framing as toward and away from a reference point (Lavender & Hommel, 2007; Markman & Brendl, 2005; Seibt, Neumann, Nussinson, & Strack, 2008), and they depend upon an evaluative processing context being induced (Lavender & Hommel, 2007; Rotteveel & Phaf, 2004).[2] Moreover, Eder and Rothermund (2008) recently showed that valence modulations of lever movements are moderated by the evaluative meaning of the response labels that are used in the task instructions. In several experiments, standard affective mapping effects of affective stimuli on lever movements were replicated when the standard response labels *toward* and *away* were used but were reversed when response labels of opposite valence (*downward* and *upward*, respectively) were used in the movement instructions. These results imply that action instructions and action goals determine the evaluative implications of movements that interact with stimulus evaluations on a representational level.

Influence of Approach and Avoidance Behavior on Stimulus Evaluations

Experimental research on the influence of motor patterns on basic evaluative processes can be traced back to the early ideas of the James–Lange theory on the groundings of emotional experience in physiological and bodily patterns (James, 1884) and to scientific research suggesting an influence of facial expressions on emotional experiences and judgments (facial feedback hypothesis; McIntosh, 1996). One intriguing line of research has employed behavioral positions of arm flexion and extension assumed to be associated with approach and avoidance states, respectively.[3] In several studies, arm flexion induced a positive shift in evaluative judgments of stimuli and arm extension a negative shift in stimulus ratings. Such a motor-induced bias in evaluative processing was observed with evaluative ratings of unfamiliar, novel displays (e.g., Cacioppo et al., 1993; but see also Centerbar & Clore, 2006), with evaluative judgments of familiar, neutral words (e.g., Priester, Cacioppo, & Petty, 1996), and with evaluations of clearly valenced stimuli (e.g., Neumann & Strack, 2000). Motor-induced biases were also found to be contingent on an evaluative processing context (Cacioppo et al., 1993; Förster & Strack, 1998), and they are typically explained with reference to a behaviorally induced processing preparedness or regulatory style that facilitates the encoding of (motivationally) congruent stimuli (Gawronski, Deutsch, & Strack, 2005; Förster & Stepper, 2000).

Summary

Experimental research has produced a large amount of evidence for bidirectional influences between stimulus evaluations and specific motor reactions: The affective value of stimuli has an effect upon the preparation and selection of approach and avoidance reactions (S–R influence); conversely, arm positions of flexion and extension associated with approach and avoidance have an influence upon the evaluative processing of stimuli (R–S influence). Even though the behavioral manipulations employed in investigations of the two directions of influence differ in some important aspects (e.g., dynamic lever pulls and pushes in S–R studies vs. static arm flexion and extension in R–S studies), researchers treat them as conceptually similar because of the relation between pushing and arm extension on the one hand and pulling and arm flexion on the other hand (e.g., Chen & Bargh, 1999; Rotteveel & Phaf, 2004). As a consequence of these assumptions, theorists have proposed that both directions of influence might be mediated by similar structures on a central, representational level (Neumann, Förster, & Strack, 2003).

Another principle uniting the two research lines is the patterning of the influence along a compatibility relation: Approach reactions are compatible with positive evaluations and avoidance reactions with negative evaluations. The mediation of this affective compatibility relation still requires explanation, as is discussed next.

Motivational Account of the Bidirectional Evaluation–Behavior Link

The dominant account of the evaluation–behavior link proposes that motivational states mediate between stimulus evaluations and behavioral tendencies of approach and avoidance. Positively valenced, appetitive stimuli are assumed to be associated with a motivational orientation of approach (attachment, consumption, copulation), and negatively valenced, aversive stimuli are assumed to be linked to a motivational orientation of avoidance (withdrawal, escape, defense). This affect–motivational organization of behavioral responses explains how affective stimuli prepare approach and avoidance reactions (e.g., Chen & Bargh, 1999; Lang et al., 1990); in addition, it accounts for an influence of arm positions on stimulus evaluation by the additional assumption that behavioral dispositions of approach and avoidance activate congruent motivational orientations via backward associations (Cacioppo et al., 1993; Neumann & Strack, 2000). Finally, the motivational framework proposes that a bidirectional evaluation–

[1] Another large body of evidence for a valence–behavior relationship concerns modulations of (exteroceptive) behavioral reflexes in the processing of affective stimuli (e.g., Lang et al., 1990). This research line is not discussed here, because there is no evidence for a bidirectional relationship between reflexes and affective stimuli processing.

[2] Rotteveel and Phaf (2004) and Lavender and Hommel (2007) have argued that salient and obtrusive manipulations of the emotional value of stimuli might induce an evaluative processing strategy even without an explicit instruction to do so, explaining purported goal-independent congruency effects in simple detection tasks (Chen & Bargh, 1999, Experiment 2) and lexical decision tasks (e.g., Wentura, Rothermund, & Bak, 2000, Experiment 3).

[3] Hedonic properties of arm extension and flexion were already reported by James (1884) and Münsterberg (1892). However, in their introspective studies they experienced arm extension as pleasant and arm flexion as unpleasant, which is exactly the opposite assignment from the one proposed by present-day theories.

behavior relationship is set up “whenever there is an isomorphic (one-to-one) contingency between behavior and evaluation” (Neumann et al., 2003, p. 386). In line with this contingency assumption, analogous behavioral effects on evaluative processes were observed with head shaking in the vertical (“yes”) and horizontal (“no”) directions (Förster & Strack, 1996; Tom, Petterson, Lau, Burton, & Cook, 1991) and with upright (elated) and slumped (depressed) body postures (Förster & Stepper, 2000; Stepper & Strack, 1993).

To summarize, the motivational account of the evaluation–behavior link proposes two motivational “translator” systems as a solution of the bidirectional translation problem: Motivational orientations of approach and avoidance reciprocally connect affective stimuli with motor structures on a central, representational level, and affective stimuli as well as long-term associated motor responses are hypothesized to activate these motivational systems. Activations of motivational systems by one part of the evaluation–behavior link are then assumed to facilitate the processing of the other part of the link.

Common-Coding Account of the Bidirectional Evaluation–Behavior Link

Recent cognitive–psychological research has revealed analogous bidirectional relationships between other stimulus and response features to which motivational systems appear irrelevant. In fact, research on S–R compatibility effects on reaction times suggests that stimulus features facilitate or interfere with response selection whenever there is correspondence between stimulus features and response features on any perceptual, conceptual, or structural dimension (Kornblum, Hasbroucq, & Osman, 1990; Proctor & Vu, 2006). Furthermore, there is complementary research showing a reverse influence of action properties on stimulus perception. For instance, in an experiment by Wohlschläger (2000; see also Ishimura & Shimojo, 1994), participants were to turn a knob either in a clockwise or counterclockwise direction. During the turning movement a circular motion display was continuously shifted clockwise about a constant angle, so that the motion direction (clockwise vs. counterclockwise) of the display was ambiguous to the perceiver. The results showed that unseen rotational hand movements primed the perception of rotational motion in the direction of the hand movement. This effect was obtained even when movements were merely planned during the display presentation rather than executed, showing that action planning was sufficient to prime visual motion perception. These and other studies (e.g., Bekkering & Neggers, 2002; Creem-Regehr, Gooch, Sahm, & Thompson, 2004; Hamilton, Wolpert, & Frith, 2004; Hommel & Schneider, 2002; Müsseler & Hommel, 1997a, 1997b; Repp & Knoblich, 2007; Schubö, Prinz, & Aschersleben, 2004; Schütz-Bosbach & Prinz, 2007) point to crosstalk between action and perception on common, cognitively specified dimensions (e.g., spatial direction or amplitude) that is structurally analogous to the relationship between motor behaviors and evaluations.

Bidirectional interactions between perception and action planning are at odds with classic linear stage models that view perception and action as functionally separable modules in a unidirectional flow of information, with sensory input being translated into motor output in discrete processing stages (e.g., Massaro, 1990). Instead, these findings are more supportive of models that propose a continuous processing of sensory events and action events in a common representational domain. This assumption of a common coding of stimulus and response features is a key principle of the theory of event coding (TEC; Hommel, Müsseler, Aschersleben, & Prinz, 2001) that is designed to explain mutual interactions between products of perceptual processes and the first steps of action planning. Adopting an *ideo-motor* or *effect-based view of action control*, the TEC assumes that motor responses become activated through the anticipation of the responses’ sensory consequences in action planning (e.g., Beckers, De Houwer, & Eelen, 2002; Elsner & Hommel, 2001; Greenwald, 1970; Kunde, Koch, & Hoffmann, 2004). Perceived features of objects and planned features of motor actions are cognitively represented by means of structurally identical event codes (Hommel, 2004), with the effect that stimulus and action features may prime each other on the basis of their overlap in the common representational domain (Prinz, 1990, 1997). In consequence, the TEC not only explains biases in action preparation as a consequence of stimulus processing (with S–R compatibility effects serving as prime examples), it also predicts a reverse influence of action planning on perceptual processes.

In sum, cognitive research into the perception–action relationship and affective research into the evaluation–behavior link both reveal a reciprocal connection between stimulus processing and action preparation. As a general framework of the perception–action link, the TEC is able to account for perception–action interactions in a wide range of processing domains, including the evaluative one (Eder & Klauer, 2007; Hommel et al., 2001; Lavender & Hommel, 2007). An affective extension of the TEC might consequently be able to theoretically integrate research findings on the link between stimulus evaluations and approach and avoidance reactions. Most importantly, the TEC’s approach to the bidirectional translation and evaluation–behavior compatibility problems differs from that of the motivational account. First, evaluative features of a stimulus and affective properties of a response are assumed to be linked not directly but via a common-coding domain in which affective codes, among others, interact. Second, whether congruence between affective codes in the common domain will result in facilitation of, or interference with, processing depends on whether they are co-activated within the activation or integration phases of the event coding cycle; the motivational account predicts only facilitation from congruence. Third, the common-coding account does not, like the motivational account, assume direct and inflexible translation between, for example, the direction of a movement and its affective valence coding. Instead, the affective coding of a movement (or of a stimulus) depends on how the movement is construed or represented in the common domain, which may in turn be influenced by context and instructions.

Affective Blindness Toward Response-Compatible Stimuli

The motivational account of the evaluation–behavior link assumes that bodily expressions of approach and avoidance facilitate the processing of motivationally congruent evaluative information. In line with this assumption, several studies have shown that affective information is processed faster and more efficiently in congruent body positions than in incongruent body positions (Förster & Stepper, 2000; Gawronski et al., 2005; Neumann & Strack, 2000).

The TEC, however, relates the encoding efficiency of affective information to the dynamics of event coding. Two stages of event coding are assumed in forming episodic representations of perceptual and motor events. In a first *activation stage*, distributed stored feature codes of perceived or to-be-produced events are activated, with the effect that they become more accessible. For example, a positively valenced stimulus will activate the feature code "positive." This code is also part of the representation of approach-related behaviors, such as a lever pull, that is set up during action planning. The preactivation of the feature "positive" will consequently bias the selection between approach and avoidance reactions in favor of the approach reaction (Eder & Rothermund, 2008). Conversely, the encoding of affective perceptual information might similarly benefit from activations of evaluative response codes during the planning of approach and avoidance behaviors, explaining a biasing influence of approach and avoidance behavior on stimulus evaluations.

Code activation alone, however, is not assumed to be sufficient for event coding because an additional mechanism is needed to "bind" the information to the relevant events and to distinguish it from information pertaining to other events in the common-coding domain (Hommel, 2004). This feature binding is accomplished in a subsequent *integration stage*, in which the activated features' codes are bound together into a coherent (but not unitary) event code, with the effect that they become less accessible to temporally overlapping events. Given a common formatting, such an episodic occupation of feature codes might facilitate an unambiguous segregation of overlapping events in a common-coding domain, reducing the risk of so-called "binding errors" (e.g., illusory conjunctions; Treisman & Schmidt, 1982).[4] Note that, just as increased accessibility implies compatibility benefits, the subsequent decreased accessibility implies compatibility costs.

To summarize, the dynamic TEC model leads one to expect benefits of (affective) feature overlap in the initial activation phase but costs of (affective) code compatibility for the subsequent integration phase (Stoet & Hommel, 1999, 2002). This prediction of compatibility costs (i.e., better task performance in incompatible trials) due to feature integration in action planning has been extensively tested (Hommel & Müsseler, 2006; Kunde & Wühr, 2004; Müsseler & Hommel, 1997a, 1997b; Müsseler, Steininger, & Wühr, 2001; Müsseler, Wühr, & Prinz, 2000; Oriet, Stevanovski, & Jolicoeur, 2003, 2007; Stevanovski, Oriet, & Jolicoeur, 2002, 2003, 2006; Wühr & Müsseler, 2001, 2002; see Müsseler & Wühr, 2002, for an overview) and was recently generalized by Eder and Klauer (2007) to the evaluative domain.

In Eder and Klauer's (2007) experiments, two tasks overlapped temporally: The planning and execution of extrinsically valenced button presses overlapped with evaluations of masked positive and negative words (see Figure 1). On each trial, participants were to prepare a left or right button press without time pressure according to the evaluative implication of a response cue. In line with previous research on extrinsic affective Simon effects (e.g., De Houwer, 2003), it was assumed that a button press assigned to a positively valenced response cue would acquire a positive meaning and that a button press mapped onto a negative movement cue would be short-term associated with a negative meaning. Participants had unlimited time to prepare the cued button press, granting

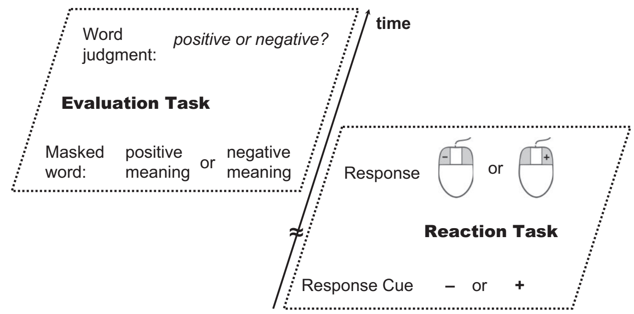

Figure 1. Dual-task setup in Eder and Klauer (2007) that required a valence identification of masked positive and negative words (evaluation task) during the execution of extrinsically valenced button presses (reaction task).

sufficient time for an integration of the evaluative response meaning into the action plan. Response readiness was then indicated by the participant with a simultaneous press of both response buttons, followed by the speeded execution of the cued single button press. The double button press additionally initiated the presentation of a masked positive or negative word, the valence of which was to be identified as correctly as possible. The valence judgments were analyzed with a signal detection model that disentangled effects on participants' ability to discriminate stimulus valence from possible shifts in response criteria induced by the action planning. The results of two experiments revealed reduced evaluative sensitivity (d') toward response-compatible stimulus valences: A positive word meaning was harder to detect when a positively charged button press was prepared than when a negatively charged response was planned. An analogous impairment was found for evaluations of negative words presented during the execution of a negatively charged button press. This specific impairment in valence discrimination (an effect referred to as *action-valence blindness*) reflected a genuine discrimination difficulty, as strategic factors like judgmental bias induced by the action planning and interference between the movement cue and the masked word were ruled out as alternative explanations.

The experiments by Eder and Klauer (2007) provided first evidence for the hypothesis that in the preparation of evaluatively charged motor responses, valence codes are bound to motor representations in a feature integration process that impairs access to these codes in overlapping evaluations of same-valenced stimuli. The observed compatibility disadvantage in the processing of evaluatively congruent information is, however, at odds with the assumption of motivational accounts that affectively charged motor actions (see the contingency assumption above) facilitate the encoding of affectively congruent information (Gawronski et al., 2005; Neumann et al., 2003).

[4] From a functional point of view, reduced accessibility of integrated feature codes should not be equated with code inhibition: Inhibition typically refers to a decrease of code activation below baseline activity, whereas integrated features are assumed to be in a heightened state of activation. Thus, integrated features are still active, but access to them is impaired. For a more thorough discussion of feature integration mechanisms and their implementation in the human brain, see Hommel (2004, 2006) and Colzato, van Wouwe, and Hommel (2007).

A number of procedural aspects of the experiments by Eder and Klauer (2007) might, however, weaken the stringency of the above conclusion. First, the majority of studies investigating motor influences on affective processing used approach- and avoidance-related behaviors that might be more closely tied to motivational systems than key presses that are transiently associated with positive and negative meaning only within the context of the current task. Accordingly, motivationally grounded benefits in the identification of response-compatible stimuli might be more likely detected with approach and avoidance reactions that are assumed to be associated with motivational orientations through deeply ingrained associations acquired in the course of a lifetime. Second, Eder and Klauer asked participants to select left and right button presses according to the evaluative implication of a movement cue and thus, the motor task itself involved explicit evaluations (of the movement cue); in contrast, in typical studies of a motor influence on stimulus evaluations, participants do not perform evaluative classifications in the motor task. Accordingly, action-valence blindness effects might be attributed to a different process that might come into play when explicit evaluative categorizations in the motor task overlap with valence identifications in time.

In this article, we attempt a more stringent test of the code occupation hypothesis, taking these procedural differences into account. In a series of experiments, participants were to prepare and execute lever pulls and pushes that are assumed to be associated with motivational orientations of approach and avoidance (e.g., Chen & Bargh, 1999; Neumann et al., 2003). The lever movements were selected as responses to simple, acoustic stimuli that carried no (differential) evaluative meaning. In line with the dynamic model of the TEC, we expected impaired valence detection of response-compatible stimuli (i.e., an affective R–S compatibility disadvantage) during the generation of approach- and avoidance-related lever movements. The motivational account alternatively predicted enhanced identification of response-compatible stimuli (i.e., an affective R–S compatibility advantage) due to a motivationally induced processing preparedness.

Experiment 1

Experiment 1 tested these hypotheses in a dual-task setup that required the identification of masked positive and negative words during the execution of approach- and avoidance-related lever movements. On each trial, participants had unlimited time to prepare a lever pull toward the body (approach movement) or a lever push away from the body (avoidance movement) as a response to evaluatively neutral, acoustic stimuli. Right before movement execution, a to-be-evaluated target word was presented on the screen, the valence of which was either compatible (i.e., approach–positive, avoidance–negative) or incompatible (i.e., approach–negative, avoidance–positive) with the prepared approach or avoidance movement. For this dual-task situation, an affective extension of the TEC predicted worse identification of response-compatible stimulus valences than of response-incompatible valences. In contrast, the motivational account leads one to expect better identification of response-compatible stimulus valences than of response-incompatible stimulus valences.

Method

Participants. Forty students (21 women, 19 men) with normal or corrected-to-normal visual acuity participated in the experiment for course credit or for payment. Three participants were left-handed. The participants were between 18 and 36 years of age ($M = 25.4$) and all of them were fluent in German.

Apparatus and stimuli. In a dimly lit experimental chamber, participants were seated at a distance of 50 cm from a 17" VGA color monitor with a 70 Hz refresh rate. Stimulus presentation and measurement of response latencies were controlled by a software timer with video synchronization (Haussmann, 1992). An IBM-compatible joystick was connected to the game port of the computer and placed between the monitor and the participant (see Figure 2). The participant was asked to grip the lever of the joystick with the dominant hand and to perform the lever movement until the dead stop position was reached (subtending an angle of approximately 23°). The button at the front of the lever was tinted red and introduced to the participant as Fire Button 1, and the button at the top of the lever was tinted yellow and described as Fire Button 2.

An acoustic signal (600 Hz) emitted by the internal loudspeaker of the computer served as the movement-specifying stimulus. The tone signal was presented in a time window of 375 ms either a single time (no tone: 100 ms; tone: 175 ms; no tone: 100 ms) or two times (tone: 175 ms; no tone: 75 ms; tone: 175 ms). Participants were instructed to prepare a joystick movement toward the body when the tone occurred a single time and to prepare a lever movement away from the body when the tone was presented two times.

Target words were 12 clearly positive ($M = 1.92$, $SD = 0.44$) and 12 clearly negative adjectives ($M = –2.00$, $SD = 0.62$) that were selected from a standardized word pool on the basis of their evaluative norms (Schwibbe, Röder, Schwibbe, Borchardt, & Geiken-Pophanken, 1981; see Appendix A). The subsets of positive and negative adjectives did not differ in number of letters

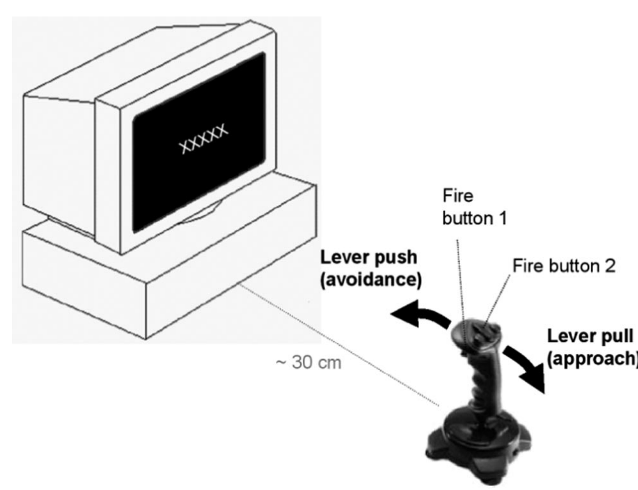

Figure 2. Position of the joystick relative to the monitor. Participants were seated behind the joystick and gripped the lever with their dominant hand. A response was registered when an excursion of the lever subtended an angle of 23° in any direction.

(range: 8–9), frequency of usage, valence extremity, and point of uniqueness (with all *Fs* < 1). Different sets of 9 positive and 9 negative adjectives were used for the practice trials. Six consonant strings of comparable length (8–9 letters) were constructed as "noise" stimuli that shared no letter with the test or practice adjectives on any specific letter position. Consonant strings were used because of the profound difficulties in finding words consistently rated as neutral in valence. All stimuli were presented in lowercase letters in grey on a black background at the center of the computer screen.

Design. The experimental design was a crossed 2 (lever movement: approach vs. avoidance) × 3 (word: positive vs. neutral vs. negative) factorial design. Each block consisted of three trials from each of the six conditions of the design, resulting in 18 trials per block that were presented in random order. Each participant worked through 16 experimental blocks, resulting in 96 response-compatible (approach–positive, avoidance–negative), 96 response-incompatible (approach–negative, avoidance–positive), and 96 response-neutral (approach–neutral, avoidance–neutral) movement–word combinations.

Procedure. Each experimental session consisted of an adjustment phase and an experimental phase. In the adjustment phase, the duration of the target presentation was individually adjusted in a staircase procedure to constrain the valence identification rate to a window between 59% and 84% (see also Müsseler & Hommel, 1997a). Participants were instructed to identify the valence of masked positive and negative words as accurately as possible. Target words were the same adjectives that were later used as targets in the experimental phase. The sequence of trial events was as follows: fixation cue (asterisk; 100 ms), blank screen (100 ms), premask (nine white Xs in a row; 14 ms), adjective for the individually set presentation time (starting with 112 ms in the first block), postmask (nine white Xs in a row; 1,000 ms), blank screen (257 ms), and identification judgment screen (until judgment response). The identification screen prompted the participant to enter the valence judgment with the colored fire buttons without time pressure but within 2 s starting from screen onset. On the identification screen, the words "positiv" (positive) and "negativ" (negative) appeared on the left and right sides of the screen, respectively, and were assigned to Fire Buttons 1 (left word) and 2 (right word). The horizontal placement of the valence words, and hence the valence mapping, varied between trials in random order, and each of the two mappings appeared with equal probability in each block. Feedback reported wrong valence judgments and violations of the 2-s time limit. The intertrial interval was 1 s.

Participants performed eight blocks with 12 trials each in the adjustment phase. After each block, the target duration was either decreased by one screen refresh cycle (14 ms) if the error rate was equal or lower than 16% or increased by one refresh cycle if the error rate was equal or above 41%. The final presentation time was computed by averaging across presentation times of the last three blocks (rounded up or down to the next multiple of the refresh cycle).

In the experimental phase, the valence identification task was combined with the lever movement task. Figure 3 illustrates the sequence of events in this phase. Each trial started with the presentation of a brief acoustic signal as movement cue that sounded either a single time or two times. A single tone demanded the preparation of a lever pull toward the body (approach reaction); a double tone demanded a lever push away from the body (avoidance reaction). Task instructions emphasized that there was unlimited time for the preparation of the lever movements. When the participant felt ready to execute the lever push or pull, he or she first pressed the colored Fire Buttons 1 and 2 simultaneously and then executed the cued lever movement as quickly as possible within a time limit of 750 ms. The double button press additionally initiated the valence identification task with the same procedures as in the adjustment phase, except for (a) the omission of a fixation

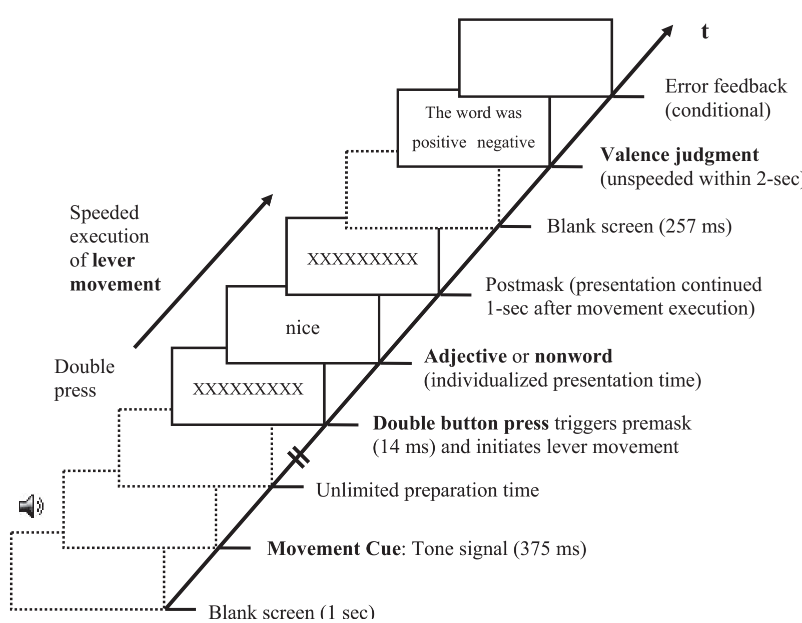

Figure 3. Sequence of events in an experimental trial of Experiment 1. t = time.

mark, (b) the prolonged presentation of the postmask that was taken off the screen 1,000 ms after a lever movement was registered, and (c) the presentation of neutral consonant strings (noise trials). The presentation duration of consonant strings was fixed to a brief 42 ms, to prevent participants from becoming aware of them. Furthermore, an error in valence identification was fed back in half of the noise trials to maintain the illusion of word presentations. A trial ended with error feedback that reported, when appropriate, a lever movement in a wrong direction, deviation from the middle resting position at the time of the double button press, false valence identification of the word, and violations of the time limits for the movement and the valence judgment. In addition, a detailed performance summary was given at the end of each block.

Participants worked first through 18 practice trials with 9 response-compatible and 9 response-incompatible assignments (i.e., no neutral stimuli were presented in the practice block), followed by the 288 experimental trials. The final word-presentation time of the adjustment phase set the initial presentation duration of the word in the practice block but was still adjusted (if necessary) after each experimental block according to the staircase procedure detailed above.

Signal detection model. For analyses of valence identification performance, we adapted Eder and Klauer's (2007) signal detection model to disentangle effects on participants' valence discrimination ability from possible shifts in response criteria induced by the action planning. Figure 4 shows the signal detection model and its parameters. For each movement planning condition, a separate response criterion was computed to model the possibility that the planning of push and pull responses differentially biases the judgments "positive" or "negative." The relative position of the response criteria c_{pull} and c_{push} on the strength-of-evidence axis was used to identify judgmental strategies that might lead to underestimating or overestimating action-induced effects on the valence identification. For instance, participants might be biased to judge "positive" after a push response and "negative" after a pull response when uncertain about the word valence, thus mimicking action-valence blindness without changes in evaluative sensitivity (contrast bias). Alternatively, participants might prefer the judgment "positive" after a pull response and "negative" after a push response when uncertain, masking action-valence blindness in hit rate measures uncorrected for response bias (assimilation bias). Accordingly, judgmental biases necessitate a signal detection analysis that corrects for a systematic overestimation (contrast bias) or underestimation (assimilation bias) of action-valence blindness.

Six model parameters were defined by crossing word valence (positive vs. neutral vs. negative) and lever movement (pull vs. push): two response criteria, c_{pull} and c_{push}, and four parameters for the means of the distributions of positive and negative word signals (+, –) preceded by either of the two lever movements ($d'_{-,\ push}$, $d'_{-,\ pull}$, $d'_{+,\ push}$, $d'_{+,\ pull}$). The distribution of neutral targets, shown as the shaded area in Figure 4, was given a zero mean, independently of the kind of prior movement planning. Correct identifications of the valence of the word defined hits (e.g., judgment "positive" when a positive word was presented during a lever push), and the same valence judgment in the corresponding

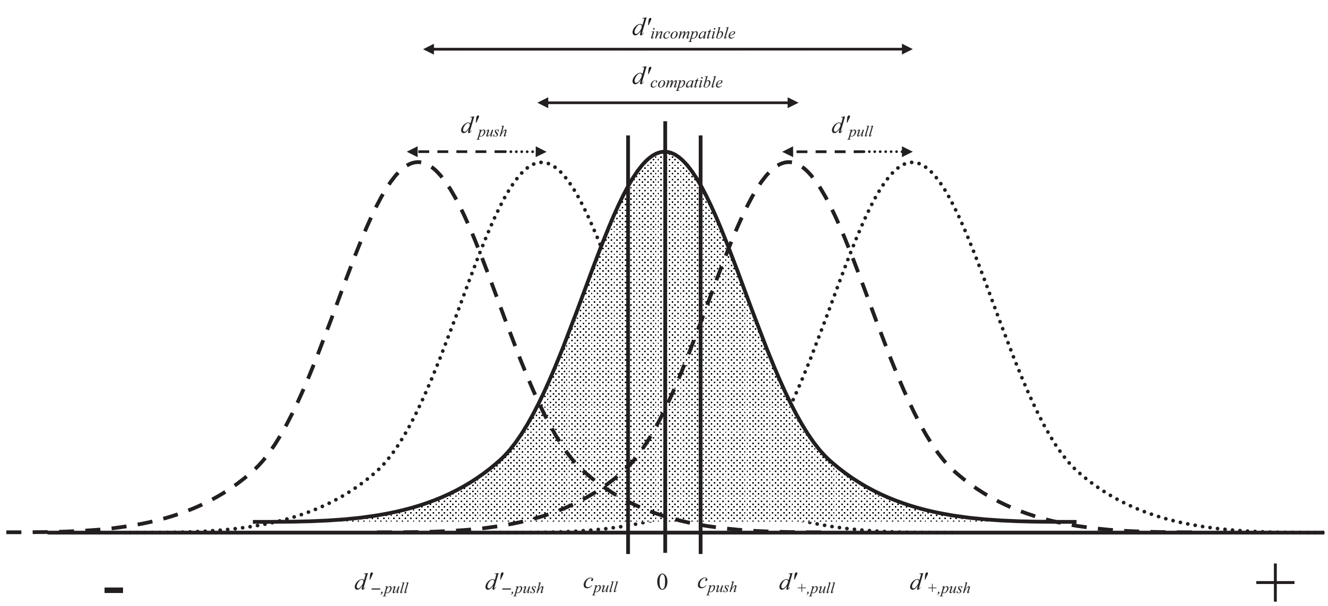

Figure 4. Graphical representation of the signal detection model and its parameters. The shaded distribution in the middle indicates the noise distribution. Approach- (pull) and avoidance- (push) related movement conditions are indicated by the subscripts *pull* and *push*, respectively. Positive and negative word signals are specified by the subscripts + and –, respectively. Positive values on the response criterion *c* signify an inclination toward the decision "negative" and negative values a tendency to decide "positive." The means d' of the different target distributions are indexed relative to a zero mean assigned to the neutral targets. The sensitivity indices $d'_{compatible}$ and $d'_{incompatible}$ quantify the discriminability of (the valences of) positive from negative targets separately for conditions with compatible and incompatible movement.

movement condition of the noise trials defined false alarms (e.g., judgment "positive" when a neutral word was presented during a lever push). Parameter values were estimated from each participant's data, using an iterative search algorithm that maximized the likelihood of the observed data. The effects of movement preparation on the valence perception were modeled by shifts of the target distributions on the strength-of-evidence axis. In the case of action-valence blindness, avoidance-related push responses should induce a small shift of negative word signals to the right of average size d'_{push}, thereby making an erroneous positive judgment somewhat more likely. Analogously, approach-related pull movements should produce a small shift of each positive target to the left of average size d'_{pull}, making an erroneous negative judgment more likely. In the case of an action-induced processing preparedness, motor-induced shifts in the opposite directions were expected. We assessed action-valence blindness for each kind of target valence by computing $d'_{push} = d'_{-,\ push} - d'_{-,\ pull}$ and $d'_{pull} = d'_{+,\ push} - d'_{+,\ pull}$, with positive values indicating action-valence blindness. Alternatively, we computed d' values for discriminating positive from negative words separately for response-compatible targets ($d'_{compatible} = d'_{+,\ pull} - d'_{-,\ push}$) and response-incompatible targets ($d'_{incompatible} = d'_{+,\ push} - d'_{-,\ push}$). An overall index of action-valence blindness can be computed by subtracting $d'_{compatible}$ from $d'_{incompatible}$, or equivalently, by adding d'_{push} and d'_{pull} (i.e., action-valence blindness = $d'_{incompatible} - d'_{compatible} = d'_{push} + d'_{pull}$). Thus, positive values of this index indicate a disadvantage of R–S compatibility and negative values an advantage in valence detection.

Results

The mean presentation duration of the words was 74 ms (SD = 41). Trials with a lever movement at the time of the double button press (1.4% of all trials), in the wrong direction (2.6% of all trials), and exceeding the time limit of 750 ms (3.2% of all trials) were excluded from further data analyses. Error rates did not interact with the compatibility factor (all $Fs < 1$). Supplementary analyses of the proportion of correct valence identifications are described in Appendix B.

Signal detection analyses. A comparison of the response bias indices c_{pull} and c_{push} revealed an assimilation bias in the valence judgments: Participants responded "positive" more frequently after moving the lever toward the body ($c_{pull} = -0.10$, $SE = 0.05$) than after moving the lever away from the body ($c_{push} = 0.04$, $SE = 0.05$) when uncertain about the target valence, $t(39) = -2.71$, $p < .01$. To test for action-induced changes in evaluative sensitivity, the d' parameters were subjected to a 2 (lever movement: pull vs. push) × 2 (word: positive vs. negative) repeated-measures analysis of variance (ANOVA) that yielded a significant main effect of word valence, $F(1, 39) = 324.04$, $p < .001$, and a significant main effect of lever movement, $F(1, 39) = 4.28$, $p < .05$. The latter main effect corresponds to an overall action-valence blindness effect. The interaction between the two factors was not significant, $F(1, 39) = 1.47$, $p = .23$. A follow-up comparison of the aggregated discriminability indices d' in movement-compatible and movement-incompatible viewing conditions revealed an impaired valence identification of response-compatible word valences ($d'_{compatible} = 0.92$, $SE = 0.08$) relative to response-incompatible valences ($d'_{incompatible} = 1.14$, $SE = 0.08$), $t(39) = -2.07$, $p < .05$, replicating action-valence blindness with approach- and avoidance-related lever movements (see Figure 5).

Reaction times. Movement times of the lever responses were measured from the onset of the double button press to the registration of the lever movement and analyzed for an influence of word valence as a function of affective behavior–evaluation compatibility. A comparison of the movement times showed that word valence processing did not cause differences in the execution speed of congruent (M = 267 ms, SE = 21.6) and incongruent lever responses (M = 267 ms, SE = 21.6; $t < 1$).

Discussion

The results are clear cut. The preparation and execution of approach- and avoidance-related lever movements selectively im-

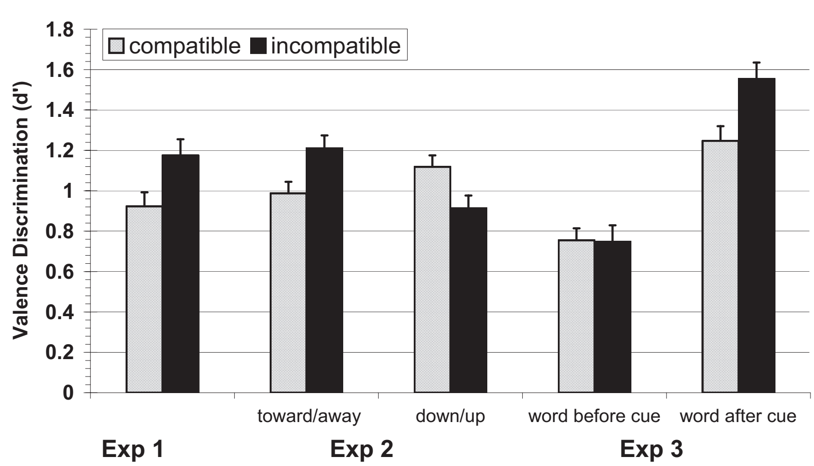

Figure 5. Evaluative sensitivity (d') for response-compatible and response-incompatible stimulus valences in Experiments (Exp) 1–3. Compatibility is defined with respect to the arm movement and stimulus valence (compatible: pull–positive/push–negative; incompatible: push–positive/pull–negative). Error bars indicate the standard error.

paired the identification of response-compatible positive and negative stimuli. This action-valence blindness effect is in line with an affective extension of the TEC, according to which action planning interferes with stimulus evaluation when both draw upon a shared valence code that is already occupied by the action plan. A reduced evaluative sensitivity toward response-compatible stimuli is, however, at odds with a motivational account that assumes that the generation of approach and avoidance movements always facilitates the processing of (motivationally) congruent pieces of information.

Experiment 2

A common-valence-coding account of the evaluation–behavior link explains crosstalk between affective stimuli and approach and avoidance reactions in terms of an evaluative S–R code correspondence in a common representational domain. In line with an evaluative response-coding view of approach and avoidance behaviors (Eder & Rothermund, 2008), it is assumed that evaluative implications of action instructions and action goals assign affective codes to motor responses on a representational level that match or mismatch the valence of presented stimuli. Accordingly, changes of the evaluative action frame are hypothesized to go along with different evaluative response codings of identical movements, setting up different affective congruency relations between affective stimuli and motor reactions.

Experiment 2 tested this evaluative response-coding hypothesis with respect to a motor influence on stimulus evaluations. Previous research has shown that standard mapping effects between affective stimuli and lever movements *toward* and *away* from the body are reversed when the same lever movements are instructed as *downward* pull and *upward* push responses that carry an opposite evaluative meaning (for evaluative ratings of the response labels, see Eder & Rothermund, 2008). In Experiment 2, we applied this response label manipulation to the lever movements in the reaction task to investigate an influence of evaluative response codings on the identification of positive and negative stimuli. In the toward/away instruction condition, participants were instructed to prepare a lever pull toward the body (positive response coding) and a lever push away from the body (negative response coding), replicating Experiment 1. In the down/up instruction group, the identical lever movements were instructed as a downward lever pull (negative response coding) and an upward lever push (positive response coding), respectively. If representations of pushing and pulling lever movements integrate valence codes that are flexibly specified by the task context, evaluations of positive and negative stimuli should be selectively impaired by the preparation of lever movements that are controlled by response labels with a similar evaluative meaning. Alternatively, if pushing and pulling movement components are intrinsically associated with motivational orientations of approach and avoidance, respectively, the variation of the response labels should have little impact upon an influence of lever pulls and pushes on stimulus evaluations.

Method

Participants. Eighty-one students (55 women, 26 men) volunteered for the experiment in fulfillment of course requirement or for payment. All participants had normal or corrected-to-normal vision and were fluent in German. Six participants were left-handed. The data set of 1 participant was discarded because his percentage of correct lever movements within the time limit (M = 61.5%) was several standard deviations below the mean correct rate of the rest of the sample (M = 96.2%, SD = 3.3; n = 80).

Stimuli, design, and procedure. Target stimuli in the valence identification task were 48 clearly positive (M = 1.92, SD = 0.44) and 48 clearly negative adjectives (M = –2.00, SD = 0.62) that were selected from the same standardized word pool as in Experiment 1 (Schwibbe et al., 1981; see Appendix A). Positive and negative adjectives did not differ in number of letters (range: 4–9), frequency of usage, and valence extremity (with all $Fs < 1$). An additional 10 positive and 10 negative adjectives were used in the practice trials (10 compatible and 10 incompatible trials) of the experimental phase. Six consonant strings of ascending length (range: 4–9) were the neutral "noise" stimuli.

The instructions for the lever movements were varied between participants, with 40 participants in each instruction group. In the toward/away instruction group, participants were instructed to pull the joystick lever toward the body in response to a single tone and to push the lever away from the body in response to a double tone. In the up/down instruction group, participants were to pull the lever downward in response to the single tone and to push the lever upward in response to the double tone. The instructions of the two groups were identical in all other aspects. In the valence identification task, the time interval between movement registration and presentation of the identification screen was increased to a minimum of 2 s. All other aspects of design and procedure were identical with Experiment 1.

Results

Averaged across all participants, the presentation duration of the words was 80 ms (SD = 40). Trials with a lever movement at the time of the double button press (0.8% of all trials), in the wrong direction (2.5% of all trials), and with a time exceeding 750 ms (1.3% of all trials) were excluded from data analyses. Error rates interacted neither with the compatibility factor (with all $ps > .20$) nor with the instruction group (all Fs < 1). The compatibility relation was defined along a correspondence between lever movement and word valence (compatible: pull–positive, push–negative; incompatible: pull–negative, push–positive), irrespective of instruction group. Supplementary analyses of the percentages of correct valence identifications are listed in Appendix B.

Signal detection analyses. A comparison of the response bias indices c_{pull} and c_{push} in a mixed ANOVA with instruction group (toward/away vs. up/down) as a between-participants factor revealed an assimilation of uncertain valence judgments to the evaluative meaning of the movement instruction; that is, there was an interaction of instruction group and lever movement, $F(1, 78) = 16.91$, $p < .001$. Members of the toward/away instruction group were more inclined to judge "negative" after a lever push away from the body (c_{push} = 0.28, SE = 0.03) than after pulling the lever toward the body (c_{pull} = 0.13, SE = 0.04), $t(39) = 3.48$, $p <$ .01. Conversely, in the up/down instruction group, participants responded "positive" more frequently after pushing the lever upward (c_{push} = 0.13, SE = 0.05) than after pulling the lever downward (c_{pull} = 0.21, SE = 0.04), $t(39) = –2.27$, $p < .05$. The main effects of lever movement (push vs. pull) and instruction group were not significant (with both $ps > .27$).

To test for action-induced changes in evaluative sensitivity, the d' parameters were subjected to a 2 (lever movement: pull vs. push) × 2 (word valence: positive vs. negative) × 2 (instruction group: toward/away vs. up/down) mixed ANOVA. This analysis yielded a significant main effect of word valence, $F(1, 78) = 1{,}678.40$, $p < .001$, and a crossover interaction between instruction group and lever movement (push vs. pull), $F(1, 39) = 10.17$, $p < .01$. The main effect of instruction group ($F < 1$) and all other effects did not reach significance. The interaction between instruction group and lever movement was further explored with the perceptibility indices $d'_{compatible}$ and $d'_{incompatible}$ within each instruction group. As displayed in Figure 5, participants in the toward/away instruction group showed an impaired identification of response-compatible stimulus valences ($d'_{compatible} = 0.99$, $SE = 0.06$) relative to response-incompatible valences ($d'_{incompatible} = 1.21$, $SE = 0.06$), $t(39) = -2.15$, $p < .05$, replicating the action-valence blindness effect observed in Experiment 1. With up/down instructions of the lever movements, however, participants were better in detecting response-compatible valences ($d'_{compatible} = 1.12$, $SE = 0.05$) than response-incompatible valences ($d'_{incompatible} = 0.91$, $SE = 0.07$), $t(39) = -2.41$, $p < .05$, showing that the (evaluative) meaning of the instructed response labels rather than pushing and pulling per se interacted with stimulus evaluations.

Reaction times. Movement times of the lever responses in each instruction group were analyzed for an influence of target valence. A mixed ANOVA revealed nearly identical movement times in each instruction group ($F < 1$). Processing the valence of target words made no difference in the execution speed of congruent ($M = 230$ ms, $SE = 11.5$) and incongruent lever responses ($M = 229$ ms, $SE = 11.6$; $F < 1$), irrespective of the instructed movement framing, $F(1, 78) = 2.78$, $p = .10$.

Discussion

Experiment 2 tested the hypothesis that evaluative implications of action instructions and movement goals assign affective codes to lever responses that interact with evaluative stimulus attributes in a common representational domain. This evaluative response-coding hypothesis was pitted against the assumption that movements of arm flexion and extension (or the codes that control such movements) are associated with motivational orientations of approach and avoidance. Identical lever movements were either instructed as a movement toward (pull) and away (push) from the body or as a downward (pull) and upward (push) movement. Results replicated impaired detection (d') of response-compatible valences relative to response-incompatible valences with toward/away instructions but not with an upward/downward framing of these movements. In the latter instruction group, the valence of response-compatible stimuli was better detected than that of response-incompatible stimuli, supporting the view that the (evaluative) meaning of the instructed response labels rather than pushing and pulling as such is critical for the interaction with stimulus evaluations. Note that a reversed action-effect on valence detection was expected under our evaluative response-coding framework due to a reversed evaluative R–S congruency relation with up/down instructions; in fact, when the affective congruency relation is reordered to reflect the evaluative match between the evaluative meaning of the response labels and the affective stimuli (i.e., compatible: toward/up–positive, away/down–negative; incompatible: toward/up–negative, away/down–positive), an action-valence blindness effect was evident in both instruction groups, revealing that participants were "blinded" by the evaluative action frame in the evaluation of same-valenced stimuli.

Experiment 3

The TEC explains action-valence blindness with an encapsulation of valence codes in action planning that impairs code access or code integration in immediately subsequent evaluations of same-valenced stimuli in a common-coding domain. In the preparation of approach and avoidance actions, valence codes related to movement control and semantic action knowledge are raised above rest level in an initial feature activation process and then linked to an action episode in a subsequent feature integration process. Once the episodic integration of a valence code is completed, the (action) episode then impairs a simultaneous linking of its bound features to another (perceptual) episode such as a valenced target word presented for evaluative classification. Thus, action-valence blindness should critically depend on a temporal overlap between movement planning and stimulus evaluation: Presenting the affective stimulus before an action plan is formed or after response execution when an action plan is already dissolved should not produce this specific interference.

In Experiment 3, we tested this prediction by manipulating the point in time at which the to-be-evaluated word was presented. In half of the experimental trials, the target word was presented some time after the movement cue, when an action plan is already established (word after cue). In the other half of the experimental trials, the target word appeared shortly before the arrival of the movement-imperative auditory signal (word before cue), so that activation of the word's valence is more likely to precede the point at which a valence feature becomes bound to an action. Participants were instructed to respond with lever movements toward and away from the body as fast as possible to the movement cue. With this setup, we sought to test the following predictions: (a) Impaired identification of response-compatible stimuli was expected with word evaluations after the movement cue but not before the cue; (b) compatible word-evaluations should facilitate the preparation of approach and avoidance reactions when presented before the movement cue, showing that early parts of movement preparation benefit from a priming of compatible response features.

Method

Participants. Fifty students (30 women, 20 men) volunteered for the experiment in fulfillment of course requirement or for payment. All participants had normal or corrected-to-normal vision and were fluent in German. The data set of 1 participant was discarded due to a computer failure, and the data set of another participant was dropped from analyses because he reacted erroneously in more than 45% of the trials. Six participants were left-handed.

Apparatus and stimuli. The same apparatus as in Experiment 1 was used. The number of adjectives was increased to 60 for each valence category; the positive ($M = 1.92$, $SD = 0.48$) and negative adjectives (M = –1.94, SD = 0.58) were selected according to their evaluative norms and matched with respect to number of letters (range: 4–9), frequency of usage, and valence extremity (with all Fs < 1). Two additional sets of 12 positive and 12 negative adjectives were selected for the practice trials. The auditory signals of Experiment 1 served as movement cues; however, the total duration of the signal was reduced to 300 ms, and the onset of the double tone (tone: 125 ms; no tone: 50 ms; tone: 125 ms) was matched to the onset of the single tone (tone: 300 ms).

Design and procedure. The experiment had a completely crossed 2 (lever movement: pull vs. push) × 3 (word: positive vs. neutral vs. negative) × 2 (presentation condition: word before cue vs. word after cue) design, with all factors varied within participants. The adjustment phase of the word presentation time was reduced to five blocks, starting with 86 ms in the first block. All other conditions of this phase were identical with those of Experiment 1.

The lever movement task was changed to a speeded response task with different time limits granted for action planning and movement execution. Participants were instructed to respond to the auditory signal as quickly as possible with the correct lever movement. A double button press was still required before movement execution, and 1,000 ms were granted for the planning portion and 500 ms for the execution part of the lever movement. With these different time limits, participants were encouraged to utilize the time until the double button press for movement preparation in order to achieve a reasonable response performance in the subsequent movement execution period. Participants received feedback of a time limit violation at the end of a trial.

The valence identification task consisted of two variants with different target onsets: In the simultaneous presentation condition (word after cue), target onset was linked to the double button press as before. In the advance presentation condition (word before cue), the target word was presented 57 ms prior to the movement cue. In both presentation conditions, the backward mask was shown for 1,000 ms and thereafter replaced by a blank screen. The interval between movement registration and onset of the identification screen was fixed to 1,257 ms. All other procedural conditions were identical to those of Experiment 1.

The experimental phase started with 24 practice trials that were followed by 20 blocks with 18 trials each. Each combination of the 2 (lever movement: pull vs. push) × 3 (word: positive vs. neutral vs. negative) × 2 (presentation condition: word before cue vs. word after cue) design was repeated three times across each pair of blocks in random order. Trials with erroneous lever movements were repeated at the end of the experimental session in random order and presented in blocks of up to 18 trials.

Results

The mean presentation duration of the words was 94 ms (SD = 38). On average participants repeated 39.2 (SD = 22.4) trials because of an erroneous lever movement. Trials with a lever movement at the time of the double button press (0.3% of all trials), in the wrong direction (5.9% of all trials), and with time limit violations for the preparation interval (1.0% of all trials) or the execution part (5.1% of all trials) were discarded from the following analyses. Appendix B reports supplementary analyses of the proportion of correct valence identifications.

Signal detection analyses. A comparison of the response bias indices c_{pull} and c_{push} in a repeated-measures ANOVA with presentation condition (word before cue vs. word after cue) as an additional factor revealed an assimilation bias in uncertain valence judgments. Participants were more inclined to judge "negative" after pushing the lever away from the body (c_{push} = 0.19, SE = 0.04) than after pulling the lever toward the body (c_{pull} = 0.05, SE = 0.04), $F(1, 47) = 10.86$, $p < .01$. This assimilation bias was similarly pronounced in both presentation conditions, $F(1, 47) = 2.75$, $p > .10$. The main effect of presentation condition was not significant ($F < 1$).

To test for action-induced changes in evaluative sensitivity, d' parameters for target-valence perceptibility were analyzed in a 2 (R–S compatibility: compatible vs. incompatible) × 2 (presentation condition: word before cue vs. word after cue) repeated-measures ANOVA. This analysis yielded a significant main effect of presentation condition, $F(1, 47) = 121.00$, $p < .001$. As shown in Figure 5, detection performance was worse when the to-be-evaluated word was presented before the movement cue (d' = 0.75, SE = 0.04) than when it was shown at the time of the double button press (d' = 1.40, SE = 0.05). The main effect of movement–word compatibility was not significant, $F(1, 47) = 2.78$, $p > .10$, but the expected interaction between both factors reached significance, $F(1, 47) = 4.69$, $p < .05$. Comparisons of the means revealed an action-valence blindness effect when the word presentation was linked to the double button press ($d'_{compatible}$ = 1.25, SE = 0.07; $d'_{incompatible}$ = 1.55, SE = 0.08), $t(47) = –2.79$, $p < .01$, but no systematic difference when the target words appeared before arrival of the movement cue ($d'_{compatible}$ = 0.75, SE = 0.06; $d'_{incompatible}$ = 0.75, SE = 0.08; $t < 1$).

Reaction times. Reaction times (i.e., the time interval between onset of the response cue and movement registration) of correct lever movements were analyzed for an influence of movement–word compatibility (compatible vs. incompatible) with presentation condition as an additional factor. The ANOVA showed that participants responded with similar overall speed in each presentation condition; that is, there was no main effect of presentation condition ($F < 1$). The main effect of movement–word compatibility was not significant, $F(1, 47) = 3.99$, $p = .051$, but the interaction between both factors reached significance, $F(1, 47) = 4.09$, $p < .05$ (see Figure 6). Comparisons of the means showed that participants responded faster when a response-compatible word was presented before the movement cue (M = 827 ms, SE = 16.5) than when a response-incompatible word was processed (M = 837 ms, SE = 17.3), $t(47) = –2.56$, $p < .05$. When the presentation of the word was linked to the double button press, however, the reaction times were not reliably influenced by the processing of a congruent (M = 827 ms, SE = 14.0) versus incongruent word valence (M = 827 ms, SE = 13.8; $t < 1$).

Discussion

Experiment 3 investigated the time course of action-valence blindness by presenting the to-be-evaluated word either before or during action planning. Results showed that evaluative sensitivity (d') toward response-compatible stimuli was reduced when the word presentation was linked to a double button press that indicated a response readiness (word after cue) but not when the valenced word was presented before the arrival of the movement

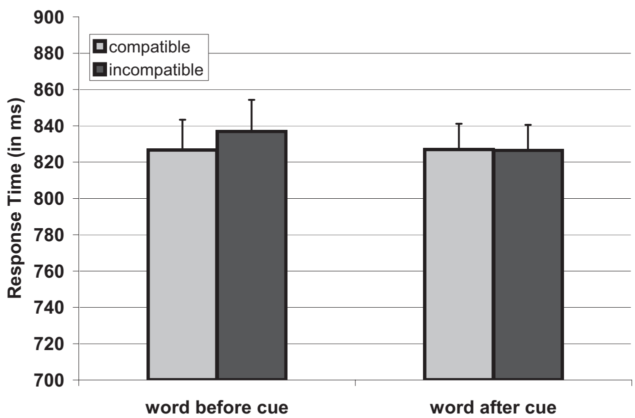

Figure 6. Influence of response-compatible, response-incompatible, and neutral words on lever movement speed in Experiment 3. Error bars indicate the standard error.

cue (word before cue). This result pattern corroborates that a temporal overlap between action planning and stimulus evaluation is necessary for action-valence blindness and supports the assumption that an action episode, once established, blocks perceptual processes from simultaneously accessing its codes.[5] In addition, the results also rule out a memory-based explanation that attributes action-valence blindness to a failure in the retention of similarly valenced items in short-term memory. Such a retention failure should have increased with the retention interval that was considerably longer in the advance presentation condition (word before cue) than in the simultaneous presentation condition (word after cue); this expectation was clearly not supported by the data, suggesting that action-valence blindness is due to a difficulty in valence discrimination rather than to a failure in the retention of similarly valenced items during action planning (see also Wühr & Müsseler, 2001).

Another main finding of Experiment 3 was an affective S–R compatibility effect in the speed of the lever movements: Participants selected compatible lever movements faster than incompatible lever movements when the word evaluation preceded the movement cue by a short time period. This observation is consistent with the expectation of a compatibility benefit in the activation stage of movement planning. Movement planning should benefit from increased activation of (not yet integrated) common valence codes in congruent trials, but not in incompatible trials. Note, in addition, that the joint observations of S–R and R–S compatibility effects within a single task setup provide strong evidence for an evaluation–behavior link, which is, to our knowledge, the first demonstration of a bidirectional coupling between affective stimuli and approach and avoidance reactions using the same sets of stimuli and responses.

General Discussion

Theories on the bidirectional evaluation–behavior link are faced with two explanatory problems: First, how are stimulus evaluations translated into motor reactions and motor behaviors into evaluations (*bidirectional translation problem*)? And second, why is this translation process more effective for certain evaluation–behavior combinations than for others (*evaluation–behavior compatibility problem*)? In this article, we evaluated a motivational account and a common-coding account with respect to the answers to these questions. In a dual-task setup, evaluations of masked positive and negative stimuli were required during the generation of approach and avoidance reactions. The motivational account of the evaluation–behavior link predicted improved identification of response-compatible stimulus valences due to motivationally induced processing preparedness. The common-coding account in combination with the idea of feature integration, in contrast, predicted impaired identification of response-compatible affective stimuli at some time intervals due to encapsulation of common valence codes in the course of affective action planning. The results of three experiments unequivocally supported the common-coding model.

In Experiment 1, the valence of a positive stimulus was harder to detect during the execution of an approach reaction (lever pull) than during the execution of an avoidance reaction (lever push) and vice versa for the valence of negative stimuli. This action-valence blindness effect was replicated in Experiment 2 with movement instructions toward (lever pull) and away (lever push) from the body, but the influence of the lever movements on the stimulus evaluations was reversed when these movements were instructed as a downward lever pull and an upward lever push that bear an opposite evaluative meaning (see also Eder & Rothermund, 2008). This shows that participants were "blinded" by a congruent evaluative meaning of the instructed response labels (toward and upward with a positive meaning, away and downward with a negative meaning) rather than by features of the movements themselves. Experiment 3 finally revealed that action-valence blindness depends on a temporal overlap between movement generation and stimulus evaluation: Stimulus evaluation was selectively impaired when the stimulus was presented during action planning but not when the stimulus appeared before movement preparation. This result pattern refutes a memory-based explanation in which action-valence blindness is attributed to a failure in the retention of similarly valenced items in short-term memory; instead, the results support an explanation by means of motor-induced difficulties in the evaluative discrimination of compatible stimuli. Taken together, the observed action-valence blindness provides distinctive support for the claim that evaluative motor codings interfere with evaluative stimulus codings when both require the episodical binding of a shared valence code in a common representational domain. Action-valence blindness effects, however, contradict motivational accounts that assume facilitated processing of (motivationally) congruent pieces of information during the generation of approach and avoidance movements.

[5] On the basis of the activation–integration model of the event-coding process, one might have expected improved identification of response-compatible words at the onset of movement preparation (word before cue). However, such an activation benefit was unlikely in our task procedure for two reasons: (a) Evaluative word processing had already progressed at the time of the arrival of the movement cue (57 ms stimulus onset asynchrony [SOA] plus movement cue-decoding time), and (b) backward affective priming has been shown to be extremely fleeting (Fockenberg, Koole, & Semin, 2006). Thus, the task procedure was not optimized for the detection of activation benefits in the processing of response-compatible stimuli.

The common-coding account explains interactions between evaluative stimulus and response attributes via valence codes shared in a common representational domain. Valence codes referring to stimulus- and response-related episodes are assumed to directly interact with each other in a common representational area. This common representational domain might be located in a semantic space that represents the affective meaning of stimuli as well as of responses; in fact, Experiment 2 yielded strong evidence that participants were blinded by the evaluative meaning of the response label applied to steer the lever movement, rather than by the physical features of flexing and extending arm movements (see also Eder & Rothermund, 2008). This might suggest that any activation of evaluative knowledge without any reference to perceptual and motor events is already sufficient to produce specific processing impairments. For several reasons, however, we doubt that our result pattern can be fully explained without taking action-specific processes into account. First, cognitive and neuroscientific research on action control has accumulated much evidence that conceptual action knowledge used to organize goal-directed movements becomes an integral part of these motor representations (e.g., Barsalou, 2002; De Houwer, 2004; Gerlach, Law, & Paulson, 2002; Glenberg & Kaschak, 2002; Kray, Eenshuistra, Kerstner, Weidema, & Hommel, 2006; Lindemann, Stenneken, van Schie, & Bekkering, 2006; Tranel, Kemmerer, Adolphs, Damasio, & Damasio, 2003; Wenke & Frensch, 2005). In line with this research, Eder and Rothermund (2008) showed that an evaluative congruency relation between affective stimuli and written response label words (*toward* and *away*) systematically influenced the selection of pushing and pulling lever movements that enacted the written response label words, but not a selection between left and right lever movements that were unrelated to the meaning of these labels. Thus, correspondence between affective stimuli and response labels on a purely symbolic level was not sufficient to engender affective congruency effects. Second, research on action-induced blindness toward spatially compatible stimuli yielded clear-cut evidence for a response-related contribution to the perceptual impairment (Hommel & Müsseler, 2006; Müsseler et al., 2000; Oriet et al., 2007). One study (Stevanovski et al., 2006), for instance, examined the impact of adding or removing an overt response on the size of the blindness effect. A series of experiments revealed larger blindness effects in the presence of an overt response than in the absence of an overt response. This result suggests that action planning makes a distinctive contribution to the blindness effect over and above an effect produced by short-lived symbolic activations. In sum, there are strong reasons to believe in a semantic–evaluative activation that is closely tied to action preparation processes and that interacts with stimulus evaluations in a common representational area.

Affective Response–Stimulus Correspondence: Beneficial or Detrimental?

The present experiments repeatedly produced a detrimental influence of approach and avoidance reactions on the identification of response-compatible affective stimuli: The valence of stimuli was less easy to discriminate during the execution of compatible approach and avoidance reactions than during the execution of incompatible reactions. This action-valence blindness is in line with cognitive research that has revealed analogous impairments in the perception of response-compatible spatial stimulus features. However, it appears to be at odds with several studies that have demonstrated "beneficial" effects of approach and avoidance reactions on the processing of compatible affective stimuli. How can this discrepancy be explained?

First, previous studies investigating motor effects on stimulus evaluations employed static arm positions of flexion and extension known from isometric exercises to manipulate approach and avoidance states; in our experiments, however, dynamic pushing and pulling lever movements were used to operationalize approach and avoidance. It is possible that static arm flexion and extension engage the motor system differently than lever movements that are more typical for dynamic approach and avoidance reactions. For instance, it is possible that for the maintenance of static arm positions an action representation is formed once, at the start of the motor task, and then transferred into long-term memory for later use. The stored motor program is then retrieved from long-term memory, when needed, making a (re)binding of action-related features dispensable. Note, however, that systematic research into the motor control of static arm positions is scarce, making it difficult to derive precise hypotheses for this motor area.

Second, different research paradigms might involve different processes that contribute to motor effects on stimulus evaluations in different ways. For instance, Centerbar and Clore (2006) observed more positive evaluations of mildly positive *and* negative stimuli during the maintenance of congruent arm positions. The authors explained this result with a hedonically marked processing fluency that arises from "matching" action–stimulus combinations (see also Cretenet & Dru, 2004). Other studies (Briñol & Petty, 2003; Tamir, Robinson, Clore, Martin, & Whitaker, 2004) showed that the influence of head shakes and nods on evaluative judgments is context dependent and moderated by the subjective meaning of the behavioral expression in the judgment task. In short, it is likely that several mechanisms moderate the relationship between motor behaviors and evaluative appraisals, with their contributions varying across different paradigms.

Third, a number of studies have claimed improved processing of response-compatible affective stimuli, even though the empirical results are consistent with an alternative interpretation in line with action-valence blindness. Gawronski et al. (2005), for instance, observed less detrimental effects of response-compatible relative to response-incompatible affective distracter stimuli on the memorization of meaningless stimuli or on secondary task performance. Given these results, the authors concluded that "the stronger attention grabbing power of orientation-incongruent stimuli results from the higher amount of attentional capacity required to encode these stimuli" (p. 192). The present findings, however, suggest an alternative interpretation: the distracting influence of response-compatible stimuli was reduced due to impaired processing of these stimuli, to the benefit of secondary task performance. In fact, without additional cost–benefit analyses it is not possible to decide whether the facilitatory effect of response-compatible stimuli was due to more effortful encoding of response-incompatible stimuli or, alternatively, to impaired processing of response-compatible distracters. Note that cost–benefit analyses of motor-induced blindness effects so far yielded only evidence for an R–S compatibility cost but not for a benefit of an R–S incompatibility (Müsseler et al., 2001; Oriet et al., 2003).

There is, however, one finding in the present experiments that closely resembles previous results indicating an assimilative motor bias on evaluative judgments. In all three experiments, neutral consonant strings were more often interpreted as "positive" in meaning after the execution of an approach reaction and "negative" after the execution of an avoidance response than vice versa (see comparisons of c_{pull} and c_{push} in Experiments 1–3). This action-induced judgment bias conceptually replicates previous findings that participants evaluate meaningless stimuli (e.g., Chinese ideographs for non-Chinese-reading participants) more positively when viewed during arm flexion than during arm extension (e.g., Cacioppo et al., 1993), with the main difference being that in our experiments the participants were not aware of the neutral stimulus presentations.[6] In other words, participants assimilated evaluative judgments to the valence of a foregoing motor reaction in the absence of an evaluative signal, "creating" more positive evaluations after approach behaviors and more negative evaluations after avoidance behaviors. An action-induced assimilative response bias might also explain faster classifications of positive and negative stimuli in congruent behavioral positions of approach and avoidance than in incongruent body positions (Neumann & Strack, 2000, Experiment 1). In fact, assimilative consequences of an affective action–stimulus correspondence have been shown exclusively in processing tasks that either (a) lack right–wrong responses (e.g., evaluative ratings or valenced item generations; Cacioppo et al., 1993; Förster & Strack, 1997, 1998; Priester et al., 1996) or (b) require very quick evaluative responses (e.g., speeded evaluative decisions; Neumann & Strack, 2000). Such task settings might foster the adoption of a more lenient and malleable response criterion susceptible to motor-induced evaluative activations, masking concomitant changes in the evaluative sensitivity toward presented stimuli. Thus, both perceptual changes as well as action-induced response bias can be parsimoniously explained in terms of enhanced activation level of (integrated) affective feature codes in the course of action planning.

Another theoretically interesting possibility is that task-defined processing goals produce changes in evaluative sensitivity as well. In processing tasks with an emphasis on very quick evaluative responses or on "intuitive" evaluative impressions, participants may not attempt to discriminate the source of evaluative activations in selecting an appropriate response, and combined activations of similar (i.e., compatible) evaluative information stemming from different sources (such as an action and a target stimulus) might result in a stronger evaluative signal than combinations of dissimilar (i.e., incompatible) evaluative activations. In our action-valence blindness experiments, however, participants were explicitly urged to identify the valence of masked target stimuli correctly without time pressure. Here, a discrimination of the evaluative target information from distracting (motor-derived) evaluative information was necessary, and the selection against a similar (i.e., compatible) evaluative background was more difficult than the selection against a dissimilar (i.e., incompatible) evaluative background. Taken together, differential emphasis on discriminating the source of evaluative activation (and hence event segregation) might explain why, ceteris paribus, compatible evaluative signals are facilitatory in one task context and detrimental in another task context. Consistent with this idea, a number of studies have shown that accuracy versus speed demands moderate beneficial and detrimental effects of similar (i.e., compatible) information on task performance in evaluative (Glaser, 2003; Wentura, 1999; Wentura & Rothermund, 2003) and cognitive tasks (e.g., Bavelier, Deruelle, & Proksch, 2000; Grosjean, 2001; Miller & Bauer, 1981; Milliken, Joordens, Merikle, & Seiffert, 1998). Note that accuracy and speed demands refer here to end poles on a continuum rather than to discrete processing modes, and a variety of factors beside blatant task instructions might produce transient, intraindividual shifts on this continuum (e.g., temporal prime–target separation, distracter salience, response conflict) as well as more enduring interindividual differences (e.g., chronic accuracy motivation).

In sum, event-coding processes, grounded in a common-coding representation, are able to account for beneficial as well as detrimental effects of affective action–stimulus correspondence. As a result of being represented in a common code, affective stimuli prime responses with a congruent evaluative meaning, and evaluative attributes of motor actions prime congruent evaluative meanings of stimuli. Enhanced activation of shared valence codes might bear an advantage in contexts that require fast and undifferentiated responses to environmental stimuli; however, it might be disadvantageous in limited processing conditions that require a segregation of the evaluative flow into distinct episodic representations (leading to binding conflicts). Hence, both effects can be viewed as consequences of a distributed feature coding in the human brain that represents perceptual as well as motor events in a common set of codes, including their affective features.

Common Valence Coding in Action and Evaluation: The Role of Motivation

An affective extension of the TEC explains affective compatibility effects between perceptual and motor events by means of code overlap in a common representational domain. Code overlap is beneficial when the evaluative code is activated but not yet integrated into an episodical structure; in contrast, it produces costs when the shared affective code has already been bound to a perceptual or motor "event file." Thus, a common access of motor and perceptual representations to valence codes sufficiently accounts for mutual interactions between these representations, provided that processes of event formation are engaged. The idea of a common valence coding does not, however, explain where behavior and evaluative meaning originally derive from (i.e., the causes of events). These processes are beyond its explanatory scope, and in our view it is here where motivational forces are at work.

In our experiments, participants were instructed to evaluate briefly flashed words during the generation of lever movements. Thus, it was the participants' compliance with the task instructions that "motivated" the generation of perceptual and motor events. Without this motivation, action plans that occupy valence codes would not have been formed. Motivation is also required to explain

[6] In Experiments 2 and 3, participants were asked in postexperimental questions whether they noticed any stimuli that were presented near the perceptual threshold and whether they believed that a word was presented in every experimental trial (yes/no). Only 29 out of 80 and 13 out of 40 participants in Experiments 2 and 3, respectively, did not believe that a target word was presented in every trial. None of the participants mentioned consonant strings or other meaningless items in their answers to these questions.

the "good" versus "bad" meaning of events. For instance, a positive coding of "moving the lever toward the body" might be motivationally grounded because bringing things toward oneself might be more often linked with positively appraised consequences than with negative ones (cf. Neumann & Strack, 2000). The positive and negative connotation of "upward" and "downward" movements, respectively, might be similarly grounded in affective experiences (Meier & Robinson, 2004; Stepper & Strack, 1993). Thus, motivational factors are needed to explain the formation of perceptual and motor representations as well as their evaluative contents. Such "hot" codings might then be relayed to a "cold" common-coding domain, setting up a correspondence relation between evaluative stimulus and response properties that allows for direct and automatic interaction without further motivational mediation.

Conclusions

Theories on the bidirectional evaluation–behavior link have to explain (a) bidirectional evaluation–behavior translations and (b) compatibility phenomena between stimulus evaluations and motor behaviors. We proposed a common-coding solution to these problems that capitalizes on a commensurable format of stimulus and response representations: Evaluative attributes of stimuli and responses prime each other in a common-coding domain, enhancing the activation level of evaluatively congruent features in this coding space. However, once activated valence codes were integrated into an event file, access to them is blocked. The latter hypothesis of an impaired access to response-compatible stimuli (i.e., a compatibility disadvantage) was tested in a series of experiments that demanded evaluations of masked positive and negative stimuli during the generation of approach- and avoidance-related lever movements. In all experiments, evaluative sensitivity (d') was reduced for response-compatible stimuli relative to response-incompatible stimuli. This action-valence blindness conceptually replicates analogous interference effects in the cognitive domain, and it was shown to depend on the evaluative meaning of the prepared responses (Experiment 2) and on temporal action–evaluation overlap (Experiment 3). Impaired discrimination of response-compatible affective stimuli challenges motivational accounts of the evaluation–behavior link according to which broad motivational orientations of approach and avoidance mediate between evaluation and behavior. As an alternative, we suggested a common-coding interface that operates on motivated codings of stimuli and responses. Hence, motivation might determine what representations enter the common-coding domain but not how these representations influence each other within and across perceptual and motor domains.

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Appendix A

Word Material

Words used in Experiments 1, 2, and 3 are indicated by the superscripts a, b, and c, respectively.

Positive words. achtsam [attentive][bc], angenehm [comfortable][bc], anziehend [appealing][abc], befähigt [competent][bc], begabt [talented][c], belesen [literate][bc], beliebt [popular][bc], charmant [charming][bc], dankbar [thankful][bc], denkfähig [cogitative][bc], ehrlich [honest][c], engagiert [committed][abc], entspannt [relaxed][a], fair [fair][c], findig [resourceful][bc], fleiβig [diligent][c], flexibel [flexible][c], freimütig [frank][bc], freudig [joyful][bc], friedlich [peaceful][bc], fröhlich [happy][c], gebildet [educated][c], geduldig [patient][c], gefällig [complaisant][bc], geistvoll [brilliant][ac], gelassen [calm][bc], gelehrig [teachable][bc], gemütlich [comfortable][bc], gerecht [just][c], gesellig [companionable][a], gesittet [civilized][bc], gewitzt [shrewd][bc], groβmütig [noble][bc], grundgut [thoroughly good][bc], gütig [benevolent][bc], herzlich [cordial][bc], human [humane][bc], humorvoll [humorous][a], korrekt [accurate][bc], kreativ [creative][c], liebevoll [affectionate][bc], loyal [loyal][bc], milde [benign][bc], musisch [musical][bc], nett [nice][bc], optimal [ideal][bc], originell [fancy][ac], praktisch [convenient][bc], redlich [candid][bc], reinlich [tidy][bc], sachlich [objective][bc], sanft [gentle][bc], sensibel [sensitive][abc], sinnlich [sensual][a], sonnig [sunny][bc], sorgsam [careful][bc], spendabel [generous][b], standhaft [firm][c], taktvoll [tactful][bc], tolerant [tolerant][ac], treu [trusty][bc], vergnügt [cheery][ac], verliebt [enamored][a], weich [mild][b], witzig [witty][bc], zart [tender][bc], zärtlich [caressing][bc].

Negative words. abgebrüht [hard-nosed][b], abhängig [addicted][c], abweisend [abrasive][abc], aggressiv [aggressive][bc], anmaβend [presumptuous][abc], arglistig [dissembling][bc], arrogant [arrogant][b], barsch [harsh][bc], beklommen [apprehensive][ac], bockig [recalcitrant][bc], bösartig [malignant][bc], böse [evil][bc], boshaft [malicious][bc], brutal [brutal][bc], dumm [stupid][c], eitel [vain][bc], ekelhaft [disgusting][a], entmutigt [crestfallen][bc], fanatisch [fanatic][bc], furchtbar [dreadful][bc], gefühllos [dead-hearted][bc], gehässig [spiteful][bc], geizig [stingy][c], gemein [nasty][c], gierig [greedy][bc], giftig [noxious][bc], grausam [atrocious][c], grimmig [grim][bc], habgierig [possessive][c], hart [hard][b], herrisch [bossy][abc], herzlos [heartless][c], hochmütig [snobbish][bc], hochnäsig [sniffy][bc], jähzornig [irascible][bc], kalt [cold][bc], kaputt [broken][bc], knauserig [miserly][bc], knickerig [cheeseparing][b], korrupt [corrupt][c], krittelig [faultfinding][b], kühl [chilly][bc], langsam [tardy][c], lästig [annoying][bc], launisch [capricious][bc], lieblos [loveless][c], monoton [monotonous][c], neidisch [envious][ac], nervös [nervous][bc], peinlich [embarrassing][bc], penibel [fussy][bc], rüde [rude][c], schlampig [sloppy][ac], schlecht [bad][bc], schmutzig [filthy][bc], schuldig [guilty][bc], starr [rigid][bc], teuer [expensive][bc], tödlich [deathly][bc], träge [sluggish][c], traurig [sad][bc], unehrlich [dishonest][a], untertan [tributary][c], verbissen [stubborn][bc], verlogen [dishonest][ac], widerlich [abhorrent][a], willenlos [abulic][a], zänkisch [quarrelsome][bc], zwanghaft [obsessive][a], zynisch [cynical][bc].

Appendix B

Analyses of the Proportion Correct Identification

Experiment 1. For each participant, the percentages of correct valence identifications were determined for each movement–word combination and subjected to a repeated-measures analysis of variance (ANOVA) with word valence (positive vs. negative) and movement–word compatibility (compatible: pull–positive, push–negative vs. incompatible: pull–negative, push–positive) as within-participants factors. The analysis revealed better identification of positive words (M = 71.1%, SE = 1.6) than of negative words (M = 66.5%, SE = 1.2), $F(1, 39) = 5.22$, $p < .05$. The main effect of movement–word compatibility ($M_{compatible}$ = 69.2%, SE = 1.2; $M_{incompatible}$ = 68.4%, SE = 1.2; $F < 1$) and the interaction, $F(1, 39) = 1.63$, $p > .20$, were not significant.

Experiment 2. A mixed ANOVA with instruction group (toward/away vs. up/down) as a between-participants factor and word valence and movement–word compatibility as within-participants factors revealed better identification of the valence of negative words (M = 71.5%, SE = 0.7) than of positive words (M = 67.8%, SE = 0.7), $F(1, 78) = 10.6$, $p < .01$. The main effects of instruction group, $F(1, 78) = 2.21$, $p = .14$, and movement–word compatibility ($M_{compatible}$ = 70.1%, SE = 0.6; $M_{incompatible}$ = 69.2%, SE = 0.7), $F(1, 78) = 1.09$, $p = .30$, and the interactions were not significant (with all $ps > .10$).

Experiment 3. A repeated-measures ANOVA with word valence (positive vs. negative), movement–word compatibility, and presentation condition (word before cue vs. word after cue) revealed a significant main effect of presentation condition: Identification of positive and negative adjectives that were presented before the response cue (M = 64.2%, SE = 0.7) was markedly worse than valence identification of words presented after the cue (M = 74.8%, SE = 0.8), $F(1, 47) = 124.3$, $p < .001$. The main effect of movement–word compatibility also reached significance, with more correct identifications of response-compatible words (M = 70.5%, SE = 0.7) than of response-incompatible words (M = 68.4%, SE = 0.7), $F(1, 47) = 6.8$, $p < .05$. The interactions between both factors and all other effects were not significant (with all $ps > .20$).

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