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Both Distance Change and Movement Goal Affect Whole-Body Approach-Avoidance Behavior

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Objective: Approach and avoidance behaviors with respect to pleasant and unpleasant stimuli are explained by two theories. The motivational distance regulation (DR) account posits that the physical distance between the self and the stimulus is essential. In contrast, the cognitive evaluative response coding (ERC) account holds that the significance of the movement goal, provided with a response label, is crucial. The aim of the present study was to determine which account fares best in explaining approach-avoidance tendencies in whole-body movements. ***Method:*** We adopted a whole-body approach-avoidance paradigm involving stepping sideways to tease apart the effects of distance change and response coding. Thirty-six participants stepped sideways on a force platform in response to facial expressions, with instructions crafted to induce distance change separately from the labels given to the movements. In the first experiment the emotion was relevant to the task goal, whereas in the second experiment the emotion was task irrelevant. ***Results:*** The analysis of variance showed greater support for the cognitive ERC account with regard to step initiation (reaction time: significant Emotion × Label interaction; $p < .05$; $\eta_p^2 = .14$), but appeared to favor DR with regard to gait execution (peak velocity; significant Emotion × Distance interaction; $p < .05$; $\eta_p^2 = .14$). The results of the second experiment yielded support for the notion that emotion only affects behavior when relevant to the task goal, that is, for the ERC account. ***Conclusions:*** Both cognitive and motivational mechanisms play a role in whole-body approach-avoidance behavior, suggesting parallel cognitive processing routes.

Public Significance Statement
A smiling face invites us to come closer, whereas an angry face warns us to keep a distance. Such approach/avoidance action tendencies are not only driven by our emotions, but also by our thoughts, such as our plans and intentions. We studied how these action tendencies are translated into muscle commands to move our body closer or further away, by means of a single step.

Keywords: approach-avoidance, distance regulation, evaluative response coding, stepping, whole-body movement

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Emotion theories hold that emotions motivate us to approach pleasant and avoid unpleasant situations (e.g., Lang & Bradley, 2010). Experimental psychologists typically study approach and avoidance reactions by asking participants to perform binary responses to emotion eliciting stimuli, such as positive and negative words (cf. Krieglmeyer et al., 2010) or positive and negative facial expressions (cf. Rotteveel & Phaf, 2004). Results consistently indicate that approach responses are facilitated by pleasant stimuli and avoidance responses by unpleasant stimuli. The aim of this study is to experimentally contrast two theoretical accounts in the emotion literature that are both able to explain this effect.

According to one account, pleasant and unpleasant stimuli automatically trigger approach and avoidance motivational states, which facilitate adaptive motor responses. Pleasant (unpleasant) stimuli invite motor responses that decrease (increase) the distance between the self and the object (Krieglmeyer et al., 2010; Markman & Brendl, 2005). This motivational account has been coined distance regulation (DR; Beatty et al., 2016).

In contrast, accounts based on cognitive psychology emphasize the importance of the anticipated consequences of an action in approach-avoidance behavior (Eder & Hommel, 2013). In particular, two cognitive accounts have been proposed in the literature, called the cognitive evaluation (CE) and evaluative response coding (ERC) account, respectively (Beatty et al., 2016). Both state that if stimuli and motor consequences share a feature (e.g., valence), the stimulus-response pair is compatible along this dimension, and responses are facilitated. While the CE account is rather general, the ERC account makes very specific predictions about response labels and their effect on behavior. Eder and Rothermund (2008) found that a positive stimulus (e.g., a pleasant word) solicited motor responses that were labeled positively ("up" or "toward"), while it impeded those same motor responses when they were labeled negatively ("down" or "away"). Similarly, negative words speeded responses that were negatively labeled compared to the same responses that were positively labeled. Thus, the instructions fully determined the coding of evaluative actions, regardless of the physical characteristics of the movement patterns, such as distance change.

To our knowledge, only one study to date has attempted to directly contrast the DR and ERC accounts experimentally. Krieglmeyer et al. (2010) employed a paradigm to disentangle the effects of distance change and response coding as a function of the valence (positive/negative) of a set of words. In particular, participants moved a manikin on the screen upwards or downwards by pressing the up or down key, causing the distance between the manikin and the valenced word to either increase or decrease, depending on whether the manikin initially appeared below or above the word. Importantly, participants were instructed to imagine *being* the manikin. The significant interaction found between distance and label showed that distance compatibility (faster responses for moving the manikin toward a positive word and away from a negative word than vice versa) only occurred in the label compatible block (congruent; positive—up, negative—down), but not in the label incompatible block (incongruent; positive—down, negative—up). This finding seemed to favor the motivational view of approach-avoidance responses over the evaluative response coding view without fully refuting the latter. Overlooking all experimental results Krieglmeyer et al. (2010) concluded that both motivational distance change and evaluative response coding play a role in approach-avoidance behavior. More generally, they took their findings to imply that automatic response tendencies and more cognitive or reflective processes are operating in parallel. If true, this would imply that DR and ERC are not mutually exclusive but reflect qualitatively different motivational and evaluative processes.

However, one could argue that in order to assess the effect of distance change on approach-avoidance behavior, a physical distance change is necessary. In the case of Krieglmeyer et al. (2010) there was no net distance change between the participants and the stimulus; instead participants had to imagine themselves being a figure on the screen. A whole-body task involving an actual distance change between the participant and the stimulus could thus cast further light on approach-avoidance behavior and the validity of the DR and ERC account (cf. Kozlik et al., 2015).

In the whole-body paradigm (see, e.g., Naugle et al., 2010; Stins & Beek, 2011) participants step in a certain direction in response to an affective stimulus, thus changing the distance between the self and the stimulus. These studies have found comparable effects to those found in the manual approach-avoidance tasks, such as facilitation of forward motion toward pleasant stimuli. This facilitation has not only been found in gait initiation parameters (such as reaction time), but in movement execution as well, including step size and velocity (Naugle et al., 2010), thereby broadening the set of motor outcomes that are informative about the emotion-movement coupling.

The whole-body paradigm generally focuses on forward and/or backward stepping in response to valenced stimuli presented directly in front of the participant. However, in order to tease apart the effects of distance and response label, forward and backward steps will pose a problem. To illustrate, the instruction participants receive when they have to make a step forward in response to a stimulus (thus decreasing the distance between the self and the stimulus) will inadvertently contain a positive response label (i.e., *forward*; cf. Eder & Rothermund, 2008). Likewise, instructing participants to make a backward step in certain conditions (thus increasing the distance between the self and the stimulus) will ensure a negative response label to be present (i.e., *backward*). This means that by using forward and backward movements, decreases in distance will always be paired with a positive response label and increases in distance with a negative response label. This makes it impossible to differentiate between the two accounts.

The present experiments were designed to circumvent the approach and avoidance labels that are inherently associated with forward and backward stepping by having participants perform a neutral movement, namely, stepping sideways. This ensured that we could experimentally induce positive or negative response labels to an identical movement by instructing participants to "step toward" (approach) or "step away from" (avoidance) an affective stimulus. We reasoned that this experimental paradigm would enable us to tease apart the effect of distance change and response label on gait initiation in response to valenced stimuli.

Our stimuli were happy and angry facial expressions (cf. Roelofs et al., 2009; Rotteveel & Phaf, 2004; Volman et al., 2011; Welsch et al., 2020). By presenting two stimuli simultaneously side-by-side (one neutral face and one happy or angry face) a step to the right could, for example, increase the distance between the self and a happy face presented on the left, but could be labeled positively (e.g., "step *toward* the neutral face") or negatively (e.g., "step *away from* the emotion face").

The DR account would predict facilitation of movement when moving closer to a happy face and further away from an angry face, regardless of the response label assigned to the movement. The ERC account would predict facilitation of movement when the response label is congruent with the valence of the stimulus. In this case, facilitation emerges when a happy face is paired with any movement with a positive response label ("toward"), regardless of whether this movement increases or decreases the distance to the happy face. The online Supplemental Material (OSM) 1 and 2 shows the predictions of the DR and ERC accounts for each of the eight conditions on.

The predictions described here are based on the assumption that the emotional stimulus to which people respond is relevant for achieving the task goal. However, cognitive accounts like the ERC account and the more general CE account state that the influence of emotion on behavior will greatly diminish when it is irrelevant. Both cognitive accounts argue that the cognitive representation of the response combined with a matching evaluative goal mediates the influence of emotion on behavior. This implies that when there is no affective evaluation required to perform the task (e.g., responding to the spatial orientation or gender of affective stimuli instead of their valence), valence will not affect performance (Lavender & Hommel, 2007). In other words, the absence of affective evaluation goals diminishes the effect of emotion on behavior.

Support for the CE account was found in multiple studies. By instructing subjects to focus on non-emotional aspects of the stimuli such as spatial orientation (Lavender & Hommel, 2007), gender (Roelofs et al., 2009; Rotteveel & Phaf, 2004; Stins et al., 2014; Volman et al., 2011), or the position of a small item next to a facial expression (Welsch et al., 2020), the influence of emotional content on performance was reduced, in line with the conclusions of the meta-analyses conducted by Beatty et al. (2016) and Phaf et al. (2014).

However, some studies contradict these findings. For example, while emotional content was irrelevant to the participant (they responded to the grammatical category instead), Krieglmeyer et al. (2010) still found faster responses when approaching positive and avoiding negative words, while Rinck and Becker (2007) found faster avoidance responses in spider-fearful individuals even when responding to picture orientation (a picture of a spider) instead of content. In addition, the meta-analysis performed by Laham et al. (2015) contradicted the findings of the meta-analyses by Beatty et al. (2016) and Phaf et al. (2014), yielding no significant support for CE.

In light of these considerations, our second experiment was designed to assess the importance of an evaluative goal in the task. The design was identical to the first experiment, except that responses were based on the gender of the stimuli instead of their emotional expression (cf. Stins et al., 2014). The CE and ERC accounts predict that no effects of emotion on the behavior should be found since it is task irrelevant. In contrast, the motivational account would predict that emotion effects persist even in the absence of evaluation goals (Krieglmeyer et al., 2010), due to their alleged automaticity.

The experiments presented here represent a novel way to directly pitch the two prevailing accounts of approach-avoidance behavior against each other with mutually exclusive predictions within a single experimental design.

Materials and Methods Experiment 1

Participants

Thirty-six participants volunteered to take part in the experiment (20 females and 16 males; mean age = 20.4 years; *SD* = 2.6 years). The experiment was approved by the local ethics committee. All participants gave informed consent before the experiment.

Materials and Methods

A custom-built strain gauge force platform (1 m × 1 m; 1000 Hz sampling frequency) was used to record posturographic data. The force platform records forces with eight sensors, four in the *z*-direction and two in both the *x* and *y* directions. The total forces in three directions (Fx, Fy, and Fz) were calculated from these sensors, which were in turn used to calculate the moments (Mx, My, and Mz). The Mx and My vectors were used to determine the center of pressure (COP), that is, the point of application of the ground reaction force (Brenière et al., 1987).

Pictures of male and female faces with different emotions were shown at eye-level on a 55″ television screen, placed at a distance of 90 cm in front of the participant. Images were 41 cm high and 27.5 cm wide. Two faces were presented simultaneously with a horizontal distance of 54.5 cm between their centers. The pictures were adopted from the Radboud Faces Database (RaFD; Langner et al., 2010). All of the 20 male and 19 female Caucasian models available in the RaFD were used with three facial expressions: happy, angry, and neutral (all frontal gaze direction). In total, 117 pictures were used, all with frontal gaze direction and frontal camera angle. Stimulus presentation was accomplished in MATLAB, using the Psychophysics Toolbox extensions (Kleiner et al., 2007). Image onset was detected by a light sensor, which was attached to the bottom left corner of the screen. The light sensor was sampled simultaneously with the force plate channels, enabling the synchronization of the stimulus presentation and data collection.

Procedure

Participants always started in the middle of the force platform. Foot positions were indicated with tape. They were instructed to stand with their feet at shoulder width. Every trial started with the appearance of one of four instructions on the screen: (a) step toward the emotion face, (b) step away from the emotion face, (c) step toward the neutral face, and (d) step away from the neutral face. All instructions were in Dutch. We emphasize that the wording of the instructions was crucial in assigning response labels to the performed movements, either by labeling them as an "away" or a "toward" movement (see also Statistical Analysis Section). After the appearance of a fixation cross, two faces appeared on the screen side by side, one in the left visual field and one in the right visual field of the participant. The genders of the faces were just as often opposite as the same. One of the faces had a neutral expression and the other showed an emotion (either happy or angry). Based on the instruction, participants had to decide whether to move left or right, and then execute the step as soon as possible in the required direction. No instructions were given regarding step execution. The movement consisted of a step in the horizontal plane with the lateral leg stepping outwards (for a step to the right, the right leg would be moved to the right first), followed by the other leg, during which the body was kept parallel to the monitor.

The timing of events was as follows (see also Figure 1): Before each trial one of the instructions was shown. This instruction remained the same within each block of 20 trials. After the instruction disappeared, a fixation cross appeared for a random duration of between 2 and 4 s. Then two faces were presented, one with a neutral facial expression, the other either happy or angry. These two faces remained visible for 4 s, allowing the participant enough time to execute a lateral step, depending on the instruction. After 4 s, the faces disappeared from the screen and participants stepped back to the starting position. The instruction reappeared on the screen, starting the next trial. Four practice trials and twenty recorded trials were included in each block. Participants completed a total of four blocks, with instructions remaining the same for the whole duration of the block. The order of the four instructions was randomized. Participants were debriefed and received course credits for their participation.

Data Reduction

Recording of gait initiation can give rise to a wide variety of biomechanical variables that characterize the step (e.g., timing, speed, and distance), which may all be affected by emotion. Our main predictions were framed in terms of response selection (reaction time) but we also expected facilitation of response execution (step size and peak velocity; Naugle et al., 2010). Figure 2 shows a visual representation of the dependent variables and how they were calculated.

The data were filtered using a second-order bi-directional Butterworth low-pass filter (cut-off at 45 Hz). The data were subsequently downsampled from 1000 to 100 Hz to facilitate the subsequent data analysis. How each dependent variable was calculated is described below.

Reaction Time

Reaction time (RT) was defined as the moment the participant initiates their movement. It was determined by calculating the time between the onset of the faces on the screen and the first instance the medio-lateral force exceeded 5 N in either direction.

Peak Velocity

Peak velocity (PV) was defined as the maximum velocity of the COP in meters per second during step execution.

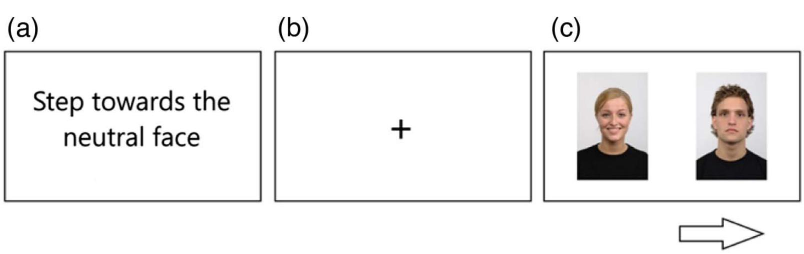
Step Size

The step size (SS) was defined as the distance in medio-lateral direction in centimetres between the COP before stepping and the COP after the step is completed.

Statistical Analysis

The three GI parameters were analyzed with a 2 (Emotion: happy/angry) × 2 (Label: toward/away) × 2 (Distance [to the emotional face]: closer/further) repeated measures (RM) analysis

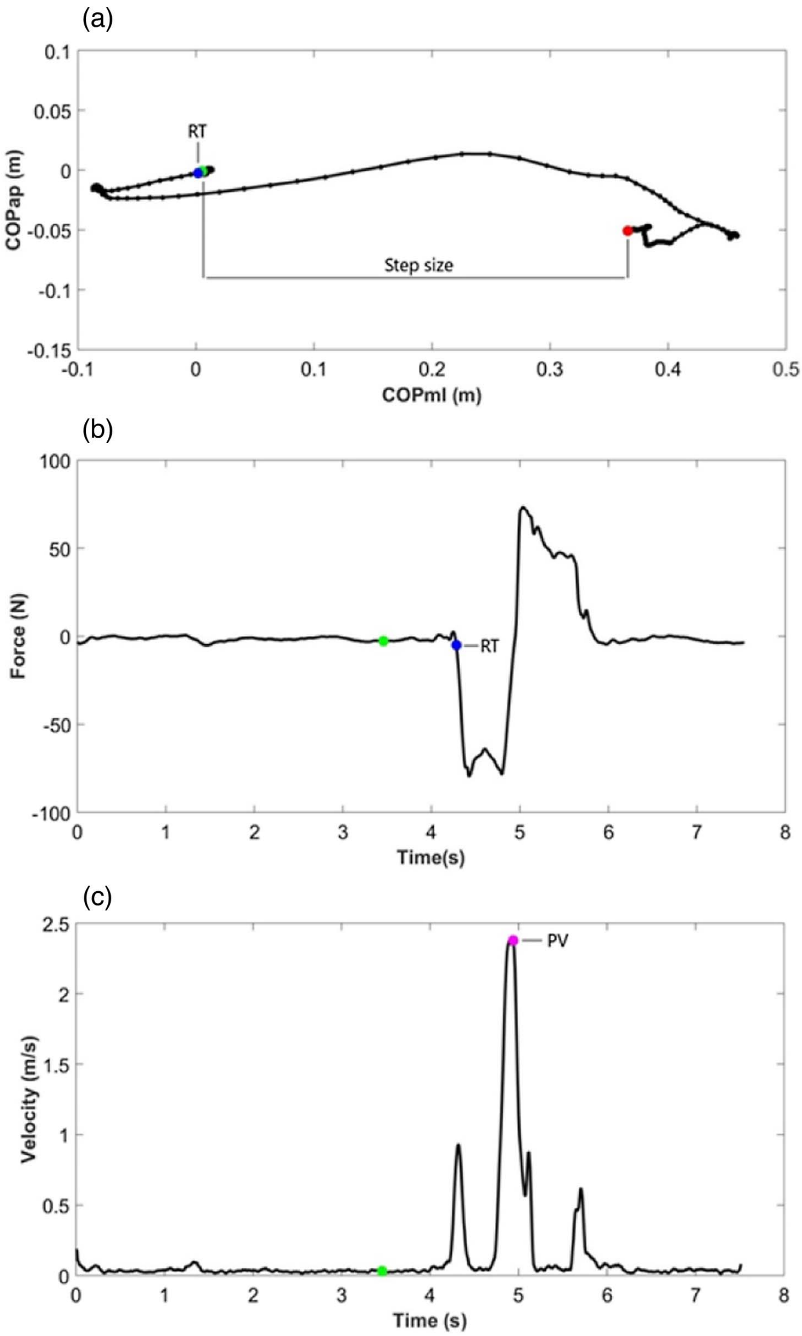
Figure 1
Exemplar Trial Showing the Instruction for That Trial (a), Followed by the Fixation Cross (b), Followed by a Set of Two Faces (c), in This Case Happy and Neutral



Note. In this example the participant was required to take a step to the right, thus decreasing the distance between the self and the neutral face and increasing the distance between the self and the happy face, while the movement is labeled as "toward." Pictures were adopted from the Radboud Faces Database (Langner et al., 2010).

Figure 2

Visual Representation of a Typical Step to the Right Including the Dependent Variables



Note. Across all three panels, the green dot indicates the onset of the visual stimulus, that is, the cue for step initiation. Panel (a) shows the center of pressure in both anterior–posterior and medio-lateral direction of the execution of a typical step to the right. The red dot represents the final position after the step has been made. The reaction time and step size are marked. Panel (b) shows the force in medio-lateral direction from the moment the fixation cross appears on the screen until the trial ends. The blue dot represents the reaction time: the time at which the force in medio-lateral direction exceeds 5N. Panel (c) shows the velocity of the COP trace, again from the moment the fixation cross appears until the end of the trial. Peak velocity is the maximum velocity reached during the execution of the step and marked by the magenta-colored dot.

of variance (ANOVA) using the statistics program JASP (Version .10, JASP Team, 2019). Alpha was set to .05.

Significant effects were analyzed with post-hoc paired-samples *t*-tests with a Bonferroni-corrected alpha of .05 divided by the number of tests. Partial eta squared (η^2_p) and generalized eta squared (η^2_G) are reported as effect sizes for the RM ANOVAs. For the post-hoc tests, Hedges's $g_{average}$ and a common language (CL) effect size (which is a percentage that reflects the probability of a participant having a larger result in one condition compared to the other) are reported. For details on these measures, see Lakens (2013).

An additional exploratory analysis including gender of the face and gender of the participant was performed. An earlier study using a comparable paradigm (Stins et al., 2014) found that gender, combined with emotion, had a clear influence on reaction time. Furthermore, in our second experiment participants had to respond to the gender of the stimuli, which is why we decided to look further into the putative effects of gender in the present study. Since neither the DR nor the ERC account makes predictions based on gender, and since gender was not part of the original hypotheses for these experiments, we considered this an exploratory analysis. Since this exploratory analysis was focused only on gender and emotion, we collapsed the data over the factors Distance and Label. Thus for each GI parameter, a three-way RM ANOVA was performed with gender of the participant (male/female) as a between-subjects factor, and gender of the face displaying the emotion (male/female) and emotion (happy/angry) as within-subject factors.

Results Experiment 1

Three participants were removed from the analysis because they did not follow the instructions or made too many mistakes. For the remaining 33 participants, 7.0% of the steps were removed (185 out of 2,640) due to missing data (5), stepping in the wrong direction (66), being "indecisive" (i.e., repeated weight shifting prior to stepping; 47), not standing still as instructed, quantified as excessive sway 500 ms pre-stimulus (sway $> 3 \times SD$; 16), responding too fast (RT $<$ 200 ms; 4) or too slow (RT $>$ 1,400 ms; 47). Note: these criteria were based on extensive visual inspection of the COP traces.

Statistical details for all dependent variables can be found in Table 1. The results are shown in Figure 3.

Reaction Time

Two significant main effects were found: an effect of Emotion, with happy faces eliciting overall faster responses compared to angry faces, and an effect of Label, reflecting faster responses when a step was labeled as "toward" compared to "away." In addition, significant interaction effects were found for Emotion and Label and for Distance and Label.

The interaction between Emotion and Label was explored by performing four post-hoc pairwise comparisons, all of which were significant. A happy face with a movement labeled as "toward" elicited the fastest RT compared to both a happy face with an "away" labeled movement, $t(32) = -9.13$, $p < .001$, Hedges's $g_{av} = 1.25$, CL effect size = 94%, as well as an angry face with a "toward" labeled movement, $t(32) = -11.17$, $p < .001$, Hedges's $g_{av} = .92$, CL effect size = 97%. Note that this effect stems purely from the labeling of the movement; it is present regardless of whether the distance to the happy face increased or decreased. In turn, an angry face paired with a "toward" labeled step showed significantly faster RT compared to an angry face with an "away" labeled step, $t(32) = -6.31$, $p < .001$, Hedges's $g_{av} = .86$, CL effect size = 86%. Finally, when the movement was labeled as "away," a happy face yielded faster responses compared to an angry face, $t(32) = -6.50$, $p < .001$, Hedges's $g_{av} = .65$, CL effect size = 87%. All of these effects were present regardless of whether the distance to the emotional face increased or decreased with the movement made.

The significant interaction between Emotion and Label was driven by the significantly larger difference between "toward" and "away" for happy faces (600 vs. 734 ms, respectively) compared to angry faces (704 vs. 808 ms, respectively); $t(32) = 2.32$, $p < .05$, Hedges's $g_{av} = .33$, CL effect size = 66%.

The interaction between Label and Distance to the emotional face was also analyzed with four post-hoc comparisons, which were all significant. RT was fastest when a step was labeled as

Table 1
F *Values, p Values,* η^2_p*, and* η^2_G *for All Dependent Variables of Experiment 1*

Dependent variable	*F*	*p*	η^2_p	η^2_G
Reaction time				
Emotion	$F(1, 32) = 118.86$	$p < .001$	.79	.11
Distance	$F(1, 32) = 1.58$	$p = .22$	.05	.00
Label	$F(1, 32) = 70.29$	$p < .001$	.69	.18
Emotion × Distance	$F(1, 32) = .30$	$p = .59$	.01	.00
Emotion × Label	$F(1, 32) = 5.39$	$p < .05$	.14	.004
Distance × Label	$F(1, 32) = 18.94$	$p < .001$	.37	.06
Emotion × Distance × Label	$F(1, 32) = .51$	$p = .48$	.02	.00
Peak velocity				
Emotion	$F(1, 32) = .40$	$p = .53$	.01	.00
Distance	$F(1, 32) = 2.51$	$p = .12$	.07	.00
Label	$F(1, 32) = .70$	$p = .41$	.02	.00
Emotion × Distance	$F(1, 32) = 5.22$	$p < .05$	.14	.00
Emotion × Label	$F(1, 32) = .002$	$p = .96$	.00	.00
Distance × Label	$F(1, 32) = .05$	$p = .83$	.00	.00
Emotion × Distance × Label	$F(1, 32) = 3.36$	$p = .08$	.10	.00
Step size				
Emotion	$F(1, 32) = 15.53$	$p < .001$	.33	.001
Distance	$F(1, 32) = 2.74$	$p = .11$	.08	.001
Label	$F(1, 32) = 2.67$	$p = .11$	.08	.001
Emotion × Distance	$F(1, 32) = 1.22$	$p = .28$	.04	.00
Emotion × Label	$F(1, 32) = 4.03$	$p = .053$	.11	.00
Distance × Label	$F(1, 32) = .30$	$p = .59$	.01	.00
Emotion × Distance × Label	$F(1, 32) = 1.63$	$p = .21$	.05	.00

Note. Statistically significant effects are shown in bold.

"toward" and brought the participants closer to the emotional face. This RT value was significantly lower compared to both a movement labeled as "toward" that increased the distance $t(32) = -5.05$, $p < .001$, Hedges's $g_{av} = .44$, CL effect size = 81%, and a movement labeled as "away" that decreased the distance to the emotional face, $t(32) = -7.44$, $p < .001$, Hedges's $g_{av} = 1.48$, CL effect size = 90%. Decreasing the distance to the emotional stimulus and labeling it as "away" showed the slowest RT, with it being significantly slower compared to labeling a movement as "away" but increasing the distance, $t(32) = 3.14$, $p < .005$, Hedges's $g_{av} = .61$, CL effect size = 71%. Finally, moving further from the face with the emotion and labeling the movement as "away" evoked a slower RT compared to labeling the movement as "toward," $t(32) = -3.44$, $p < .005$, Hedges's $g_{av} = .43$, CL effect size = 73%. All of these significant effects were present regardless of whether the emotion displayed on one of the faces was anger or happiness.

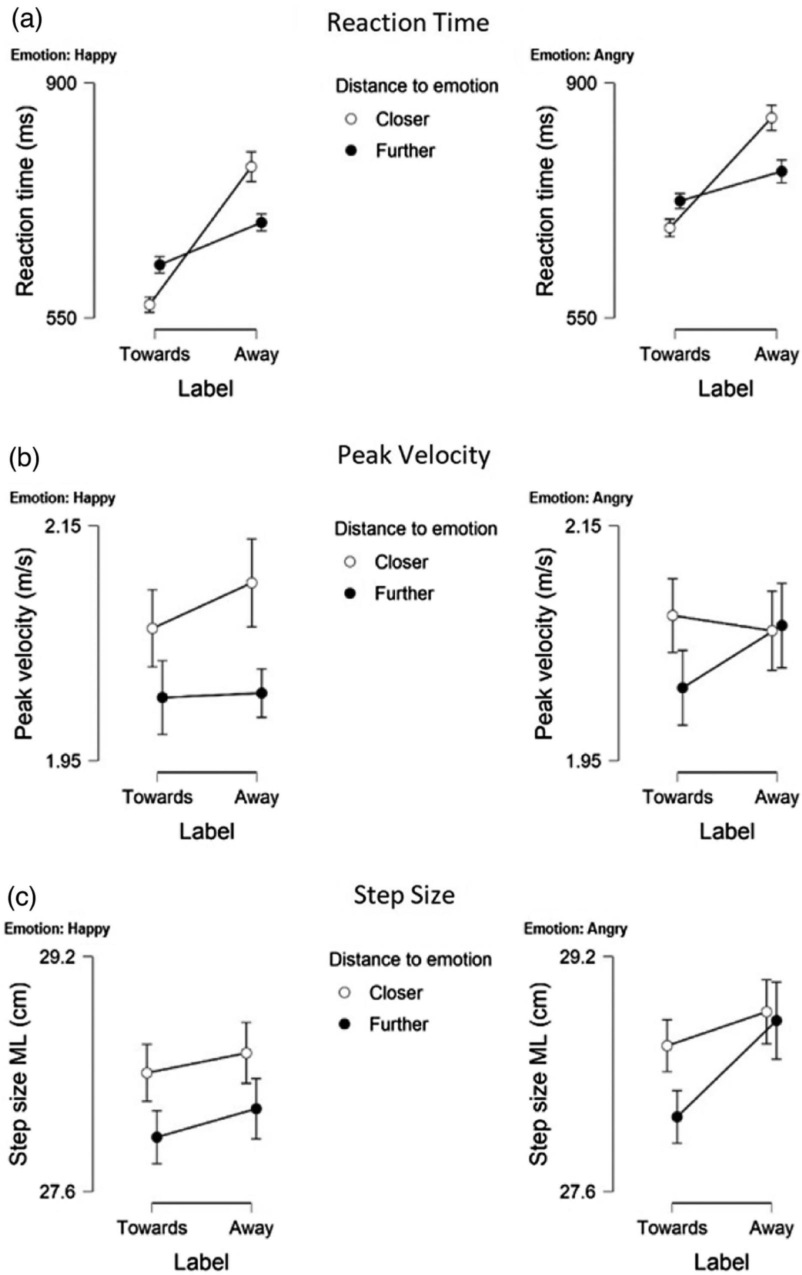
The significant interaction between the Label of the movement and the Distance to the emotional stimulus can be evaluated as follows: the difference in RT between the "toward" and "away" conditions was larger when decreasing the distance to the happy or angry face (627 vs. 811, respectively) compared to increasing the distance (677 vs. 730, respectively); $t(32) = 4.35$, $p < .001$, Hedges's $g_{av} = 1.08$, CL effect size = 78%.

Peak Velocity

Only a significant interaction effect between Emotion and Distance was found. None of the four post-hoc comparisons were significant when using a Bonferroni-corrected alpha of .0125. No significant differences were found when comparing the peak velocity of moving closer to a happy face to either moving further from a happy face, $t(32) = 2.39$, $p = .023$, or moving closer to an angry face, $t(32) = .88$, $p = .39$. Similarly, increasing the distance to an angry face did not elicit a significantly different peak velocity compared to increasing the distance to a happy face, $t(32) = -1.80$, $p = .081$, or decreasing the distance to an angry face, $t(32) = .77$, $p = .45$.

Figure 3

Results for All Dependent Variables of Experiment 1: (a) Reaction Time in Milliseconds, (b) Peak Velocity in Meters per Second, (c) Step Size in Centimeters



Note. The data points for all eight conditions include a vertical bar representing the standard error.

Step Size

A main effect of Emotion was found in that slightly smaller sideway steps were made with a happy face (28.27 cm) compared to an angry face (28.57 cm).

Exploratory Analysis

Reaction Time

Apart from the effect of Emotion, $F(1, 31) = 108.24$, $p < .001$, $\eta^2_p = .78$, $\eta^2_G = .14$, which was found in the main analysis as well, no other factors were significant. Participants responded faster when a happy face was on the screen (666 ms) compared to when an angry face was on the screen (754 ms).

Peak Velocity

A significant effect for Gender of the participant was found, $F(1, 31) = 5.22$, $p < .05$, $\eta^2_p = .14$, $\eta^2_G = .14$. Females showed a significantly lower peak velocity (1.84 m/s) compared to males (2.25 m/s).

Step Size

Apart from the effect of Emotion, $F(1, 31) = 15.82$, $p < .001$, $\eta^2_p = .34$, $\eta^2_G = .001$, similar to the main analysis, no other factors were significant. Step size was slightly smaller when a happy face was on the screen (28.25 cm) compared to an angry face (28.58 cm).

Discussion Experiment 1

Using a novel version of the whole-body approach-avoidance task we attempted to contrast the motivational account and the evaluative-coding account to gain a better understanding of the nature of the coupling between valence and movement. In Experiment 1, we found two important results for RT.

First, we found a significant interaction between valence and response label, but not between valence and distance change. The ERC account would predict a crossing interaction such that positive items and the label "toward," as well as negative items and the label "away" would be relatively fast compared to the incongruent combinations. Instead, the interaction in question (Figure 3a) is only in partial agreement with the ERC account. Specifically, there was a clear effect in the expected direction for happy faces: responses labeled as "toward" were initiated 134 ms faster than responses labeled as "away," regardless of distance change (Figure 3a, left). However, a smaller unexpected effect in the same direction was observed for angry faces, with responses labeled as "toward" being initiated 104 ms faster than responses labeled as "away" (Figure 3a, right).

Second, we found a significant interaction between distance and label. The 184 ms advantage when moving closer by means of a step labeled "toward" compared to labeled "away" is larger than the 53 ms advantage when moving further from an emotional face with a "toward" label than with an "away" label. Thus, when physically reducing the distance to an emotional stimulus (either happy or angry), a concurring label ("toward") speeds up the response because it matches the distance change, while a conflicting label ("away") slows down the response. In sum, there was support for the ERC account but for happy faces only. No support was found for the DR account.

In contrast to RT, PV showed an interaction between emotion and distance to the emotional stimulus. The results hint at a slightly higher PV when moving closer to a happy face compared to moving further away from it, providing moderate support for DR. Finally, the SS results showed only a main effect of emotion, but did not provide any support for either theoretical account.

The exploratory analysis including gender only showed one additional significant effect for PV, in that female participants showed a lower PV compared to males. This difference in PV could be due to anthropometric gender differences such as muscle strength, and we consider it irrelevant for the present research question.

Experiment 2

Experiment 2 was conducted to examine whether we would find significant effects of emotion on behavior when no evaluative goal is present for the participants. Instead of responding to the emotional expression displayed on the face, participants responded to the gender. The DR account posits that "functional movements" should not be affected by the goal of the movement, while both ERC and CE accounts predict no (or a reduced) effect of emotion when emotional content is irrelevant.

Materials and Methods Experiment 2

Participants

Thirty-six new individuals participated (21 females; mean age = 20.1 years; *SD* = 2.2 years).

Materials and Methods

See Experiment 1.

Procedure

Experiment 2 was almost identical to the first experiment, with one key difference: participants now had to respond to the gender of the faces on the screen instead of the emotion. So while one of the faces still displayed emotion and the other face was neutral, this difference in affective content was no longer the main focus for the participants. In this experiment the four instructions were: (a) step toward the male, (b) step away from the male, (c) step toward the female, and (d) step away from the female. The stimulus set-up was such that there was always one male and one female face in each trial.

Data Reduction

See Experiment 1.

Statistical Analysis

The statistical analysis was identical to Experiment 1. Note that, even though the instructions emphasized moving toward/away from a particular gender, the main analysis performed on Experiment 2 did not focus on gender but used emotion as factor. However, the exploratory analysis did take gender into account, similar to Experiment 1.

Results Experiment 2

The data for all 36 participants were used. Out of all 2,880 steps, 6.42% were excluded (185 steps) for the following reasons: missing data (3), stepping in the wrong direction (55), being indecisive (85), excessive sway (25), responding too fast (4) or too slow (13). Statistical details for all dependent variables can be found in OSM 3.

Reaction Time

The RT data are shown in Figure 4. A significant main effect was found for Label, $F(1, 35) = 65.39$, $p < .001$, $\eta^2_p = .65$, $\eta^2_G = .21$, with RT being faster when movements were labeled as "toward" compared to when they were labeled as "away." In addition, a significant interaction between Distance and Label was found, $F(1, 35) = 6.36$, $p < .05$, $\eta^2_p = .15$, $\eta^2_G = .003$.

Four post-hoc comparisons were performed to investigate the interaction, with a Bonferroni-corrected alpha of .0125. When moving closer to the emotional face, RT was faster when the movement was labeled as "toward" compared to when it was labeled as "away," $t(35) = -8.25$, $p < .001$, Hedges's $g_{av} = 1.15$, CL effect size = 92%. Comparably, when moving further from the emotional face, RT was also faster when the movement was labeled as "toward" compared to when it was labeled as "away," $t(35) = -7.00$, $p < .001$, Hedges's $g_{av} = .92$, CL effect size = 88%. The comparison between moving closer with the label "toward" and moving further with the label "toward" was not significantly different, $t(35) = -1.52$, $p = .14$. It also did not matter whether participants increased or decreased their distance to an emotional face when the movement was labeled as "away," $t(35) = 2.44$, $p = .02$. These effects were present regardless of the affective content of the stimuli.

The interaction between Distance and Label was driven by the difference in RT between the movements labeled as "toward" and "away" when increasing the distance to the emotion (520 vs. 645 ms, respectively) and this difference when the distance to the emotion decreases (508 vs. 664 ms, respectively), $t(35) = 2.52$, $p < .05$, Hedges's $g_{av} = .27$, CL effect size = 66%.

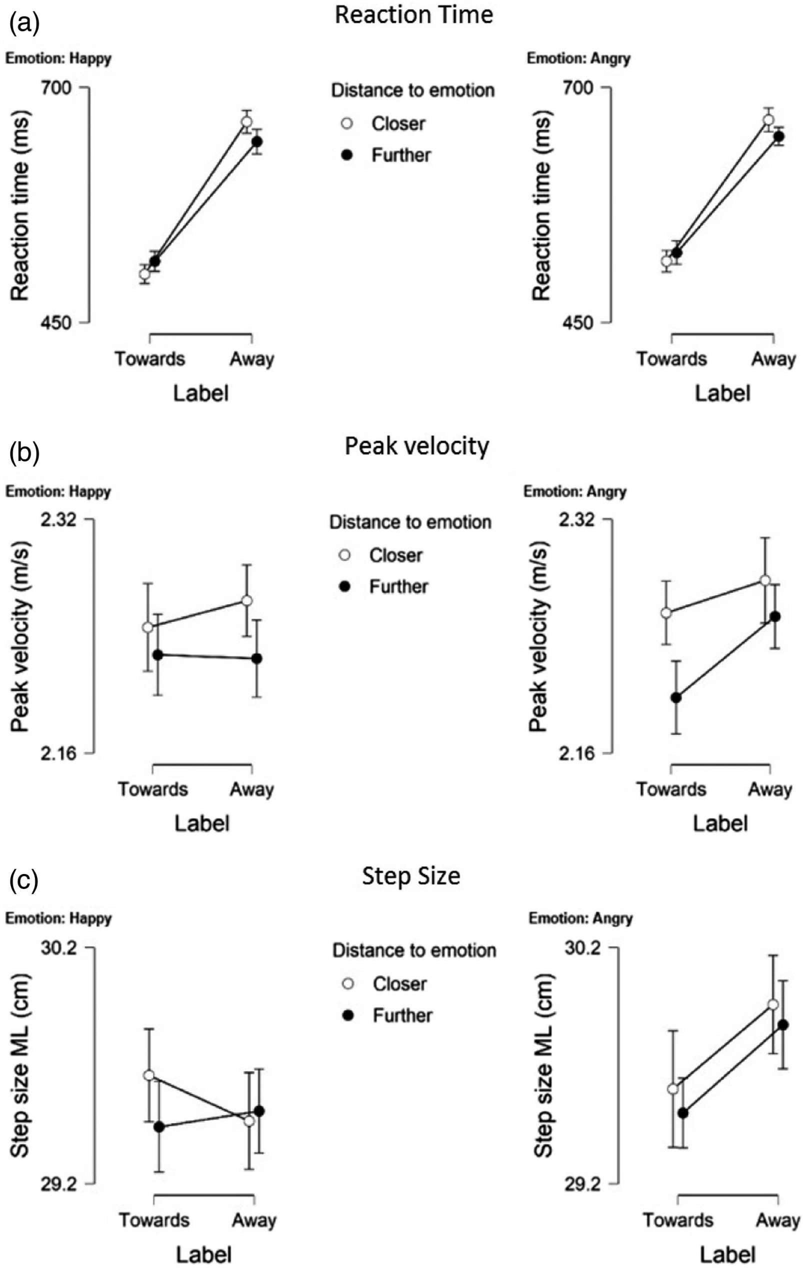
Peak Velocity

The data showed a significant main effect for Distance, $F(1, 35) = 5.01$, $p < .05$, $\eta^2_p = .13$, $\eta^2_G = .001$. Data showed a slightly higher peak velocity when moving closer to an emotional face (2.26 m/s) than when moving further away from an emotional face (2.23 m/s), regardless of how the movement was labeled or the emotion of the face.

Step Size

No significant effects were found.

Figure 4
Results for All Dependent Variables, Experiment 2: (a) Reaction Time in Milliseconds, (b) Peak Velocity in Meters Per Second, (c) Step Size in Centimeters



Note. The data points for all eight conditions include a vertical bar representing the standard error.

Exploratory Analysis

Reaction Time

A significant three-way interaction was found between Emotion, Gender of the stimulus, and Gender of the participant: $F(1, 34) = 5.25$, $p < .05$, $\eta^2_p = .13$, $\eta^2_G = .004$. To explore this interaction, separate ANOVAs with Emotion and Gender of the stimulus were performed for male and female participants separately. For male participants, no significant effects were found in this ANOVA. For female participants, the interaction between Emotion and Gender of the stimulus was significant: $F(1, 20) = 9.88$, $p < .05$, $\eta^2_p = .33$, $\eta^2_G = .015$.

Post-hoc comparisons showed a significant difference for female participants between responding to happy female and angry female faces, $t(20) = -3.00$, $p < .05$, Hedges's $g_{av} = .29$, CL effect size = 74%, in that the (female) participants responded faster to happy females compared to angry female faces. The three other contrasts were not significant with a Bonferroni-corrected alpha of .0125: happy males compared to angry males, $t(20) = 1.92$, $p = .070$, happy males compared to happy females, $t(20) = 2.06$, $p = .053$, and angry males compared to angry females, $t(20) = -2.16$, $p = .043$.

Peak Velocity

A significant main effect was found for Gender of the participants, $F(1, 34) = 6.93$, $p < .05$, $\eta^2_p = .17$, $\eta^2_G = .17$. Females had a lower peak velocity compared to males. A significant effect was found for Gender of the stimulus as well, $F(1, 34) = 4.99$, $p < .05$, $\eta^2_p = .13$, $\eta^2_G = .001$. When the face displaying the emotion was male, participants had a significantly lower peak velocity compared to when the face displaying the emotion was female.

Step Size

A significant effect of Gender of the stimulus was found, $F(1, 34) = 26.48$, $p < .001$, $\eta^2_p = .44$, $\eta^2_G = .005$. Participants' step was larger when the face displaying the emotion was female compared to when it was male, regardless of whether that emotion was happy or angry or the gender of the participant.

Discussion Experiment 2

Experiment 2 examined whether movement execution was influenced by valence in the absence of an emotional evaluation goal. Similar to Experiment 1, RT failed to yield any significant effect of distance. As a result, no support was found for the motivational account, which considers distance to be a crucial factor when responding to emotional stimuli, regardless of the absence of evaluation goals (Krieglmeyer et al., 2010).

There was a significant effect of label (RT was faster when responses were labeled "toward" compared to "away"), but this effect was independent of the emotional content of the stimuli. Both the ERC and the CE account predict a disappearance of the effects of emotion when no affective evaluation goal is present (Eder & Rothermund, 2008; Lavender & Hommel, 2007), but we are well aware that we cannot use our null finding as support for this thesis.

Experiment 2 also revealed a significant interaction between distance and label. Similar to Experiment 1, the RT difference between steps with a "toward" and "away" label was larger when moving closer to an emotional face (156 ms) than when moving further away from an emotional face (125 ms). When closing the distance to the valenced stimulus, a matching label ("toward") speeds up the initiation compared to the opposite label ("away"). A similar trend, although less pronounced, was found when moving further away.

PV showed an effect of distance with higher values when moving closer to an emotional face (both happy and angry) compared to moving further away from it. This is partially in line with the motivational account, since we expected facilitation of distance decrease for happy faces, but not for angry faces.

The exploratory analysis including gender showed effects across all three dependent variables. For RT we found that female participants responded faster to happy female faces compared to angry female faces. Interestingly, both Rotteveel and Phaf (2004) and Stins et al. (2014) found this as well. Becker et al. (2007) speculated that feminine features are inherently linked to happy facial expression, possibly speeding up the faster responses to happy compared to angry female faces.

PV and SS both showed a significant decrease when a male face displayed the emotion compared to when a female face displayed it, regardless of whether the emotion was happy or angry. The presumed inherent link between masculine features and angry facial expressions (Becker et al., 2007) may have primed an avoidance response, decreasing both step execution parameters.

General Discussion

Two experiments were conducted to independently assess the effects of distance change and response label on the coupling between emotion and movement. In Experiment 1, participants responded to the presence or absence of an emotional expression by stepping sideways. Distance to the face with the emotional expression (happy or angry) and response label was manipulated independently to tease apart their effects. RT partially supported the evaluative account: happy faces were responded to quicker when paired with a "toward"-label than with an "away"-label, regardless of whether the movement changed the distance to the happy face. PV results hinted at a marginal effect in that moving closer to a happy face yielded slightly higher PV compared to moving further away from a happy face, and thus provided support for the DR account.

Experiment 2 focused on the effect of distance and response label in the absence of an explicit emotional evaluation goal. In this case, the motivational account predicts an effect of distance regardless of whether valence was intentionally processed (Krieglmeyer et al., 2010). In contrast, the CE and ERC account predict no effect of emotion on movement in the absence of an explicit emotional evaluation goal (Eder & Rothermund, 2008; Lavender & Hommel, 2007). Interestingly, this was the case for all three dependent variables in our main analysis: There was no significant interaction between distance or label and emotion for any of the dependent variables. The OSM 4 presents an overview of all significant effects across both experiments.

Regarding the exploratory analysis, Experiment 1 showed one significant effect of gender for PV, whereas Experiment 2 (in which participants responded to the gender of the stimuli) yielded significant effects regarding gender for all three dependent variables. This finding supports the CE view, according to which S-R combinations that share a common feature, in combination with a task-relevant goal, facilitate the response to that stimulus (Lavender & Hommel, 2007).

Predictions of the DR and ERC accounts are based on the assumption that pleasant items (such as happy faces) elicit an approach response, whereas unpleasant items (such as angry faces) elicit an avoidance response, albeit for both accounts for a different reason. Our results, however, did not show this contrast between the two stimulus categories. In fact, looking at Figures 3a and 4a, the similarities in RT in response to happy faces and angry faces in both experiments are striking. While for Experiment 1 the magnitude of the effect differed between happy and angry faces (since we found a significant main effect of Emotion and a significant interaction with Label), the direction of the effect was the same. For Experiment 2, no significant effect of emotion was found at all. For both emotion categories as well as both experiments, a movement labeled as "toward" yielded faster responses compared to "away."

We can think of a few reasons why happy and angry faces elicited comparable responses. First, the angry faces might have elicited an approach motivation, but somewhat weaker than with happy faces. The literature on the responses coupled to angry faces is inconclusive: Roelofs et al. (2009), Rotteveel and Phaf (2004), and Volman et al. (2011) found behavioral avoidance in response to angry faces, whereas Krieglmeyer and Deutsch (2013) and Wilkowski and Meier (2010) found facilitation of approach responses. The reason for this discrepancy has not been clarified yet.

Second, participants did not have to identify the emotion category to select their response: they only had to identify whether a face displayed an emotion or not in Experiment 1 and whether a face was male or female in Experiment 2. Third, it could be that the comparable effects for both emotions are due to a common a-specific factor such as arousal or salience (and not valence), which is arguably higher than with neutral faces (cf. Lundqvist et al., 2014, 2015). Finally, avoidance responses have not been consistently found in whole-body tasks (e.g., Bouman & Stins, 2018; Stins & Beek, 2011; Stins et al., 2011), which could be a reason why we did not find the expected RT trends in response to angry faces.

Motivational (DR) and cognitive, goal-driven (ERC) mechanisms appeared to be at work simultaneously. This is supported by two findings. The first is the presence of a significant emotion and distance interaction effect for PV in addition to a significant emotion and response label interaction effect for RT in Experiment 1, suggesting that both mechanisms affect the response. The effect of the movement goal seems to be apparent for step initiation (i.e., RT), while the distance to the emotional stimulus has an effect on step execution (i.e., PV). In other words, when selecting the response, cognitive effects are predominant and affect RT, but when executing the ensuing movement, the automatic (presumably hard-wired) effect of emotion determines movement parameters like PV. Since this is the first whole-body study to directly compare both accounts, more research is necessary to confirm this novel hypothesis. Future studies could experimentally impose certain parameters of step execution such as direction (e.g., always to the left), or extent (e.g., comparing small steps and large steps).

The second finding suggesting that both mechanisms operated simultaneously is the significant interaction between label and distance found for RT in both experiments. The crossing interaction (Figures 3a and 4a) shows that response times were much faster when a distance decrease was accompanied by a congruent movement goal ("toward") compared to an incongruent movement goal ("away"). This suggests that a match between movement goal and distance change facilitates movement initiation to a larger extent than distance change or movement goal alone.

Krieglmeyer et al. (2010) likewise suggested that increased executive control in the incongruent conditions of their manikin approach-avoidance task could have obscured the automatic motivationally driven distance effects. They concluded that both the distance change and the evaluative-coding might contribute to approach-avoidance effects independently and/or in parallel, with distance motivational effects sometimes being overruled by executive control. Additional support for this notion can be found in the neuroimaging studies of Roelofs et al. (2009) and Volman et al. (2011), who speculated that the left orbitofrontal cortex (OFC) and the left anterior prefrontal cortex (aPFC) are important for overriding automatic affective stimulus-response couplings. In addition, Kozlik et al. (2015) drew a similar conclusion in their literature overview, and the meta-analysis by Beatty et al. (2016) also found support for both accounts. Interestingly, similar ideas can be found in some of the addiction literature. For example, Machulska et al. (2015) argued that nicotine cravings can be considered as a case in which strong automatic impulsive approach response tendencies have come to dominate the more deliberate executive system.

However, the cognitive notion that effects of emotions on behavior are only apparent when emotion is relevant to the task goal is supported by the present findings as well. The significant results for Experiment 1 were centered on emotions, while the significant results for Experiment 2 were not. Experiment 2, in which participants responded to the gender of the stimuli, showed more significant results in the exploratory (gender) analysis than the planned (emotion) analysis. This suggests that the aspect of the stimulus to which most attention is paid, is a bigger driving force in steering behavior.

In sum, our study demonstrates that emotions, as communicated by facial expressions, combined with experimentally induced response labels influence the organization of goal-directed stepping. There was support for both the motivational orientation account and the cognitive-based accounts. It could be that both accounts are valid and that the mechanisms operate independently and in parallel (Kozlik et al., 2015; Krieglmeyer et al., 2010). This is consistent with dual-processing models in experimental psychology (e.g., Strack & Deutsch, 2004) that emphasize the joint existence of automatic (fast, implicit) and controlled (slow, rule-driven) processes, such as emotion. In addition, the existence of a clear goal pertaining to emotion seems to be a prerequisite for emotional effects on behavior. Future studies should attempt to further unravel the respective roles of both mechanisms in normal and abnormal (e.g., addiction, posttraumatic stress disorder) emotion regulation. This could be done, for example, by zooming in on the components that make up the full spectrum of emotional experience, such as brain, eye, heart, muscle, and skin activity, in combination with whole-body motor approach-avoidance behaviors.

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