

Affect and action: Towards an event-coding account

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Viewing emotion from an evolutionary perspective, researchers have argued that simple responses to affective stimuli can be triggered without mediation of cognitive processes. Indeed, findings suggest that positively and negatively valenced stimuli trigger approach and avoidance movements automatically. However, affective stimulus–response compatibility phenomena share so many central characteristics with nonaffective stimulus–response compatibility phenomena that one may doubt whether the underlying mechanisms differ. We suggest an “affectively enriched” version of the theory of event coding (TEC) that is able to account for both affective and nonaffective compatibility, and that can account for the observation that both types of compatibility seem to be modulated by goals and intentions. Predictions from the model are tested in an experiment where participants carried out approach and avoidance responses to either the valence or the orientation of emotionally charged pictures. Under affective instruction the positive-approach/negative-avoid mapping yielded faster responses than the positive-avoid/negative-approach mapping, but no such effect was observed under spatial instruction. Conversely, spatial compatibility effects were obtained under spatial, but not under affective instruction. We conclude that affective and nonaffective compatibility effects reflect the same mechanism.

INTRODUCTION

In the early 1980s, Robert Zajonc (1980, 1984) launched a devastating attack on the then prevalent view in cognitive psychology that cognitive processes are a necessary precursor to affect. Zajonc drew attention to the effortless and inescapable nature of affective (overt or covert) responses, arguing that evaluations can be elicited automatically, without mediation of cognitive processes or conscious awareness (see Lazarus, 1982, 1984, for a cognitivistic reply). The idea that affective processes can be triggered automatically gains much in plausibility when viewed from an evolutionary perspective (LeDoux, 1996; Öhman, Flykt, & Lundqvist, 2000, Zajonc, 1980). The

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evolutionary perspective on affect contends that humans are endowed with a primitive set of wired-in basic affective responses. Environmental stimuli that proved to be dangerous or valuable to our ancestors are systematically linked to certain behavioural responses (e.g., fleeing from a predator or approaching food).

Adopting an evolutionary perspective, neuroscientists such as LeDoux (1996) and Damasio (1999) have argued that emotions did not evolve as conscious feelings but, rather, as adaptive bodily responses controlled by the brain. According to LeDoux (1996), “the basic building blocks of emotions are neural systems that mediate behavioral interactions with the environment, particularly behaviors that take care of fundamental problems of survival” (p. 125). Building on extensive research on fear conditioning, LeDoux (1996) proposed two separate neural pathways mediating between sensory stimuli and affective responses. First, there is a subcortical pathway that transmits emotional stimuli directly to the amygdala, a brain structure that regulates behavioural, autonomic and endocrine responses by way of connections to the brain stem. This “low road” bypasses higher cortical areas believed to be involved in cognition and consciousness. It is this processing route that allows us to withdraw our hand from fire and to shrink back from a snake long before we have realised that we are in danger. Operating in parallel with the subcortical pathway, there is a second pathway to the amygdala that passes through the higher cortical areas. Although (or because) this “high road” allows for much more fine-grained processing of stimuli than the subcortical pathway, it has one major drawback: it is much slower. The existence of a subcortical pathway allows the amygdala to detect environmental stimuli relevant to survival very rapidly. This constitutes a significant evolutionary advantage—woe to the person who has to engage in a fine-grained, time-consuming cognitive analysis when faced with a hungry predator.

Affective response priming

The essence of LeDoux’s dual-pathway model is that humans are equipped to respond automatically to certain positively and negatively valenced stimuli before consciously knowing what these stimuli actually are. In a similar vein, Bradley and Lang (2000) suggest that emotions evolved from simple reflexive reactions. These primitive affective responses can be organised into two broad classes: approach movements towards positive, appetitive stimuli and avoidance movements away from negative, aversive stimuli (see also Bradley, Codispoti, Cuthbert, & Lang, 2001). An experiment conducted by Chen and Bargh (1999), Experiment 1; see also Solarz, 1960) suggested indeed that affective stimuli automatically activate corresponding action tendencies. Chen and Bargh instructed participants to

evaluate a target word by moving a lever either toward their body or away from it, depending on the valence of the word. Participants were faster to respond to positively valenced words when pulling a lever toward them (which the authors interpreted as approach) than when pushing it away (avoidance). For negatively valenced words, the pattern was reversed: participants were faster to respond when pushing the lever than when pulling it. This suggests that positively valenced stimuli prime approach responses whereas negatively valenced stimuli prime avoidance responses.¹

Even though Chen and Bargh's observations seemed to support the assumption of a fully automatic impact of affective stimuli on behaviour, later studies have suggested that this impact might be mediated by the intentions and goals of the acting individual. For instance, Klauer and Musch (2002) compared the effects of affective and nonaffective priming under evaluative and nonevaluative task goals. Affective decisions were primed by affective prime words and nonaffective decisions (e.g., colour judgements or letter-case comparisons) were primed by nonaffective primes (same colour or case). However, there was no evidence of affective priming across tasks, hence, nonaffective decisions were not primed by affective relations between the target word and a previous prime word. This observation suggests that the valence of words may not be processed as automatically as previously thought. One may object that processing words draws on rather higher cognitive processes, which are unlikely to tap into the fast and frugal low-level routes envisioned by Zajonc or LeDoux. Hence, verbal material may not be ideal for testing the automatic route from affect to behaviour. This argument also applies to a recent study by Markman and Brendl (2005). These authors demonstrated that people are faster to move positive words towards their name than away from their name, regardless of whether this response required a movement away from their body or towards their body. Even though this finding undermines Chen and Bargh's (1999) claim that positive and negative words activate particular movements automatically, the use of verbal material may well have biased the processing towards higher-level mechanisms. If the low route treats music from the Beatles and the Stones alike (to use an example of LeDoux, 1996), there is little reason to believe that it can discriminate between displays of the words "good" and "bad". Hence, the available evidence points to a critical role of goals and intentions, but the stimulus material used may have been inappropriate to allow for a fair test of the automaticity hypothesis.

¹ While some authors interpret stimulus–response mapping effects as reported by Chen and Bargh (1999) in terms of response conflict (Klinger, Burton, & Pitts, 2000), others have challenged this interpretation (Neumann, Förster, & Strack, 2003). We will get back to this issue below and suggest a solution to this apparent disagreement.

Better suited than words would seem stimuli with high ecological significance, such as human faces. Consistent with this reasoning, Rotteveel and Phaf (2004) presented subjects with facial expressions of positive and negative emotions and had them respond to either the valence of the expressed emotion (evaluative goal) or to the gender of the depicted person (nonevaluative goal) by flexing or extending their arms. As in studies with verbal material, response priming was found under the evaluative goal (where positive and negative emotions primed arm flexions and extensions, respectively) but not under the nonevaluative goal. However, even though this is encouraging, faces may not be ideal stimuli either. Indeed, while they are certainly of high ecological significance, it makes little evolutionary sense to approach or avoid the faces expressing particular emotions, rather than the events these emotions refer to. If so, it seems unlikely that dedicated processing routes developed for the fast translation of face information into manual action.

To summarise, preliminary evidence suggests that affective stimuli may prime approach and avoidance tendencies but that these priming effects might be less automatic than originally thought. However, it remains to be seen whether intentional modulation of affect–response coupling can be demonstrated with stimuli that are more plausibly related to approach and avoidance tendencies than those used hitherto.

Multiple routes in affective and nonaffective processing

Zajonc (1980), LeDoux (1996) and others have treated the processing of affective information as fundamentally different from the processing of other, nonaffective information, such as shape, colour, or location. On the one hand, this distinction might be taken to have some intuitive plausibility, as the dangerousness of a snake seems so much more important than whether it is green or yellow, apart from the fact that dangerousness just feels so different from green. On the other hand, however, it is interesting to realise that the models of affective and nonaffective processing share quite a number of architectural features. In particular, the way researchers have characterised the relation between affect and action closely resembles the way (non-affective) perception and action have been related in recent approaches (see Prinz & Hömml, 2002, for an overview). Let us consider the three most pertinent similarities.

First, the distinction between a slow, consciously and/or intentionally mediated processing stream that takes care of the controlled translation of stimulus information into appropriate actions and a fast (more or less) unmediated processing stream that activates response tendencies linked to, or congruent with, the present stimulus is not restricted to models of affective processing (such as those of Damasio, 1994; LeDoux, 1996;

Zajonc, 1980) but commonplace in approaches of perception–action coupling (e.g., De Jong, Liang, & Lauber, 1994; Hommel, 1993a; Kornblum, Hasbroucq, & Osman, 1990; Milner & Goodale, 1995; see Hommel, 2000, for an overview). As in affective theories, cognitive theories assume that the latter processing stream is more stimulus dependent and more difficult to control than the former.

Second, with respect to both affective and nonaffective processing, the available evidence suggests that the fast routes are (1) automatic in the sense that they process information that is not necessary for performing the task at hand but at the same time (2) intentional in the sense that they seem to be enabled by the current task goal. As indicated earlier, one may argue that the stimulus material used up to now does not provide a fair test of the automaticity hypothesis, but there are a number of preliminary indications that the fast route from affect to action is modulated by goals. A good example for the nonaffective processing domain is the Simon effect (Simon, 1969). This effect is observed if people give spatial responses to a nonspatial feature of a stimulus that varies randomly in location. For instance, assume that left and right key presses are carried out in response to the red or green colour of a stimulus that appears on the left or right of a display. Even though stimulus location is irrelevant to the task, subjects are commonly faster if stimulus and response spatially correspond, hence, if the stimulus appears on the side where the correct response key is located. Almost all models assume that stimulus location automatically primes the spatially corresponding response, which is beneficial if this is the correct response but interfering if this response is incorrect. Consistent with this assumption, presenting a stimulus has been demonstrated to activate the corresponding response up to the level of an (electrophysiologically measured) lateralised readiness potential, even if (in noncorresponding trials) this potential is later replaced by the potential of the actually correct response (Sommer, Leuthold, & Hermanutz, 1993). Even though this may be taken to demonstrate a strong form of automaticity, the priming of the corresponding response is only observed if subjects have implemented the instructed stimulus–response rules and are ready to go, but not if they are presented with a lateralised stimulus while awaiting the presentation of these rules (Valle-Inclán & Redondo, 1998). These observations seem to fit with the claims of Klauer and Musch (2002), Rotteveel and Phaf (2004), and Markman and Brendl (2005), that “automatic” stimulus–response translation is not independent of intentions. Thus, studies of both affective and nonaffective processing suggest that intentional processes set the stage for automatic stimulus–response translation (Bargh, 1989): The translation as such is automatic, but this automaticity is achieved only by virtue of the intentional implementation of the relevant task set—a kind of cognitively prepared reflex (Hommel, 2000).

Third, affective and nonaffective codes have been attributed very similar roles in decision making and action control (Hommel & Elsner, in press). According to the ideomotor principle developed by Lotze (1852), James (1890), and others (see Stock & Stock, 2004, for an overview), actions are represented by codes of their anticipated effects. Considering the human brain's preference for coding events in a distributed, feature-based fashion, this means that action plans are cognitively represented in terms of distributed codes of their perceived features (Hommel, 1997, 2006). The idea is that movement patterns and the perceptual (i.e., re-afferent) effects it produces are integrated and stored automatically as an infant develops or an adult gains expertise. For instance, an infant may at first grasp an object by accident but then store the grasping movement together with the feel and sight of the object. If it later wants to grasp the object again, it only needs to "think of" the intended action effect (the haptic feeling of the grasped object, say) and thereby primes the now associated movement pattern (Elsner & Hommel, 2001). This means that the perceptual representation of the action effect has now become a retrieval cue for the action and thus can be used to select the currently most appropriate or effective action, that is, the action effect that matches the action goal best. The same function has been attributed to affective codes only recently by Damasio (1994). He claims that the affective consequences of actions are stored together with the actions that produced them. This renders the representations of these consequences "somatic markers" of the action, so that actions can be selected on the basis of what affective state they are likely to create. Obviously, this is a mere extension of Jamesian ideomotor theorising, and one may indeed ask whether there is any logical or conceptual reason to separate perceptual and affective action effects.

In sum, recent research on human affect–action relationships leads to very similar conclusions as research on perception–action coupling. We suggest that this is no coincidence and more surprising from the common phenomenological point of view (focusing on perceptual vs. affective experience) than from an evolutionary approach. That is, even though perceptual experiences may "feel" very different from affective experiences, the processes underlying these experiences may be comparable. Indeed, the brain architectures for processing perceptual stimuli and affective stimuli are likely to have emerged from the same selection pressure: (1) in both cases general information about a new event (such as an approaching animal) needs to be available very quickly, so that the organism can decide in time whether approach or avoidance is more appropriate; this requires information about both affective significance (e.g., does the animal represent a threat?) and perceivable action implications or affordances (where can I go to approach or escape it?); (2) in both cases the information can be coarse, as it is only the general class of action that needs to be decided upon very

quickly—more subtle behavioural strategies (e.g., in which way to approach) can take more time; (3) what counts in both cases is overt action rather than mental experience (escaping a threat is more important for survival than feeling bad), which suggests that, if there is automatic processing, it should access action control directly.

All these shared processing characteristics (fast, coarse, and action related) are important only for a very basic form of survival, however, and may well become partly dysfunctional in more socially organised societies and artificial environments. Accordingly, what is needed is another type of information processing, one that considers more subtle, context-dependent attributes (e.g., is this snake real or made of rubber?) and that allows for preplanning actions rather than relying on external stimuli. Again, however, this selection pressure towards another, more “reflecting” type of processing should affect perceptual and affective stimuli in comparable ways. Hence, from an evolutionary approach developing a dual-route processing architecture makes sense for both affective and nonaffective stimuli.

Affect as feature: An event-coding approach

If it is true that the affective coding of events and actions follows more or less the same principles as the nonaffective coding of perceptual and action events, it should be possible to account for affective and nonaffective stimulus–response interactions in comparable ways. Here we suggest extending the currently probably most comprehensive representational theory of perception and action, the theory of event coding (TEC; Hommel, Müsseler, Aschersleben, & Prinz, 2001), to the processing of affective events. We admit that our theorising is unlikely to account for the rich phenomenal flavour of true emotions, but we do think that it explains how the affective valence of events is computed and how affective codings of stimuli and responses interact to produce mapping effects of the type reported by Chen and Bargh (1999), Markman and Brendl (2005) and others.

TEC assumes that all stimuli and responses are coded in terms of their perceivable features, and that these features are associated with the motor patterns producing them. The basic building blocks of TEC thus consist of sensorimotor units, that can be further integrated into “event files” (Hommel, 1998). For instance, carrying out a speeded key press with the index finger of the right hand may lead to the coding of this action in terms of the features <right>, <right hand>, <index finger>, <fast>, and so on, with all these features being connected to the motor pattern moving the finger. If a stimulus is processed, this would also activate all the codes representing this stimulus’ features, such as <red>, <circular>, <fruit>, etc., in the case of a cherry. This provides a natural explanation for the Simon effect: If a stimulus appears on the right, it activates, among other things, the code <right>, which is also

shared by one of the possible responses. In other words, processing the stimulus leads to the priming (i.e., partial activation) of any other stimulus and response it shares features with. If this happens to include the correct response, which is true for corresponding trials, it can be carried out faster but if the incorrect response is primed, response conflict is created, the solution of which prolongs the eventual selection of the correct response (Hommel, 1997).

Even though TEC has been developed to account for all sorts of interactions between nonaffective stimulus and response events, its ideomotor heritage makes it easy to extend it to affective coding. According to ideomotor theorising a particular action is cognitively represented by codes that refer to how it feels to carry out that action, that is, to whatever perceptual experiences one has while performing it. Perceptual experiences by no means exclude experiences relating to the affective value of action-produced events. Indeed, James' (1884) own theory of emotion claims that emotions derive from the perceptual experiences one has while acting them out. Even though James' approach has often been interpreted as "peripheral" (cf. Cornelius, 1996)—only because it considers visceral and bodily processes as possible (peripheral) *sources* of affective experiences—close reading reveals that James is more concerned with the (central) *perception* of these processes rather than the processes themselves (see Barbalet, 1999; Ellsworth, 1994). Along these lines, an approach action might be represented not only by the kinaesthetic feeling of one's hand moving forward, the visual perception that it is the right hand and that it reaches towards an object, and the tactile experience when contact with the object is being made, but also by the positive feeling one has when processing the reward that commonly follows approach actions. This "feeling" is just another perception coded by a particular cell assembly, and there is no reason why this particular code (a "somatic marker" in the sense of Damasio, 1994) should not become part of the action's long-term representation.

Figure 1 shows how ideomotor theorising along the lines of TEC works in general and how it extends to affective codes (cf. Eder & Klauer, 2007 this issue). Let us begin with spatial compatibility, such as is operative in the Simon effect. Assume you are responding to a positively valenced picture that is rotated to the right by performing an approach movement with your right hand. The depicted little rabbit is coded as <white>, <furry>, and <small>, among other things. Given the picture's orientation the stimulus will also be coded as <right> and, given the heart-warming content, as positive (depicted as a smiley). The approach action might be coded as <towards>, as carried out by the <right hand>, which is a <body part>. Assuming hand-relative spatial coding (an issue we will get back to in a moment), the movement will also be coded as <right> and, given the frequent positive experience after carrying out approach movements, as positive. As shown in the figure, this stimulus–response combination creates

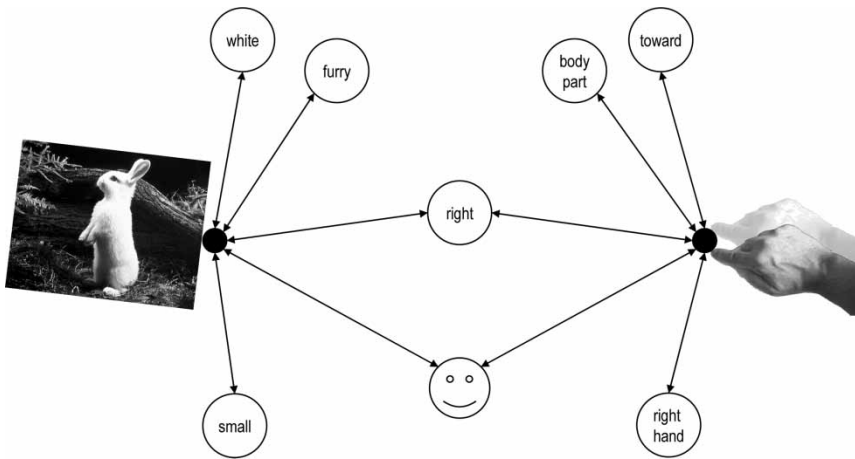


Figure 1. A cartoon model demonstrating how feature overlap between stimulus and response representations can mediate stimulus-induced response priming. The example shows a positively valenced, rightward rotated stimulus and a forward (approach) movement with the right hand. The smiley represents positive affect.

overlap with respect to two features: a spatial feature and the “affective” feature. Accordingly, processing the picture will prime the action in two ways, which should lead to benefit in comparison to a picture with negative valence and/or a left orientation. Along these lines, we cannot only account for Simon-type or other spatial or nonspatial stimulus–response compatibility effects, we can also account for the findings of Chen and Bargh (1999) and others.

Note that TEC attributes performance benefits and costs to conflict between cognitive representations of actions but not to interactions at the motor level. This has several theoretical advantages. First, it can explain why conflict can arise in tasks that comprise of only one response alternative (as in Chen & Bargh’s Experiment 2). As Neumann, Förster, and Strack (2003) have argued, response conflict at a motor level is not plausible to account for stimulus–response interactions in such tasks. However, even if an approach action is the only alternative in a given task, its features may still overlap with the features of the stimulus and thus can be primed as a consequence of that. Indeed, spatial stimulus–response compatibility effects have also been demonstrated with simple go responses and accounted for in terms of feature overlap (Hommel, 1996a).

Second, referring to cognitive response representations instead of the response’s physical realisation allows for considering top-down influences on these representations, that is, for interpretation. Consider, for instance, Chen and Bargh’s (1999) definition of approach and avoidance as lever

pulling and pushing, respectively. Pulling a lever involves flexing one's arm, which has been interpreted as typical for avoidance movements by other authors (Neumann et al., 2003). Hence, arm movements as such are ambiguous behavioural measures, since they can be defined either relative to the body of the actor or relative to an external object (cf. Markman & Brendl, 2005). Only the cognitive embedding into a particular frame of reference determines whether a given muscle movement is coded as approach or avoidance. Obviously, the same is true for spatial coding, which may refer to retinal, egocentric, allocentric, object- or effector-relative coding (cf. Hommel & Lippa, 1995).

Third, allowing for top-down influences on event representations also makes it easier to understand how action goals may modulate affective and nonaffective stimulus–response compatibility. TEC holds that perceiving a stimulus and planning an action does not involve all feature codes associated with that event to the same degree but mainly those codes that are related to the current action goal. Hence, the contribution of feature codes is “intentionally weighted” (Hommel et al., 2001). Intentional weighting is necessary to account for intentional effects, as demonstrated by Hommel (1993b). In his Simon study, subjects responded to the pitch of lateralised tones by pressing a left or right key. Each key flashed a light on the opposite side, that is, the left key flashed a light on the right side and the right key a light on the left side. When subjects were given a standard, key-related instruction (press left key to low pitch and right key to high pitch), a standard Simon effect was obtained: Subjects were faster if tone and key spatially corresponded. However, when subjects were instructed in terms of the visual action effects (flash right light to low pitch and left light to high pitch), the Simon effect completely reversed: Now subjects were faster if tone and key did not correspond! This means that the instruction must have changed the way the actions were cognitively represented. Along the lines of TEC, one can assume that each action was coded in terms of at least two opposite spatial codes: for instance, the left key press as <left>, because of the left hand and the left key involved, *and* as <right>, as it produced a light on the right. Receiving a key-related instruction was likely to weight the key-related codes more strongly, so that the two actions were more strongly represented in terms of key locations. In contrast, receiving a light-related instruction must have weighted light-related codes more strongly, so that the actions were coded in terms of light locations. In the former case, left key presses were thus primed by left stimuli but in the latter case the same left stimuli primed right key presses (Hommel, 1993b, 1996b). Along the same lines, it is easy to account for the stronger impact of features from goal-related stimulus dimensions as observed by Klauer and Musch (2002), Rotteveel and Phaf (2004), and others. Note that according to TEC,

the activation of task-irrelevant codes, and thus action priming, is both automatic and modulated by task goals at the same time.

To summarise, we suggest modelling affective and nonaffective stimulus–response compatibility effects in comparable ways and consider TEC a useful framework for that purpose. To further explore whether and how TEC-inspired theorising can be applied to affective and nonaffective compatibility, and to the impact of action goals on the behavioural expression of compatibility, we carried out a study that directly compared these two types of effects. To avoid biasing our task towards higher cognitive processes, we used nonverbal stimuli of high ecological relevance: pictures of attracting and threatening animals and scenes.

Experimental design and hypotheses

To investigate the goal-dependency of affectively and nonaffectively induced response priming, we asked participants to respond as quickly as possible to pictures on a computer screen by moving a little doll either toward the screen (approach) or away from the screen (avoidance). Note that approach movements as we defined them required arm extensions, while avoidance movements required arm flexions. This allowed us to pit hypothetical biologically hardwired stimulus–response tendencies (which would predict faster extensions to negative stimuli and faster flexions to positive stimuli) against cognitively penetrated, goal-related tendencies (which would predict the opposite outcome)—similar to the rationale of Markman and Brendl (2005). In the following, our terminology will be based on the actions' goals and thus consider the combinations of positive stimuli and movements towards the screen and of negative stimuli and movements away from the screen as *compatible*. As approach movements require arm extensions and the avoidance movements arm flexions, our terminology is exactly opposite to that used by Chen and Bargh (1999) and Rotteveel and Phaf (2004). This means that finding a *negative* compatibility effect would replicate previous findings (and suggest a strong role of muscle movements), whereas finding a *positive* compatibility effect would imply a non-replication of previous findings (and suggest a strong role for cognitive interpretations).

Each stimulus picture had either a positive or a negative valence and was rotated slightly either to the left or to the right. Half of the participants were asked to judge the affective valence of each picture (*affective instruction*), whereas the other half were asked to judge the spatial orientation of each picture (*spatial instruction*). In the affective instruction condition, the *affective mapping* varied between subjects: half of the subjects were instructed to make an approach movement in response to a positive picture and an avoidance movement in response to a negative picture; for the other half, instructions were reversed. As sketched in Figure 2, approach

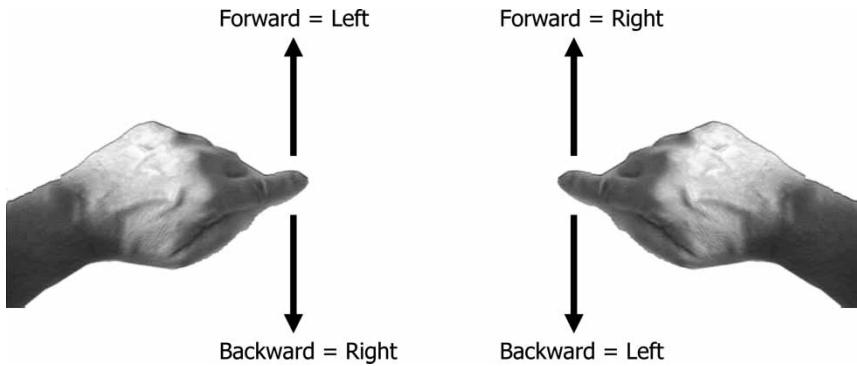


Figure 2. Illustration of hand-relative coding for the left and right hand.

movements should be associated with a <positive> feature code (indicated by the smiley), while avoidance movements should be associated with a <negative> code. Positive codes should overlap with those of the positive pictures and negative codes should overlap with those of negative pictures, so that we expected faster responses for the positive-approach/negative-avoid mapping than for the positive-avoid/negative-approach mapping.

In the spatial instruction condition, the *spatial mapping* varied between subjects: half of the subjects were asked to make an approach movement in response to a right-oriented picture and an avoidance movement in response to a left-oriented picture; for the other half, instructions were reversed. This manipulation was intended to introduce spatial stimulus–response compatibility relations. Bauer and Miller (1982) have shown that, for movements with the left hand, the mapping of forward movements upon left stimuli and backward movements upon right stimuli is preferred over the forward-right/backward-left mapping, whereas movements with the right hand are associated with the opposite preference. In other words, the left hand prefers the left-forward (approach)/right-backward (avoidance) mapping while the right hand prefers the right-forward (approach)/left-backward (avoidance) mapping. According to Lippa (1996), this interaction could be due to the effector-relative coding of movements, hence, for coding relative to the intrinsic hand axis, especially if the hands are held in an angle to the body axis. For the left hand, moving forward implies a hand- or wrist-relative displacement to the left and moving backward a displacement to the right (see Figure 3). If so, the cognitive representation of a forward (approach) movement with the left hand shares a spatial feature with left stimuli and the representation of a backward (avoidance) movement with the left hand a spatial feature with right stimuli. The opposite is true for right-hand actions: moving forward implies a displacement to the hand-relative right (see Figure 2) and moving backward a displacement to the left.

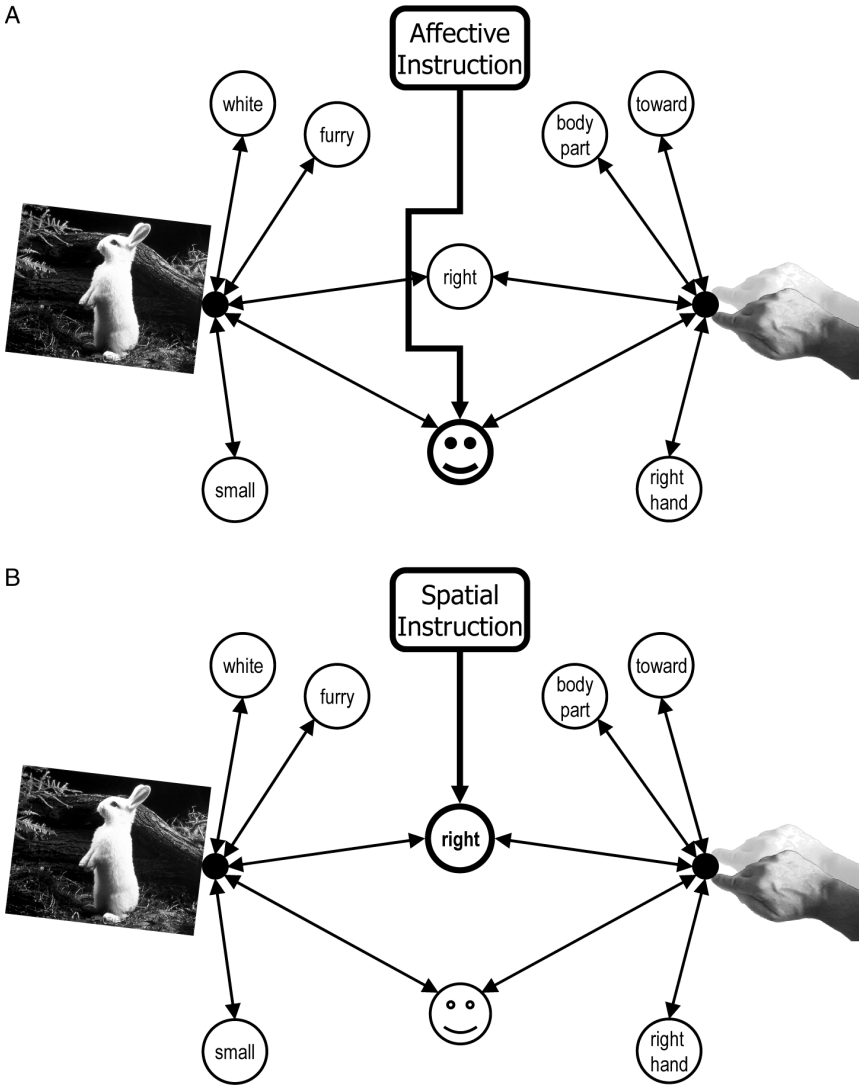


Figure 3. An adaptation of Figure 1 to demonstrate the impact of task relevance (instruction) on the “intentional weighting” of task-related features. (A) Affective instructions lead to a stronger weighting of affective codes. (B) Spatial instructions lead to a stronger weighting of spatial codes (for simplicity restricted to the <right> code).

Feature overlap between stimuli and responses should induce response priming, so that the interaction between hand and stimulus-movement mapping is likely to be just another example of a general “overlap = compatibility” principle. In the present study, we measured this

hand-relative stimulus–response compatibility effect by having participants carry out their responses with the left or the right hand, in different blocks. This allowed us to compare effects of affective and spatial stimulus–response compatibility with exactly the same stimuli and responses by varying the task instructions only.

Given the findings of previous experiments, we expected the task goal to determine how much weight each feature dimension would receive, which again should affect the size of the compatibility effect each dimension would create. As sketched in Figure 2, we expected affective instructions to weight affective features more strongly, so that affective feature overlap should show a strong compatibility effect (i.e., a main effect of affective stimulus–response mapping). Likewise, we expected that spatial instructions would weight spatial features more strongly, thus creating a strong spatial compatibility effect (i.e., an interaction of spatial stimulus–response mapping and response hand). These effects would demonstrate that our manipulations worked and that stimulus–response relations matter if they are task relevant. However, we were also interested to see whether task-irrelevant feature dimensions would create stimulus–response compatibility effects, which would point to a strong form of automaticity. To test these effects, we varied stimulus valence and stimulus orientation under both instruction conditions.

In the affective instruction condition, this meant that some stimuli were spatially response compatible (left-oriented stimuli for approach movements with the left and avoidance movements with the right hand; right-oriented stimuli for avoidance movements with the left and approach movements with the right hand) and others were spatially response incompatible. Given that only stimulus valence was relevant and that valence and orientation varied independently, finding a substantial interaction between stimulus orientation, movement, and hand (i.e., a spatial compatibility effect) would point to automatic response activation induced by spatial stimulus attributes. In the spatial instruction condition, irrelevant affective stimulus–response compatibility was manipulated along the same lines. Given that stimulus valence varied randomly, some stimuli were affectively response compatible (positive stimuli for approach movements and negative stimuli for avoidance movements, irrespective of the hand) and others were affectively response incompatible. Finding a substantial interaction between stimulus valence and movement would point to automatic response activation induced by affective stimulus attributes.

To summarise, we varied relevant affective and spatial stimulus–response compatibility *between* subjects by manipulating the task instruction and the stimulus–response mapping, that is, by making either stimulus valence or stimulus orientation task relevant. We also varied irrelevant affective and spatial stimulus–response compatibility *within* subjects by randomly varying

spatial compatibility relations in the affective task and affective compatibility relations in the spatial task. Effects of the between-subjects manipulation of mapping were intended to tap into voluntary, goal-related stimulus–response translation, whereas effects of the within-subjects manipulation of compatibility relations were intended to tap into automatic response priming.

METHOD

Participants

Fifty-six students (40 females, 16 males) volunteered on an informed-consent basis to participate in the experiment, either for partial fulfilment of course requirements or in exchange for a monetary reward. All participants had normal or corrected-to-normal vision, and were unaware of the purpose of the experiment. Their age ranged from 17 to 38 years with a mean of 21 years. All but one participant were right-handed.

Materials and apparatus

Pictures were selected from the International Affective Picture System (IAPS) developed by Lang and colleagues at the University of Florida (Lang, Bradley, & Cuthbert, 1996). Ten IAPS pictures depicting pleasant objects or events were used and 10 IAPS pictures depicting unpleasant objects or events. Digitalised versions of the IAPS pictures (117 × 84 mm) were displayed on a VGA monitor in a degraded colour palette (256 colours). All pictures were rotated slightly, either clockwise (right-oriented pictures) or counter clockwise (left-oriented pictures).²

Three square metal plates (10 × 10 cm) were positioned in front of the computer screen, as shown in Figure 4. Each plate had a tiny light-emitting diode (LED) attached to its upper-left corner. The LED (light bulb, LB) sent a light beam to the lower right corner, where a small light sensor (LS) was attached to the plate. When an object was placed in the middle of the plate, the beam was blocked, so that activation of the sensor served to indicate the presence or absence of an object on the plate.

At the beginning of each trial, a little doll was positioned on the middle plate, which is labelled “home plate” in Figure 4. The doll was faced towards the computer screen. Responses were made by moving the doll either

² Our manipulation of the spatial stimulus feature through orientation deviates from previous studies, where stimulus location was varied (e.g., Bauer & Miller, 1982). However, stimuli presented left and right from fixation are processed by different cortical hemispheres, which given the evidence of lateralised emotional systems (e.g., Davidson, 1995) might lead to unforeseeable interactions between stimulus location and affective processing.

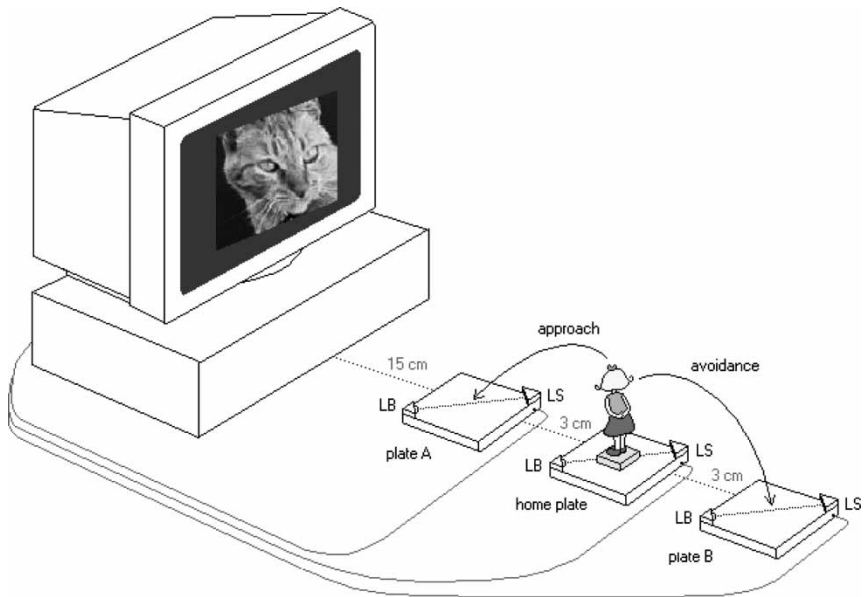


Figure 4. Equipment used to measure approach and avoidance movements.

forward onto the plate that was nearer to the computer screen (approach movement) or backwards onto the plate that was farther away from the screen (avoidance movement). Picking up the doll unblocked the light beam and triggered the measurement of reaction time (RT) from stimulus presentation. Placing the doll onto one of the other plates blocked the corresponding light beam, which triggered the measurement of movement time (MT) and completed the trial.

Procedure

Participants were seated in front of the computer screen with the three plates aligned with their sagittal body plane. Participants were assigned randomly to one of the four experimental conditions, each with its own response instructions. In all conditions, participants were instructed to pick up the doll as quickly as possible when a picture appeared on the screen and move it onto the appropriate target plate. Each picture was preceded by a small fixation cross for 1200 ms, which allowed participants to prepare a response by taking hold of the doll (without picking it up already). The picture appeared at the centre of the screen after a blank interval of 800 ms and remained visible until the response was completed (that is, until the doll was displaced onto one of the other plates). At the end of each trial, participants were asked to return the doll to the home plate. The experimenter initiated a

new trial by pressing the space bar on a keyboard that was interfaced with the computer.

The experiment consisted of 80 trials, divided into 2 blocks of 40 trials. In one of the two blocks, participants were asked to displace the doll with their right hand, and in the other block, with their left hand. Block order was balanced across participants. Each block was preceded by 6 practice trials. Each of the 20 pictures selected from the IAPS (of which 10 negative and 10 positive) was presented 4 times, twice with a left orientation and twice with a right orientation. The order of stimulus pictures was randomised within each block.

After the final trial, participants were handed a booklet containing coloured printouts of the 20 pictures used in the experiment, and were asked to evaluate them on a 9-category Likert scale ($-4 =$ very negative/unpleasant; $0 =$ neutral; $+4 =$ very positive/pleasant).³ The results are provided in the Appendix.

RESULTS AND DISCUSSION

Because possible effects of affective and spatial compatibility may be distributed over RT and MT data (i.e., people may lift the doll before having decided where to put it), total response time ($TT = RT + MT$) was chosen as the primary measure. Mean TTs and percentages of errors (PEs) were calculated as a function of affective mapping or compatibility relation (positive-approach/negative-avoid vs. positive-avoid/negative-approach), spatial mapping or compatibility relation (left-approach/right-avoid vs. left-avoid/right-approach) and response hand (left vs. right). A first omnibus analysis showed that the two instruction groups were roughly comparable, $F(1, 54) = 1.81, p = .18$. To test our hypotheses, separate analyses were conducted for the affective and the spatial instruction condition.

Affective instruction

Total response times. Trials on which an incorrect response was given (1.8%) and trials on which at least one of the response measures (RT, MT, and/or TT) qualified as outliers with $p < .001$ (1.6%) were excluded from analysis. In total, then, 3.4% of trials were excluded. TTs were analysed by means of a mixed $2 \times 2 \times 2$ ANOVA with Affective Mapping (positive-approach/negative-avoid vs. positive-avoid/negative-approach) as between-subjects factor, and Spatial Stimulus–Response Relation

³ The IAPS manual (Lang, Bradley, & Cuthbert, 1996) lists affective ratings for all pictures, but since we used a degraded colour palette we deemed it appropriate to let participants evaluate the degraded IAPS pictures (in random order).

(left-approach/right-avoid vs. left-avoid/right-approach) and Response Hand (left vs. right) as within-subjects factors.

As expected, the ANOVA revealed a main effect of affective mapping, $F(1, 26) = 5.27$, $p < .05$, see Figure 5A: The (presumably compatible) positive-approach/negative-avoid mapping ($M = 824$ ms, $SE = 33$ ms) yielded shorter TTs than the (presumably incompatible) positive-avoid/negative-approach mapping ($M = 977$ ms, $SE = 58$ ms). Note that the pattern of this effect points to a cognitively based compatibility effect: positive pictures facilitated approach actions carried out by extending the arm while negative pictures facilitated avoidance actions carried out by flexing the arm. With regard to the arm movements, this is the exact opposite of what Chen and Bargh (1999) and Rotteveel and Phaf (2004) observed. As is obvious from Figure 5B, main effects of the spatial stimulus–response relation, $F(1, 26) = 2.52$, $p = .12$, and response hand, $F(1, 26) = 0.99$, $p = .33$, as well as their interaction, $F(1, 26) = 0.44$, $p = .51$, failed to reach significance.

We also assessed whether stimulus valence and/or the degree of valence moderated the effect of affective mapping. Based on a median split of the mean affective ratings (see Appendix), we classified the valence of stimulus pictures as either moderate or strong. We then conducted an additional $2 \times 2 \times 2$ ANOVA with Affective Mapping as between-subjects factor, and Valence (positive vs. negative) and Valence Strength (moderate vs. strong) as within-subjects factors. This analysis showed that response times were shorter for negative pictures ($M = 888$ ms, $SE = 33$ ms) than for positive

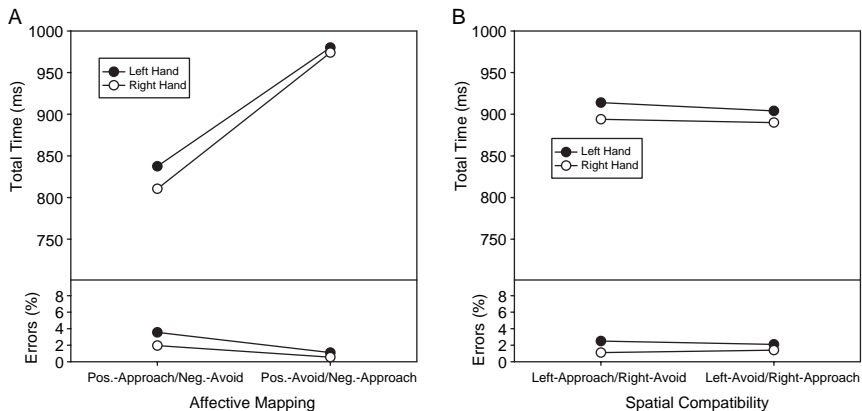


Figure 5. (A) Mean TTs (in ms) and PEs (in%) in the affective instruction mode condition as a function of affective mapping (positive-approach/negative-avoid vs. positive-avoid/negative-approach) and response hand (left vs. right). (B) Mean TTs (in ms) and PEs (in%) in the affective instruction mode condition as a function of spatial compatibility (left-approach/right-avoid vs. left-avoid/right-approach) and response hand (left vs. right).

pictures ($M = 913$ ms, $SE = 34$ ms), $F(1, 26) = 9.79$, $p < .01$. This finding is consistent with other studies showing a greater sensitivity toward negative stimuli (see Taylor, 1991, for an overview). However, as our stimulus material was not controlled for its impact on arousal, it may also be that negative stimuli were more arousing (Robinson, Storbeck, Meier, & Kirkeby, 2004). The ANOVA also revealed an interaction effect of affective mapping and valence, $F(1, 26) = 9.13$, $p < .01$, indicating that the effect of affective mapping was larger for positive pictures ($M = 825$ ms, $SE = 48$ ms vs. $M = 1002$ ms, $SE = 48$ ms) than for negative pictures ($M = 824$ ms, $SE = 47$ ms vs. $M = 953$ ms, $SE = 47$ ms). Valence strength did not moderate the effect of affective mapping.

Errors. Only the main effect of affective mapping approached significance, $F(1, 26) = 3.47$, $p < .08$, indicating that responses with the positive-approach/negative-avoid mapping ($M = 2.8\%$, $SE = 1.0\%$) were more error prone than responses with the positive-avoid/negative-approach mapping ($M = 0.8\%$, $SE = 0.4\%$). As this effect points in the opposite direction as the TT effect, we checked whether a speed-accuracy trade-off may be involved. The correlation between TTs and error rates was indeed negative, $r = -.29$, but not particularly pronounced and not reliable, $p = .13$.

Spatial instruction

Total response times. Trials on which an incorrect response was given (3.3%) and trials on which at least one of the response measures (RT, MT, and/or TT) qualified as outliers with $p < .001$ (2.4%) were excluded from analysis. In total, then, 5.7% of trials were excluded. A mixed $2 \times 2 \times 2$ ANOVA with Spatial Mapping (left-approach/right-avoid vs. left-avoid/right-approach) as between-subjects factor, and Affective Compatibility (positive-approach/negative-avoid vs. positive-avoid/negative-approach) and Response Hand (left vs. right) as within-subjects factors was conducted on the TT data.

The ANOVA revealed that response times were shorter for the left-approach/right-avoid mapping ($M = 770$ ms, $SE = 35$ ms) than for the left-avoid/right-approach mapping ($M = 912$ ms, $SE = 35$ ms), $F(1, 26) = 9.40$, $p < .01$. More importantly, the interaction effect of spatial mapping and response hand was highly significant, $F(1, 26) = 9.79$, $p < .01$. As shown in Figure 6A, the left-approach/right-avoid mapping was particularly beneficial for the left hand, whereas the left-avoid/right-approach mapping benefited the right hand. Note that due to the main effect of mapping, the interaction with hand did not yield a symmetric pattern.⁴ A comparable asymmetry has

⁴ Another factor that is likely to contribute to the asymmetry is the slight (numerical, but not statistically significant) advantage for the right hand, which is visible in all reaction-time graphs.

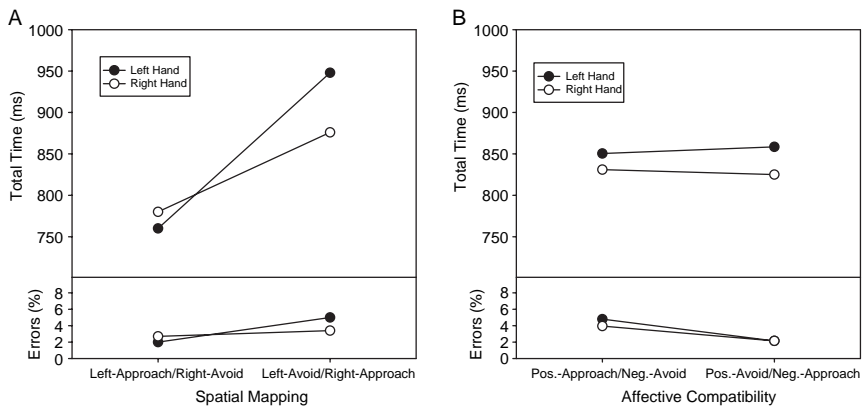


Figure 6. (A) Mean TTs (in ms) and PEs (in%) in the spatial instruction mode condition as a function of spatial mapping (left-approach/right-avoid vs. left-avoid/right-approach) and response hand (left vs. right). (B) Mean TTs (in ms) and PEs (in%) in the spatial instruction mode condition as a function of affective compatibility (positive-approach/negative-avoid vs. positive-avoid/negative-approach) and response hand (left vs. right).

been observed in the original study of Bauer and Miller (1982). However, given that Lippa (1996) found symmetric effects and Weeks and Proctor (1990) reported an overall benefit for the left-avoid/right-approach mapping, the main effect of spatial mapping should be interpreted with caution, the more so as our present manipulation of the spatial stimulus feature (i.e., by means of stimulus orientation) differs from previous manipulations (where stimulus location was varied). What is important, however, is that the interaction between mapping and hand fully replicated previous findings (Bauer & Miller, 1982; Lippa, 1996) and thus demonstrates that the manipulation of spatial stimulus–response compatibility had worked as expected. As obvious from Figure 6B, the manipulation of affective stimulus–response relation did not yield any effect ($F < 1$).

Errors. The interaction of spatial mapping and response hand approached significance, $F(1, 26) = 3.13$, $p < .09$, and the result pattern was comparable to that found in the TTs. The main effect of affective relation also approached significance, $F(1, 26) = 3.01$, $p < .10$. As in the affective task, the pattern was opposite to that obtained in the TTs of the affective task, indicating that responses with the positive-approach/negative-avoid mapping ($M = 4.4\%$, $SE = 1.1\%$) were *more* error prone than responses with the positive-avoid/negative-approach mapping ($M = 2.1\%$, $SE = 0.7\%$). However, given that the correlation between TTs and error rates was positive, $r = .18$, and far from significance, $p = .37$, a speed–accuracy trade-off does not seem to be involved.

GENERAL DISCUSSION

The empirical outcome of our study is consistent with some, but not all, of the previous findings on affect–action compatibility. First, we were able to replicate previous observations that manual approach and avoidance reactions interact with the valence of visual stimuli. Some have attributed such interactions to the facilitation of arm flexions and extensions by positive and negative stimuli, respectively (Chen & Bargh, 1999; Rotteveel & Phaf, 2004), suggesting that it is the arm movement rather than its purpose that matters for the direction of compatibility effects. This assumption, however, is inconsistent with our results, which show the exact opposite outcome pattern of that obtained by Chen and Bargh (1999) and Rotteveel and Phaf (2004): Positive stimuli facilitated arm extensions while negative stimuli facilitated arm flexions. This observation supports the claim of Markman and Brendl (2005), that it is the cognitive representation of an action that matters for compatibility effects but not its physical realisation. At the same time, it also questions the strong anti-cognitivist view of Zajonc (1980) and does not seem to fit with LeDoux's (1996) assumption of an evolutionary old, hardwired route from affect action—at least to the degree that these accounts are taken to speak to the affect–action compatibility effects under investigation.

A second interesting observation is that no effect of affective compatibility occurred in participants who focused on the spatial orientation of pictures, supporting the conclusion of Klauer and Muscher (2002) and Rotteveel and Phaf (2004) that valence-induced priming of approach and avoidance tendencies is not sufficiently automatic to operate in the absence of an affective evaluation goal. Given that one may doubt that Klauer and Muscher's verbal material and the faces used by Rotteveel and Phaf allowed for tapping into phylogenetically old mechanisms that are thought to be triggered by the visual features of rewarding and threatening events (LeDoux, 1996), confirming these previous findings with arguably more appropriate stimuli provides important converging evidence. That is, direct affective visuo-motor links either do not exist or are more cognitively mediated than previously held.

Not only did we find affective compatibility to be restricted to affective task goals, but we also saw a comparable result pattern for nonaffective compatibility: Spatial compatibility had a strong impact under spatial instruction but not under affective instruction. This mirror-symmetric pattern replicates the observation of Klauer and Musch (2002) and extends it to nonverbal material. Both affective and nonaffective stimulus–response compatibility thus seem to be much stronger if the stimulus dimension on which stimulus and response features overlap is task relevant. Even though in the present study, compatibility was actually *only* obtained for the task-relevant dimension, we believe that contributions from relevant and irrelevant

dimensions may sometimes differ more quantitatively than qualitatively—mainly because task relevance is often not a dichotomous variable.

Consider the standard Simon effect: It is produced by overlap between stimulus location and response location, even though stimulus location is nominally irrelevant to the task. However, while it is true that a Simon task can logically be performed without considering stimulus location, people need to attend to the location to process the critical nonspatial stimulus attribute and they need to carry out responses that are defined by their location in space. Hence, location is task relevant in a way, and even stimulus location is relevant in some sense. Accordingly, the location dimension may not be subject to heavy intentional weighting but depending on the task, the circumstances, and their interpretation by the subject, location codes may still have some impact. The same goes for the so-called affective Simon effect (De Houwer & Eelen, 1998). In tasks demonstrating this effect, participants respond to nonaffective stimulus features, such as the letter case, or grammatical or semantic attributes of words, by performing affectively charged actions, such as saying “good” or “bad”, or moving a manikin towards or away from the stimulus (e.g., De Houwer, Crombez, Baeyens, & Eelen, 2001). Importantly, the stimuli also have affective features that can be compatible or incompatible with the response. Similar to the spatial Simon effect, such a setup produces faster responses with affective stimulus–response compatibility, such as if one is to say “good” to the letter case of the word “sunshine”. Again, the affective valence of the stimulus words is nominally irrelevant to the task and need not be processed. And yet, given that the response set is, or at least can be, defined with regard to its affective implications, valence is task relevant to some degree, so that affective feature overlap can impact behaviour. We therefore claim that task-relevant feature dimensions are likely to receive high intentional weights, thereby boosting effects of feature overlap on these dimensions, but we do not assume that the weights for nominally task-irrelevant feature dimensions are necessarily zero. The more a dimension is directly or indirectly related to the task goal, or its interpretation by the subject, the more weight its codes will carry.

We have seen quite a number of similarities between affective and nonaffective compatibility effects. Even though this does not prove that the mechanisms underlying them are the same, it at least raises the possibility that they might be. This provides a solid basis for models that account for both affective and nonaffective effects—such the proposed affectively extended version of TEC. A number of recent observations are consistent with the extended TEC. For instance, Beckers, De Houwer, and Eelen (2002) showed that rendering a manual response “unpleasant” by having it consistently followed by a mild electric shock makes it compatible with word stimuli that refer to negative object and events. Apparently, the action acquired the valence of its consequences and sharing this valence with a

stimulus facilitated performance. This supports our interpretation of affective stimulus–response compatibility effects and demonstrates that actions are indeed represented through codes of both their affective and their nonaffective consequences. The affective quality of actions is thus not fixed but sensitive to reward and punishment, and probably to other consequences resulting in more differentiated affective experiences. An interesting implication of the affective version of TEC is that it can easily account not only for stimulus-induced response priming but also for effects from action preparation on perception. Numerous studies have revealed that planning and/or executing affect-related actions, such as manual approach or avoidance movements or smiling, facilitates the processing of affectively compatible stimulus events and colours their emotional experience (see Neumann et al., 2003, for an overview). A particularly nice demonstration stems from Strack, Martin, and Stepper (1988), who showed that having subjects contract facial muscles involved in smiling makes them judge cartoons to be funnier. Likewise, Neumann and Strack (2000) observed that subjects who were asked to flex their arm categorised positive words faster than negative words. Even though one may object that smiling and arm flexing, and their negative counterparts, might have hardwired associations with the corresponding affect, recent work suggests that any action that is associated with positive (or negative) consequences might do the trick. Indeed, Eder and Klauer (2007 this issue) demonstrated that associating left or right key presses with positive and negative stimuli is sufficient to render the representations of these actions affective enough to modulate the processing of corresponding stimuli. Again, this suggests that stimuli and responses interact with each other if they are associated with the same affective state. This means that codes of those states must be part the cognitive representations of the stimuli and responses involved.

Up to now, we have emphasised the function and purpose of actions, which apparently are of higher importance for action coding and action control than are the motoric details (Hommel et al., 2001). However, this is not meant to say that the way actions are motorically realised cannot be cognitively represented in principle. TEC does not assume that concrete motoric parameters are stored, not the least because these would be too variable to be of use for action control (Schmidt, 1975). However, whether an action is realised through flexing or extending one's arm is no doubt perceivable and may thus be considered in the action's representation. Accordingly, if approaching objects were always associated with the same kind of movement (e.g., flexion of arm muscles), a perceptual (e.g., visual and kinaesthetic) representation of that movement might well become coded into the long-term representation of the action. If so, the respective codes might well mediate stimulus–response compatibility effects, for instance, when responding to arm movements of a human model. And yet, given the

strong context dependency of the relationship between object valence and action (e.g., reaching for the same object involves flexing or extending of the arm, depending on whether the hand or the object is closer of the body) information about arm flexion or extension is unlikely to play an important role in the processing of affective information.

Taken together, we think that there are strong reasons to consider a common functional basis for representations of affective and nonaffective events. In particular, affective and nonaffective stimulus–response compatibility phenomena seem to follow comparable rules and show remarkably similar characteristics. Following the principle of Occam’s razor, it thus seems to be a good idea to explore more extensively the possibility of explaining all compatibility phenomena within the same theoretical framework—and only construct separate models if this attempt turns out to fail. As we have argued, a minor extension of the theory of event coding seems sufficient to account for the bulk of the empirical phenomena, which raises doubts in the often assumed but rarely defended conceptual distinction between cognition and affect. Indeed, at this point it makes sense to us to consider the absence of this distinction as the null hypothesis that awaits empirical disproving.

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APPENDIX

Affective ratings of stimulus pictures

	<i>M</i>	<i>SD</i>
<i>Extremely positive/pleasant</i>		
Mother and child (2311)	3.0	1.1
Puppies (1710)	2.7	1.2
Butterfly (1603)	2.6	1.1
Rabbit (1610)	2.4	1.1
Sexy woman (4250)	2.3	1.1
<i>Moderately positive/pleasant</i>		
Happy couple (2352)	2.1	1.1
Smiling woman (2030)	2.1	1.0
Mickey mouse (1999)	1.9	1.2
Smiling man (4532)	1.6	1.2
Hamburger (7540)	0.8	1.3
<i>Extremely negative/unpleasant</i>		
Mutilated body (3120)	−3.5	0.8
Injured man (3550)	−3.4	0.7
Growling terrier (1300)	−3.2	0.9
Man with gun (6260)	−2.9	1.1
Man with knife (6510)	−2.8	1.0
<i>Moderately negative/unpleasant</i>		
Skulls (9440)	−2.6	1.3
Shark (1930)	−2.5	1.0
Snake (1120)	−2.4	1.2
Angry man (2120)	−2.1	1.1
Growling German shepherd (1302)	−1.8	1.1

Note: −4 = very negative/unpleasant; 0 = neutral; +4 = very positive/pleasant. Numbers of IAPS pictures are indicated in parentheses.