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Single-step initiation supports the interplay between fear expression perception and approach motivation

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Abstract

The perception of emotional faces plays a critical role in shaping human motor responses. However, the relationship between perceived facial expressions, particularly fear, and approach-related movement remains unclear as prior research often employed ambiguous approach behaviour and task requiring emotion identification before action planning, potentially introducing biases from differences in recognition accuracy across emotions. To address these limitations, we examined the effect of emotional faces (fear, angry, happiness) on unambiguous approach-related movement, i.e., forward single-step initiation by using a go/no-go paradigm. Moreover, two conditions were conducted: in the explicit condition, motor responses depended on whether the face was emotional or neutral, while in the implicit condition, they depended on the face's gender. Results showed that the perception of emotional faces impacted forward single-step initiation in the explicit condition only. More precisely, the motor response was stronger (higher anticipatory postural adjustments amplitude) in front of fear and happy faces than angry faces, and faster (shorter anticipatory postural adjustments duration) to fear than to angry faces. Altogether, these results highlighted a movement improvement in front of a face which expressed fear compared to anger and, in a slightly more contrasting way, compared to happiness. These results supported the idea that fearful faces, although signalling threat, are associated with approach, whereas angry faces appear to be perceived as threatening and linked to avoidance movements.

Introduction

Emotion and action are two fundamental components of human behaviour that are intimately linked. The biphasic theory of emotion (Bradley et al., 2001; Lang et al., 1990) is classically used to explain the impact of emotion on motor output associated to goal-directed movement. According to this theory, emotion is fundamentally organized around two basic motivational systems: the appetitive system that induces approach behaviours and the defensive system priming avoidance behaviours. Whereas the appetitive motivational system is thought to be activated in pleasant contexts (i.e., contexts that promote survival), the defensive motivational system is thought to be activated in unpleasant ones (i.e., contexts involving threat). In line with this motivational direction hypothesis, it has been found that approach/avoidance behaviours associated to pleasant/unpleasant stimuli, respectively, are facilitated as compared to unpleasant/pleasant stimuli, respectively (e.g. Chen & Bargh, 1999; Eder & Rothermund, 2008; Seibt et al., 2008). This was originally shown in Chen & Bargh (1999) study in which participants performed a motor task requiring pulling (i.e., upper limb flexion) or pushing (i.e., upper limb extension) a lever according to the valence of a word that appeared on a screen placed in front of them. Importantly, in this setup, the flexion or extension of the arm was conceptualized as approach or avoidance behaviour, respectively. The results showed that movement performance was enhanced when the direction of the goal-directed movement (i.e., pulling/approach or pushing/avoidance) was congruent with the behavioural direction induced by the emotional word (i.e., pleasant/approach, unpleasant/avoidance). More precisely, faster response time were observed for pulling rather than pushing in response to pleasant words and for pushing rather than pulling in response to unpleasant

words. These results supported the idea that pleasant and unpleasant stimuli facilitate approach and avoidance goal-directed upper-limb movements through the activation of the appetitive and defensive motivational systems, respectively.

Moreover, using a protocol similar to that of Chen & Bargh (1999) study but with emotional faces, Marsh et al. (2005a) showed that participants performed better when pushing rather than pulling in response to anger and when pulling rather than pushing a lever in response to fear. These results suggested that while anger would prime avoidance behaviour from perceiver, indicating that this negative expression is indeed perceived as threatening, fear, on the contrary, would prime approach behaviour, insinuating that this expression would be perceived as appealing and not as aversive (Marsh et al., 2005a). These findings challenge the view that angry expression is predominantly appetitive (e.g. Carver et al., 2009; Wilkowski & Meier, 2010). For example, in the study by Wilkowski and Meier (2010), based on a variant of Chen and Bargh (1999) task (see also, for the use of a similar paradigm, Markman & Brendl (2005)), participants categorized emotional faces by moving an on-screen representation of themselves either toward or away from the emotional stimulus using a push-pull lever. On-screen movements in which participants approached angry faces with their self-representation were initiated more rapidly than movements directed away from them, regardless of whether the action involved pushing or pulling the lever (Wilkowski & Meier, 2010). In contrast, movements away from fearful faces tended to be initiated faster than movements toward them, although this effect was not statistically significant (Wilkowski & Meier, 2010).

The discrepancy between these opposite patterns of results may be attributable, at least in part, to the ambiguity of the lever-based paradigm. It has been pointed out that pulling or pushing a lever could be ambiguous as to whether it represents an approach or avoidance movement (e.g. Eder & Rothermund, 2008; Markman & Brendl, 2005; Seibt et al., 2008). In their study, Seibt et al. (2008) used two opposite conceptualizations of lever movements. According to the first one, in which the frame of reference was the self, pulling or pushing a lever was defined as approach or avoidance behaviour: executing a toward (pulling) or an away-from (pushing) participant movement. In contrast, according to the second one, in which the frame of reference was the object (i.e., a word that appeared on a screen in front of the participant), pulling or pushing a lever was conceptualized as avoidance or approach behaviour: executing a toward (pushing) or an away-from (pulling) object movement. The results showed that when the frame of reference was the self, participants performed better when pulling for positive words and when pushing for negative words. In contrast, when the frame of reference was the object, participants performed better when pushing for positive words and when pulling for negative words. It therefore appears that pulling or pushing a lever can be influenced in opposite ways by a pleasant or unpleasant stimulus, depending on the conceptualization adopted. Thus, given that Marsh et al. (2005a) used a potentially ambiguous motor task (i.e. pulling or pushing a lever), it remains unclear whether the perception of fear or anger promotes approach or avoidance movement, respectively.

Interestingly, the initiation of forward single or multi-step walking is defined as an unambiguous approach movement, as it clearly decreases the distance between the self and the affective stimulus

location (Strack & Deutsch, 2004). This transition phase between the quiet standing posture in double limb support and the single/multi-step pattern involves complex posture-movement coordination known as anticipatory postural adjustments (APAs). Investigating APAs provides valuable insight into the mechanisms of postural control in both healthy and clinical populations. In addition, the fact that this whole-body movement is daily performed to interact with the environment makes it more ecological than pulling or pushing a lever. According to the biphasic theory of emotion (Bradley et al., 2001; Lang et al., 1990), some studies showed that this whole-body goal-directed movement was impeded in terms of longer reaction time and weaker motor response when participants had to initiate the movement as soon as possible after the onset of an unpleasant picture, as compared to a pleasant one (these pictures representing different human experiences) (e.g. Gélât et al., 2011; Stins & Beek, 2011; Yiou et al., 2014). Importantly, the impeding of this whole-body approach movement in unpleasant context could stem from an emotional conflict between the motivational system engaged by the emotional stimuli (i.e., defensive) and the direction of the goal-directed movement (i.e., approach; Gélât et al., 2011). Moreover, using facial expressions, it was reported that forward single step was initiated slower (i.e., longer reaction time) towards an angry face than towards a happy face (Mirabella et al., 2022; Stins et al., 2011; Stins et al., 2014). These results were consistent with the fact that angry faces elicit avoidance behaviour through the activation of the defensive motivational system. Nevertheless, as these previous studies focused only on happy and angry expressions, it is unclear whether fear activates the appetitive motivational system. To our knowledge, only one study has examined forward single-step initiation in response to fear and angry faces (Lebert et al., 2024). Their results showed that reaction time was longer when initiating the forward step in response to fear compared to anger, supporting the view according to which anger is associated with approach and fear with avoidance (e.g. Carver et al., 2009). However, in this study (Lebert et al., 2024), it is important to note that the task required participants to execute or withhold the movement (go/no-go task) based on their identification of the emotion conveyed by the face, specifically distinguishing between fear and anger. Indeed, in one condition, participants had to move or not if the face expressed anger or fear, respectively. In the other condition, the instruction was reversed. Given that fear is usually recognized less accurately than other emotions, such as anger (e.g. Palermo & Coltheart, 2004), the longer reaction time to initiate a forward single-step in front of fearful face may result from an extended processing time to identify fear, compared to angry faces.

Taking these limitations into consideration, the main objective of the present study was to better understand the complex interplay between emotion and action and more specifically, to clarify the influence of fear and angry expressions on the spatiotemporal parameters of an unambiguous approach movement, i.e., forward single step initiation. For these purposes, a go/no-go paradigm was used during which participants performed a single step towards (i.e., approach) happy, angry, or fearful faces, without needing to distinguish between these three emotional faces to produce the movement. According to the results of Marsh et al. (2005a), we expected a facilitating effect of happy and fearful faces compared to angry faces on the motor output of the whole-body approach movement. Moreover, in the meta-analysis of Phaf et al. (2014), the instruction (i.e., whether or not to attend to stimulus valence) was identified as the most important moderator of the relationship between emotional stimuli and

approach/avoidance movements. More precisely, whereas the emotional effect on approach/avoidance movements occurs when the instructions require explicit processing of the stimulus valence (i.e., explicit condition), this effect disappears when the instructions do not require such processing (i.e., implicit condition). Importantly, the instruction effect seems to be robust, as it was observed both in upper-limb motor tasks, such as pulling or pushing a lever (e.g. Rotteveel & Phaf, 2004) and in motor tasks involving whole-body movement, such as single-step initiation (Mirabella et al., 2022). In addition, the findings that emotional stimuli influence motor behaviour only when task-relevant, and not when task-irrelevant, have been confirmed in a subsequent review (Mirabella & Montalti, 2025). Thus, the second aim of the present study was to test whether the instruction moderated the expected facilitating effect of happy and fear expressions on the motor output. To this end, participants performed two conditions. In the explicit condition, they had to move (i.e., go trials) or not (i.e., no-go trials), depending on whether the face was neutral (i.e., no-go trials) or not (i.e., go trials). In the implicit condition, they had to move or not according to the gender of the face. According to Phaf et al. (2014) and Mirabella and Montalti (2025), we predicted a facilitating effect of happy and fear expressions on forward single step in the explicit condition only.

Method

Participants

To define our sample size, we relied on the study by Stins et al. (2014) using a paradigm similar to ours. In their study, an effect of emotional faces (happiness, neutral and angry) was observed on the reaction time to initiate a single step in a condition in which only a small effect size was expected (i.e., implicit condition). We therefore sought to determine whether a similar sample size ($n = 24$) provided adequate power to test of our hypotheses. However, because Stins et al. (2014) did not examine the amplitude of APAs along the anteroposterior axis, which is the primary variable of the present study, we based our power analysis on the mean and standard deviation values reported by G elat et al. (2018). Power analysis was performed with R package "simr" (Green & MacLeod, 2016). Fixed effects parameters were estimated based on the APAs-related results by G elat et al. (2018), assuming a small effect size corresponding to a Cohen's d coefficient of 0.25. By setting the number of simulations to 1000, the estimated power was 99.80%, with a 95% confidence interval of 99.28 to 99.98. The power of the study was therefore sufficient with the parameters as they were defined. The detailed strategy and main lines of code for power analysis are available from the Open Science Framework platform (https://osf.io/a5439/?view_only=97374d8b98a443dba1391181bb21682d).

Thus, twenty-four healthy young adults (age 18–31 years, 12 women) volunteered for this study which was carried out in 2018. All had normal or corrected-normal vision, no current lower extremity injury and were unaware of the purpose of the study. Each participant signed an informed consent before the experimental procedures. The study complied with the Helsinki Declaration for human experimentation and was approved by the local ethics committee.

Experimental design

Participants stood barefoot at the back of a force platform (AMTI, 120 x 60 cm) placed 2.80 m in front of a white board of the laboratory on which emotional faces (straight angle) were presented. The positioning of the feet allowed the single step to be performed on the platform and was marked to be used in all trials.

Using a go/no-go reaction time paradigm, the task consisted in achieving a forward single step with the dominant leg (Fig. 1C). The dominant leg was determined using classical motor tasks including ball-kicking and spontaneous step initiation (Yiou et al., 2014).

Two experimental conditions were tested in a random order. In the explicit condition, participants were asked not to move (i.e., no-go response) if the emotional expression conveyed by the presented face was judged as neutral. In contrast, they were instructed to initiate a forward single step (i.e., go response) if the facial emotional expression was judged as happy, angry, or fearful. In the implicit condition, the participants judged whether the face was a male or a female regardless of the emotional facial expression. Half of the participants were asked to initiate a single step for female faces and not to move for male faces (go-women group). The other half received the reverse instruction (go-men group) (Fig. 1A). All participants underwent a training phase before being tested.

Emotional stimuli

All facial stimuli used in the present study were selected from the Karolinska Directed Emotional Faces (KDEF; Lundqvist et al., 1998) database, a widely validated set of facial expressions (Goeleven et al., 2008). For each face identity (13 men and 12 women) were selected four emotional expressions, namely neutral, fearful, angry and happiness. All faces were presented in frontal view, with a direct gaze. To ensure that the selected facial expressions were clearly and reliably recognized, a preliminary study was conducted with a separate group of 10 healthy participants (age 18–42 years, 3 women), who had to categorize expressions through an eight-alternative forced-choice task (neutral, fearful, angry, happiness, disgust, surprise, sadness, and unknown). In the end, the 10 faces¹ (5 men and 5 women) that were best recognized across all four expressions (i.e., with a recognition rate greater than 80%) were selected for the main experiment.

During the main experiment, each trial began with the presentation of a central fixation cross on the screen for 2 s, followed by a face display for 1 s. A white screen then appeared until the end of the movement (Fig. 1B).

In each condition, the faces were presented in a random order. In the explicit condition, the 10 faces (5 men and 5 women), each conveying the four emotional expressions - neutral (no-go trials), fearful, angry, and happiness (go trials) were displayed. In the implicit condition, the same previous faces displaying only expressions of fear, angry, and happiness were presented. For the go-men group, the 5 faces of man

displaying the 3 emotional expressions were presented two times (go trials). In addition, 3 faces of women displaying the 3 expressions were presented one time (no-go trials). A similar design was applied for the go-women group. In total, for each condition, participants performed 30 go and 10 no-go trials.

The Psychophysics Toolbox Version 3 (Brainard, 1997) on Matlab R2019b was used to control the visual stimuli presentation of each trial and its synchronization with the signals of the force platform.

Data reduction

All signals from the force platform were recorded at 1000 Hz. These signals were filtered with a 10 Hz low-pass, fourth order, zero-lag Butterworth filter. Coordinates of the center of pressure (CP) on the antero-posterior (AP) direction (y_P) were calculated from the ground reaction forces and the moments measured by the force platform. The displacement of CP on AP direction was derived to obtain the CP velocity (y'_P).

The body's center of mass (CM) acceleration on AP axis ($y''G$) was obtained from Newton's law and the CM velocity (y'_G) axis was calculated by simple integration, by posing that $y''G$ and y'_G equaled zero at movement onset (i.e., t_{0y}). That enabled the calculation of the peak of forward CM velocity reached during the single step.

Outcome variables

Outcome variables

Six outcome variables were studied. The initial posture corresponded to the mean CP value on AP direction computed during the 500 ms time window before face onset. A higher value indicated a center of pressure further ahead. The onset of postural modifications along the AP axis (t_{0y}) was calculated as the time at which 10% of the first peak of y'_P was reached, as in previous studies (Gélat et al., 2011; Gélat et al., 2018). The reaction time corresponded to the time delay between the onset of the emotional face and t_{0y} . The APAs duration along the AP axis was defined as the delay from t_{0y} to the time the first peak of backward shift of CP was reached. The APAs amplitude corresponded to the initial backward shift of CP. The motor performance was quantified through the analysis of the peak of forward CM velocity (V) and the time when it occurred (t_V ; Fig. 2).

Statistical analysis

On the 1440 go trials that were collected, 35 trials (2.5%) were rejected because either (a) a no-go response was produced, (b) a step was made with the wrong limb, (c) the reaction time fell outside the range 200–2000 ms, or (d) a considerable CP movement occurred during the 500 ms window prior to face onset.

All the statistical analyses were performed with R statistical software (R Core Team, 2020). Linear mixed model analyses were performed with R package “lme4” (Bates et al., 2015). The mixed model approach was chosen over generalized linear model (repeated-measure analysis of variance [ANOVA]) because it is adapted to repeated measurement by taking into account crossed random effects such as participants and items (Baayen et al., 2008; Judd et al., 2012). The distributions of all outcome variables were first examined by inspected skewness and kurtosis values and no substantial deviations from normality were observed. Subsequently, each study variable was analysed using a mixed-model with emotion (fear, angry, happiness), condition (explicit, implicit) and the interaction between emotion and condition as fixed factors and with random intercepts for both participants and faces. The significance of the effects was obtained using R package “lmerTest” (Kuznetsova et al., 2017), in which the number of degrees of freedom is estimated using the Satterthwaite method. Least-squares mean calculations and post hoc comparisons were performed with R package “emmeans” (Lenth, 2020), with Tukey adjustment for p -value adapted for multiple comparisons. For all analyses, the probability was set at $p < 0.05$. Effect sizes were calculated as R^2 estimated according to the Kenward-Roger method (Edwards et al., 2008).

Results

Reaction time

The results of the mixed model only revealed a significant main effect of condition ($F_{(1,1359.6)} = 51.48, p < 0.001, R^2 = 0.02$). The participants were faster in the implicit than in the explicit condition (Table 1).

Initial posture

A significant main effect of condition was also found on initial posture ($F_{(1,1376)} = 8.62, p < 0.01, R^2 = 0.001$). The results indicated that the CP position was further ahead in the explicit than in the implicit condition (Table 1). The other effects were not significant ($p > 0.05$).

APAs duration

The mixed model for APAs duration revealed a main effect of condition ($F_{(1,1361.3)} = 13.69, p < 0.001, R^2 = 0.092$) indicating that it was longer in the implicit than in the explicit condition (Table 1). The main effect of emotion was not significant. A significant condition by emotion interaction ($F_{(2,1367.5)} = 3.96, p = 0.013, R^2 = 0.001$) was also found. Exploration of this interaction revealed that the only significant difference was between angry and fear. More precisely, APAs duration was reduced for angry ($m = 238$ ms, $se = 10$) compared to fearful ($m = 260$ ms, $se = 10$) faces ($t = -2.67, p = 0.025$) in the explicit condition only (Fig. 3B).

APAs amplitude

The results showed that APAs amplitude was larger for the implicit than for the explicit condition ($F_{(1,1362.2)} = 53.50, p < 0.001, R^2 = 0.021$) (Table 1). No main effect of emotion was observed, whereas the

interaction was significant ($F_{(2,1362.4)} = 10.16, p < 0.001, R^2 = 0.05$). The APAs amplitude was larger with fearful ($t = 4.67, p < 0.001$) and happy ($t = 2.41, p = 0.047$) relative to angry faces in the explicit condition only (Fig. 3A). The other differences were not significant ($p > 0.05$).

Motor performance

Amplitude in the peak of CM velocity (V) did not show any significant main effect or interaction ($p > 0.05$). Nevertheless, all fixed effects were significant for the time for reaching this peak (tV). The main effect of condition ($F_{(1,1376)} = 91.32, p < 0.001, R^2 = 0.04$) indicated that it was shorter in the implicit than in the explicit condition (Table 1). The main effect of emotion ($F_{(2,1376)} = 6.64, p = 0.0013, R^2 = 0.003$) revealed a shorter tV for fearful ($m = 961$ ms, $se = 28$) than for happy ($m = 982$ ms, $se = 28$) faces ($t = -3.63, p = 0.003$). Exploration of the interaction ($F_{(2,1376)} = 7.49, p < 0.001, R^2 = 0.003$) revealed that tV was shorter with fearful compared to angry ($t = 3.78, p < 0.001$) and happy ($t = -4.42, p < 0.001$) faces in the explicit condition (Fig. 3C). The other differences were not significant ($p > 0.05$).

Table 1
Estimated marginal mean scores on the spatiotemporal parameters of step initiation in the implicit and explicit conditions.

	Implicit	Explicit	p^1
Reaction time (ms)	604 (13)	637 (13)	***
Initial posture (cm)	-44 (0.35)	-43.9 (0.35)	*
APAs duration (ms)	265 (9)	250 (9)	***
APAs amplitude (cm)	- 4.57 (0.22)	- 3.97 (0.22)	***
tV (ms)	948 (28)	994 (28)	***
V (m/s)	0.563 (0.024)	0.563 (0.024)	NS

Note: Values in parentheses are standard errors. p p value, ***: $p < 0.001$, *: $p < 0.05$, NS: not significant.

¹ Significance level for the difference between conditions

Discussion

The main aim of the present work was to gain a deeper understanding of the intimate link between emotion and action. More specifically, we sought to clarify the relationship between motivational responses (i.e., approach vs. avoidance) and the perception of emotional facial expressions, particularly fear.

To lift ambiguities noted in the existing literature, we adopted two methodological refinements. First, we used a whole-body approach movement, i.e., forward single-step initiation, which provide a clearer

operationalization of approach than the lever task commonly employed. Second, we designed the task so that participants were not required to distinguish between emotional expressions (angry, fear or happiness) to plan and program the forward movement, thereby reducing potential biases due to differences in recognition accuracy, particularly the difficulty in identifying fear compared to anger (Palermo & Coltheart, 2004). Data gathered bring important contributions further addressed below.

Motor responses to emotional faces in the explicit condition.

In the explicit condition, the perception of emotional faces impacted the motor output associated to a whole-body approach movement. The most striking result of the present study highlighted a motor strategy adaptation in response to fearful faces compared to angry faces, such that the motor strategy for fear appeared to be facilitated than for anger. More specifically, the longer duration of APAs in response to fearful faces likely allowed for a sufficiently greater APAs amplitude, i.e. a larger backward shift of the CP during this movement phase. This more efficient anticipatory postural strategy for fear, compared to anger, likely contributed to improved overall movement performance, i.e. by speeding up the single-step initiation, as evidenced by a reduction in the time for reaching the peak of CM velocity, without, however, impacting the peak CM velocity amplitude. Thus, the results obtained in the present study using an unambiguous approach movement are consistent with those obtained in a previous study for the ambiguous lever motor task (Marsh et al., 2005a). These results support the idea that angry faces appear to be perceived as threatening and associated with avoidance movements, and that fearful faces, while signalling a threat, are associated with approach movements. As already suggested, the fact that angry faces elicit avoidance is not surprising (Marsh et al., 2005a) and the results of previous empirical studies supported this view (e.g. Seidel et al., 2010). For example, when participants were asked to judge the number of forward or backward steps they would take if they were standing in front of a face expressing anger, sadness, disgust or happiness, participants were most willing to move backward in front of faces expressing anger (whereas they were willing to move forward only for faces expressing happiness) (Seidel et al., 2010). Moreover, while smiling faces were perceived as having an affiliative function, angry faces indicated the intention to aggress and called for backing off (Horstmann, 2003). In addition, by using a social free-choice paradigm, the proportion of avoidance responses was shown to be greater for anger than for fear (Mennella et al., 2020). Regarding fear faces, more surprisingly, they have been shown to elicit approach behaviours due to their association with child faces which also elicited approach (Hammer & Marsh, 2015). Furthermore, it was shown that while angry faces were judged to be associated with traits relating to maturity, strength, and dominance, faces expressing fear were associated with traits representing dependence, weakness, submissiveness, and warmth (Marsh et al., 2005b). Consequently, in the present study, it could be stated that the impeding of the whole-body approach movement in front of angry expression could stem from an emotional conflict between the motivational system engaged by the angry face (i.e., defensive) and the direction of the goal-directed movement (i.e., approach). Conversely, the improvement of forward single-step initiation in front of a fearful face could be related to a congruence between the approach-related motivational system elicited by fear and the direction of the voluntary movement.

Although our findings corroborate previous evidence associating fear and anger with approach and avoidance behaviour, respectively (Marsh et al., 2005a), they deviate from those suggesting that, unlike fear, anger would prime approach behaviours through the activation of the appetitive motivational system, as it is the case for positive emotions such as happiness (for a review, see Carver & Harmon-Jones, 2009). According to this view, when participants were engaged in autobiographical emotion recall, the initiation of forward multi-step (i.e., approach) was facilitated (i.e., greater CP displacement during APAs or step length) for happiness and anger, compared with sadness and fear (Fawver et al., 2014). As already suggested by Coombes et al. (2007), it seems important to make a distinction between viewing a given basic emotion on a face and directly experiencing this specific emotion. More precisely, it could be that perceiving fear and anger on a person's face promotes approach and avoidance responses (toward that person, as in our study), respectively, whereas directly experiencing fear and anger (e.g. through autobiographical emotion recall) preferentially drives avoidance and approach, respectively.

Furthermore, in the explicit condition of our study, participants had to identify whether the face presented to them was neutral (no-go response) or emotional (go response). Importantly, the task was designed so that participants did not need to distinguish between the three emotions (anger, fear, happiness) to produce the movement, in the sense that the same motor response had to be performed for all three emotional expressions. We believe this point to be fundamental. Indeed, given that fear is generally less easily identifiable than other emotions, such as anger (e.g., Palermo & Coltheart, 2004), biases could have been introduced if the motor response required distinguishing between fear and other emotions (happiness, anger).

However, the results of our study showed contrasted findings when the movement was performed in front of happy faces. Indeed, the more effective anticipatory postural strategy observed for happy faces, compared to angry faces, did not translate into improved overall movement performance for happiness. The modulation of APAs in response to happy faces concerned amplitude only, and not duration. It is therefore possible that, since APAs duration did not differ between happy and angry faces, the greater APAs amplitude for happy faces was not sufficient to significantly impact overall movement performance. A possible explanation for these contrasting results for happy faces is that positive emotions tend to elicit atypical and more diverse reactions than negative ones (Fredricksen, 1998).

Moreover, our results indicated that movement was faster/larger or slower/weaker depending on the emotional expression, suggesting that motor output is modulated by affective cues in explicit condition. However, these spatiotemporal variations cannot be straightforwardly interpreted in terms of approach or avoidance tendencies. For instance, the inclusion of a neutral baseline condition might have provided a clearer reference point to determine whether changes reflected approach- or avoidance-related processes. Yet, establishing such a baseline is challenging, as it is difficult to identify a truly emotion-free condition while maintaining a similar methodology (e.g. go/no-go paradigm, explicit condition that does not require distinguishing between fear and anger to plan the movement).

The main effect of condition (implicit versus explicit).

In the present study, a condition effect (implicit versus explicit) was observed on the initial posture, i.e. on the position of the centre of pressure during the waiting phase preceding the onset of the emotional face. More precisely, the centre of pressure's position was further ahead in the explicit condition than in the implicit one, reflecting a greater forward leaning of the whole-body when participants were asked to explicitly judge the valence of the forthcoming emotional face. A similar forward leaning of the whole-body was already shown during the waiting phase of fast gait initiation (Lepers & Brenière, 1995), suggesting that these changes in initial posture create favourable conditions for rapid gait. In our study, however, despite favourable initial posture in the explicit condition, the single step initiation was slowed down when the emotional face appeared, as attested for example by the increase of reaction time in the explicit condition regardless of the valence of the emotional face. Thus, in the explicit condition, it could be argued that participants did not take advantage of the favourable change in the initial posture once the emotional face has appeared. This could be explained by a general attentional capture of emotional face, which has been observed regardless of their valence (Hodsoll et al., 2011), probably interfering with the high attentional demands for walking (e.g. Lajoie et al., 1993).

Lack of emotional influence on motor response in implicit condition.

In the present study, the perception of emotional faces impacted the whole-body approach movement in the explicit condition only. When the instruction required participants to attend and judge the gender of the emotional face (i.e., implicit condition), the emotional effect observed on the movement parameters no longer appeared. This result is consistent with previous data obtained in upper-limb (Phaf et al., 2014) and whole-body (Mirabella et al., 2022) reaction-time tasks, suggesting an indirect link between affect and approach-avoidance movement (Phaf et al., 2014). For example, by using similar instructions to those of the present study, it has been shown that the impact of emotional (angry, happiness) faces on reaction time to initiate a forward step in the explicit condition disappeared in the implicit condition (Mirabella et al., 2022).

Thus, although emotional faces are highly relevant cues for social interaction (e.g. Blair, 2003; Fridlund & Russel, 2006) and tend to be processed even more automatically than emotional words (Beall & Herbert, 2008), their impact on movement production could be vanished when participants have no explicit requirement to process the emotional expression of the face. It is possible that facial expressions were nevertheless processed automatically, but not to an extent strong enough to produce a measurable impact on subsequent behaviour. This interpretation is consistent with the fact that participants were engaged in real approach movements (e.g., single-step initiation) while responding only to symbolic faces (i.e., pictures of human emotional expressions).

Conclusion

The current study provides a better understanding of the links between emotion and action. In particular, the results supported the non-traditional idea that angry faces appear to be perceived as threatening and

linked to avoidance, whereas fearful faces, although signalling threat, are associated with approach movements. Importantly, this interpretation relies on the unambiguous approach movement we employed, i.e., forward single step initiation, which was faster and larger in response to fearful than to angry faces. To further support this interpretation, future studies should include a baseline condition to provide a reference point while avoiding potential biases.

Declarations

Author Contribution

All authors contributed to the study conception and design. Formal analysis and visualization are performed by Jean-Luc Kop and Laure Coudrat. First draft of the manuscript was performed by Laure Coudrat.

Acknowledgement

Dedicated to the memory of Thierry Gélat (1958 - 2018)

Data Availability

Individuals can access detailed description of the strategy and main line of code for power analysis, data file and its codebook through the Open Science Framework website (https://osf.io/a5439/?view_only=97374d8b98a443dba1391181bb21682d). We have no conflicts of interest to disclosure.

References

1. Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modelling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390–412. <https://doi.org/10.1016/j.jml.2007.12.005>
2. Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. <https://doi:10.18637/jss.v067.i01>
3. Beall, P. M., & Herbert, A. M. (2008). The face wins: Stronger automatic processing of affect in facial expressions than words in a modified Stroop task. *Cognition and Emotion*, *22*(8), 1613–1642. <https://doi.org/10.1080/02699930801940370>
4. Blair, R. J. R. (2003). Facial expressions, their communicatory functions and neuro-cognitive substrates. *Philosophical Transactions of the Royal Society of London Series B: Biological Sciences*, *358*(1431), 561–572.
5. Bradley, M. M., Codispoti, M., Cuthbert, B. N., & Lang, P. J. (2001). Emotion and motivation I: defensive and appetitive reactions in picture processing. *Emotion*, *1*(3), 276–298.

<https://doi.org/10.1037/1528-3542.1.3.276>

6. Brainard, D. H. (1997). The psychophysics toolbox. *Spatial Vision, 10*(4), 433–436.
<https://doi.org/10.1163/156856897X00357>
7. Carver, C. S., & Harmon-Jones, E. (2009). Anger is an approach-related affect: evidence and implications. *Psychological Bulletin, 135*(2), 183–204. <https://doi.org/10.1037/a0013965>
8. Chen, M., & Bargh, J. A. (1999). Consequences of automatic evaluation: Immediate behavioral predispositions to approach or avoid the stimulus. *Personality and Social Psychology Bulletin, 25*(2), 215–224. <https://doi.org/10.1177/014616729902500200>
9. Coombes, S. A., Cauraugh, J. H., & Janelle, C. M. (2007). Dissociating motivational direction and affective valence: specific emotions alter central motor processes. *Psychological Science, 18*(11), 938–942. <https://doi.org/10.1111/j.1467-9280.2007.02005.x>
10. Eder, A. B., & Rothermund, K. (2008). When do motor behaviours (mis)match affective stimuli? An evaluative coding view of approach and avoidance reactions. *Journal of Experimental Psychology: General, 137*(2), 262–281. <https://doi.org/10.1037/0096-3445.137.2.262>
11. Edwards, L. J., Muller, K. E., Wolfinger, R. D., Qaqish, B. F., & Schabenberger, O. (2008). An R2 statistic for fixed effects in the linear mixed model. *Statistics in Medicine, 27*(29), 6137–6157.
<https://doi.org/10.1002/sim.3429>
12. Ekman, P. (1992). An argument for basic emotions. *Cognition and Emotion, 6*(3–4), 169–200.
<https://doi.org/10.1080/02699939208411068>
13. Fawver, B., Hass, C. J., Park, K. D., & Janelle, C. M. (2014). Autobiographically recalled emotional states impact forward gait initiation as a function of motivational direction. *Emotion, 14*(6), 1125–1136. <https://doi.org/10.1037/a0037597>
14. Fredrickson, B. L. (1998). What good are positive emotions? *Review of general psychology, 2*(3), 300–319. <https://doi.org/10.1037/1089-2680.2.3.300>
15. Fridlund, A. J., & Russell, J. A. (2006). The functions of facial expressions. *The Sage handbook of nonverbal communication, 299–319*.
16. Gélat, T., Coudrat, L., & Le Pellec, A. (2011). Gait initiation is affected during emotional conflict. *Neuroscience Letters, 497*(1), 64–67. <https://doi.org/10.1016/j.neulet.2011.04.030>
17. Gélat, T., Coudrat, L., Ferrel-Chapus, C., & Vernazza-Martin, S. (2018). The duration of emotional image exposure does not impact anticipatory postural adjustments during Gait Initiation. *Brain Sciences, 8*(11), 195. <https://doi.org/10.3390/brainsci8110195>
18. Goeleven, E., De Raedt, R., Leyman, L., & Verschuere, B. (2008). The Karolinska directed emotional faces: a validation study. *Cognition and emotion, 22*(6), 1094–1118.
<https://doi.org/10.1080/02699930701626582>
19. Green, P., & MacLeod, C. J. (2016). SIMR: An R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution, 7*(4), 493–498.
<https://doi.org/10.1111/2041-210X.12504>

20. Hodsoll, S., Viding, E., & Lavie, N. (2011). Attentional capture by irrelevant emotional distractor faces. *Emotion, 11*(2), 346–353. <https://doi.org/10.1037/a0022771>
21. Horstmann, G. (2003). What do facial expressions convey: Feeling states, behavioral intentions, or actions requests? *Emotion, 3*(2), 150–166. <https://doi.org/10.1037/1528-3542.3.2.150>
22. Judd, C. M., Westfall, J., & Kenny, D. A. (2012). Treating stimuli as a random factor in social psychology: A new and comprehensive solution to a pervasive but largely ignored problem. *Journal of Personality and Social Psychology, 103*(1), 54–69. <https://doi.org/10.1037/a0028347>
23. Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software, 82*(13). <https://doi.org/10.18637/jss.v082.i13>
24. Lajoie, Y., Teasdale, N., Bard, C., & Fleury, M. (1993). Attentional demands for static and dynamic equilibrium. *Experimental Brain Research, 97*, 139–144. <https://doi.org/10.1007/BF00228824>
25. Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1990). Emotion, attention, and the startle reflex. *Psychological Review, 97*(3), 377–395.
26. Lebert, A., Vilarroya, O., & Stins, J. (2024). Stepping into emotions: investigating the effect of angry and fearful faces on forward stepping and quiet stance. *Frontiers in Human Neuroscience, 18*, 1411246. <https://doi.org/10.3389/fnhum.2024.1411246>
27. Lenth, R. V. (2020). *emmeans: Estimated marginal means, aka least-squares means* (Version 1.4.8) [R package]. Comprehensive R Archive Network (CRAN). <https://CRAN.R-project.org/package=emmeans>
28. Lepers, R., & Brenière, Y. (1995). The role of anticipatory postural adjustments and gravity in gait initiation. *Experimental Brain Research, 107*, 118–124. <https://doi.org/10.1007/BF00228023>
29. Lundqvist, D., Flykt, A., & Öhman, A. (1998). *The Karolinska Directed Emotional Faces (KDEF) [Database of facial expressions]*. Karolinska Institutet, Department of Clinical Neuroscience. <https://www.kdef.se>

Footnotes

1. KDEF faces: AF01, AF14, AF21, AF22, AF29, AM08, AM10, AM11, AM17, AM22.

References

1. Marsh, A.A., Ambady, N., & Kleck, R.E. (2005a). The effects of fear and anger facial expressions on approach- and avoidance-related behaviors. *Emotion, 5*(1), 119–124. <https://doi.org/10.1037/1528-3542.5.1.119>
2. Marsh, A. A., Adams Jr, R. B., & Kleck, R. E. (2005b). Why do fear and anger look the way they do? Form and social function in facial expressions. *Personality and Social Psychology Bulletin, 31*(1), 73–86. <https://doi.org/10.1177/01461672042713>
3. Mennella, R., Vilarem, E., & Grezes, J. (2020). Rapid approach-avoidance responses to emotional displays reflect value-based decisions: Neural evidence from an EEG study. *NeuroImage, 222*,

117253. <https://doi.org/10.1016/j.neuroimage.2020.117253>
4. Mirabella, G., Grassi, M., Mezzarobba, S., & Bernardis, P. (2023). Angry and happy expressions affect forward gait initiation only when task relevant. *Emotion, 23*(2), 387–399. <https://doi.org/10.1037/emo0001112>
 5. Mirabella, G., & Montalti, M. (2025). When do facial emotions impact inhibitory control and response readiness? A gateway to understanding emotion processing. *Neuroscience & Biobehavioral Reviews, 106*289.
 6. Palermo, R., & Coltheart, M. (2004). Photographs of facial expression: Accuracy, response times, and ratings of intensity. *Behavior Research Methods, Instruments, & Computers, 36*, 634–638. <https://doi.org/10.3758/BF03206544>
 7. Phaf, R. H., Mohr, S. E., Rotteveel, M., & Wicherts, J. M. (2014). Approach, avoidance, and affect: a meta-analysis of approach-avoidance tendencies in manual reaction time tasks. *Frontiers in Psychology, 5*, 378. <https://doi.org/10.3389/fpsyg.2014.00378>
 8. R Core Team. (2020). *R: A language and environment for statistical computing* [Computer software]. R Foundation for Statistical Computing. <https://www.R-project.org/>
 9. Rotteveel, M., & Phaf, R. H. (2004). Automatic affective evaluation does not automatically predispose for arm flexion and extension. *Emotion, 4*(2), 156–172. <https://doi.org/10.1037/1528-3542.4.2.156>
 10. Seidel, E.-M., Habel, U., Kirschner, M., Gur, R. C., & Derntl, B. (2010). The impact of facial emotional expressions on behavioral tendencies in women and men. *Journal of Experimental Psychology: Human Perception and Performance, 36*(2), 500–507. <https://doi.org/10.1037/a0018169>
 11. Seibt, B., Neumann, R., Nussinson, R., & Strack, F. (2008). Movement direction or change in distance? Self- and object-related approach–avoidance motions. *Journal of Experimental Social Psychology, 44*(3), 713–720. <https://doi.org/10.1016/j.jesp.2007.04.013>
 12. Stins, J.F., & Beek, P.J. (2011). Organization of voluntary stepping in response to emotion-inducing pictures. *Gait and Posture, 34*(2), 164–168. <https://doi.org/10.1016/j.gaitpost.2011.04.002>
 13. Stins, J. F., Lobel, A., Roelofs, K., & Beek, P. J. (2014). Social embodiment in directional stepping behavior. *Cognitive processing, 15*(3), 245–252. <https://doi.org/10.1007/s10339-013-0593-x>
 14. Stins, J.F., Roelofs, K., Villan, J., Kooijman, K., Hagenaaars, M.A., & Beek, P.J. (2011). Walk to me when I smile, step back when I'm angry: emotional faces modulate whole-body approach-avoidance behaviors. *Experimental Brain Research, 212*(4), 603–611. <https://doi.org/10.1007/s00221-011-2767-z>
 15. Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of social behavior. *Personality and Social Psychology Review, 8*(3), 220–247. https://doi.org/10.1207/s15327957pspr0803_1
 16. Wilkowski, B. M., & Meier, B. P. (2010). Bring it on: angry facial expressions potentiate approach-motivated motor behavior. *Journal of Personality and Social Psychology, 98*(2), 201–210. <https://doi.org/10.1037/a0017992>

17. Yiou, E., Gendre, M., Deroche, T., & Le Bozec, S. (2014). Influence of emotion on the biomechanical organization of backward and forward step initiation. *Motor Control*, *18*(4), 368–382.
<https://doi.org/10.1123/mc.2013-0015>