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# The impact of emotional videos and emotional static faces on postural control through a personality trait approach

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## Abstract

During social interactions, perception of emotions affects motor behaviour by triggering responses like freezing or approach and avoidance reactions. It is however difficult to get a clear picture of the relationship between emotion and posture as previous studies showed inconsistent results, due to methodological differences on stimuli and/or the postural measures used. In this study, we thoroughly investigate how the perception of emotions affects postural control and action tendencies, by contrasting two types of stimuli (emotional static faces or emotional videos) expressing different types of basic emotions (happy, fear, angry, sad, disgust and neutral). We also take into account some other contributing factors relying on stable individual traits (e.g., extraversion, neuroticism, conscientiousness, empathy, etc) and emotional state (e.g., anxiety). Our results show that dynamic stimuli have a greater impact than static stimuli on postural control. Moreover, a crucial aspect of our work lay in the modulation of the relationship between emotions and posture, by stable individual traits.

**Keywords** Posture · Postural control · Emotion · Personality traits · Approach avoidance

## Introduction

Emotions are inherently multi-componential and involve a set of cognitive, subjective, physiological and motor changes that depend on the value assigned to the contextual stimulus ('good for me versus bad for me') (Mauss et al. 2005). Thus, according to Ochsner and Gross (2014) emotion may be understood as a Perception-Valuation-Action sequence, in which the perceptual stage takes stimuli as inputs. Then, the valuation stage estimates the value of the stimuli according to the individual's current goals, context, experience or personality. Finally, the action stage comprises motor responses such as peripheral responses, facial expressions or postural adjustments. In this study, we focus on the impact of emotions on motor behaviour by looking at two different

aspects of postural adjustments: postural stability and action tendencies. Action tendencies are defined as the ways the body prepares itself to act through approach or avoidance behaviour (Lang et al. 1997; Frijda 2009). In this context, passive viewing task with postural recording is considered as an adequate method to examine the impact of emotion on postural control (Lelard et al. 2019). As action tendencies are most often unintentional and rapid, the measurement of the body sway of participants standing quietly and looking at emotional images has the advantage of being direct and objective. In order to measure postural stability and approach-avoidance action tendencies, previous studies have predominantly focused on the position of the Center of Pressure (CoP) that indicates in a single point the distribution of foot pressure on the ground (Hillman et al. 2004; Azevedo et al. 2005; Perakakis et al. 2012; Brandão et al. 2016). CoP displacements allow for the calculation of several postural parameters providing information on postural stability. Thus, the area covered by the displacements, the total sway path length and the standard deviations of CoP on the medio-lateral (SD-X) and the antero-posterior (SD-Y) axes provide information about the quality of postural stability. In addition, the mean speed of the displacements reflects the amount of energy that participants need in order to stabilize their posture.

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Several studies have investigated the impact of emotional stimuli on postural adjustments using these parameters. Most of these studies reported some reduced body sway indexed by smaller area, length and/or SD-X/SD-Y in participants who were exposed to unpleasant pictures as opposed to neutral and/or pleasant pictures (Azevedo et al. 2005; Facchinetti et al. 2006; D'Attilio et al. 2013). This effect was also reported by Stins and Beek (2007) but only with participants in unipedal position. In the same way, Hagenaaers et al. (2014) found a decrease in length when participants were shown unpleasant films, but not pleasant or neutral films. Finally, using faces, Roelofs et al. (2010) reported some significant decrease in the SD-Y in response to the angry expressions as opposed to happy and neutral expressions. Such reduced body sway was mostly interpreted as 'freezing behaviour' which can be described as a 'physiological and somatic preparation for physical movement' triggered by a stimulus that may be evaluated positively or negatively by the individual (Elliot 2006, p. 112). Freezing behaviour enables to first detect relevant information, then to mobilize the whole body, and ultimately to trigger 'fight or flight' behaviour (Lang and Bradley 2010). It should be noted, however, that some other studies have found contradictory results. Brandão et al. (2016) reported an increase in speed and length for both participants exposed to both pleasant and unpleasant films or pictures relative to neutral conditions. In addition, D'Attilio et al. (2013) noted an increase in area and speed when participants were shown pleasant pictures.

Beyond freezing, emotions can also trigger approach or avoidance behaviours, mainly examined through CoP mean position on the antero-posterior axis (CoP-Y). Previous studies demonstrated that mutilation pictures led to a posterior (avoidance) shift of the CoP position comparatively with neutral and/or pleasant stimuli (Hillman et al. 2004; Lelard et al. 2014). Perakakis et al. (2012) observed an avoidance of pleasant, unpleasant and neutral pictures. On the other hand, Eerland et al. (2012) identified an approach behaviour in response to pleasant pictures and an avoidance behaviour in response to unpleasant pictures, in comparison with the neutral condition. Gea et al. (2014) observed an increase in the amplitude of participants' forward body movements while exposed to dynamic happy faces in contrast with neutral condition. In doing so, they aligned in part with Eerland's results. Finally, Azevedo et al. (2005) and Stins and Beek (2007) observed little or no emotion effect on the CoP-Y.

The various studies presented above reveal inconsistent results that may be accounted for by differences in stimuli type. Most of the studies used static stimuli presenting scenes extracted from the IAPS database (Hillman et al. 2004; Azevedo et al. 2005; Facchinetti et al. 2006; Stins and Beek 2007; Eerland et al. 2012; Perakakis et al. 2012; D'Attilio et al. 2013; Hagenaaers et al. 2014; Lelard et al. 2014), or photographs of actors' faces conveying an

emotion at its peak (Roelofs et al. 2010). In experimental settings, emotions can also be represented in a multimodal and dynamic way. To that end, some authors used videos in order to question whether the results observable with static stimuli were replicable when viewing videos with emotional content. Such dynamic emotional content were presented either in morphing videos showing an actor conveying a neutral expression, gradually reaching the emotion of interest (Gea et al. 2014) or in short film scenes (Hagenaaers et al. 2014; Brandão et al. 2016). As stated by Gross and Levenson (1995, p. 88), 'films have a relatively high degree of ecological validity, in so far as emotions are often evoked by dynamic visual and auditory stimuli that are external to the individual'. Moreover, the technical elements that constitute films emphasize actions and emotional stimuli/content. Finally, most studies (i) either categorize emotions loosely into two types of stimuli, pleasant or unpleasant, thus preventing a finer categorization of emotions, or (ii) simply compare a limited number of expressions (for example, angry, happy and neutral).

Another contributing factor that may explain these inconsistent results is that some participants' characteristics are often overlooked. In particular, it has already been suggested that the participant's emotional state, such as anxiety and fear of falling, may have an impact on postural control (Lelard et al. 2014, 2019). Similarly, Roelofs et al. (2010) show the impact of the participant's state of anxiety on body sway. In their analysis of angry faces, they show that the more anxious the participant the shorter their body sway. Furthermore, aversive life events could enhance freezing response (Hagenaaers et al. 2012). Beyond the characteristics of the participant, stable individual traits may also influence the link between emotions and posture. To our knowledge, very few studies have examined this issue. One study, in particular, reports that high scores of 'Empathic Concern' correlate with increased amplitudes of forward body movements for happy faces and with increased body sway movements for pain faces (Gea et al. 2014). However, the two-factor personality model highlights the influence of other individual traits such as general approach and avoidance temperaments (Elliot 2006). Approach tendencies are found to be positively correlated with 'Extraversion' and 'Conscientiousness' (two terms designating the emotional reactivity to positive events as well as the pursuits of goals), which may be assessed with the Big Five self-report questionnaire (John et al. 1991). Conversely, avoidance tendencies are shown to be correlated with Neuroticism (Smits and Boeck 2006).

This study aims primarily to gain further knowledge of the impact of emotions on postural control. More specifically, this study investigates the effect of the stimulus type (static faces vs film videos) on postural stability (indexed by the length of the CoP displacements) and on approach or

avoid tendencies (indexed by the mean position of the CoP-Y). The relationship between emotions and posture is examined for the first time through six basic emotions (happiness, fear, anger, disgust, sadness and neutrality) incorporating several individual traits (e.g., extraversion, neuroticism, conscientiousness, empathy, etc). We explore how certain properties of the stimulus (videos vs faces) affect body sway in relation to the stimuli's emotional content. Finally, some crucial aspect of our work lies in the possibility of modulating the interplay between emotions and posture through the prism of individuals' traits.

## Materials and methods

### Participants

Eighty-six undergraduate participants in total participated in this study. Sixteen participants presenting a depression score over 17 at the Beck Depression Inventory (Beck et al. 1996) were not included from the study. This cut-off is used in studies involving emotions since the presence of significant depressive symptoms affects the recognition of emotions (Chaby et al. 2015; Dalili et al. 2015). Moreover, eight participants showed stabilometric parameters measures superior to three standard deviations from the group average and were excluded from the analyses below. Furthermore, we also inspected the individual time courses of the CoP-Y to remove data from six participants showing loss of postural stability due to erratic movements (self-touching, moving their lower limbs, etc). The data from fifty-six participants (40 females; 16 males) were then analyzed (mean age= 21.4  $\pm$ 2.8).

The study protocol was approved by the ethics committee from the Paris Descartes University (Reference No. IRB: 20130500001072). All participants were informed about the procedure prior to the experiment and provided their written informed consent. Participants received course credits for their participation.

### Self-report measures

Participants completed several questionnaires assessing different individual traits: the *Beck Depression Inventory-II scale* (Beck et al. 1996), measuring the intensity of depressive feelings, the *STAI-Y* (Spielberger 1993) evaluating anxiety trait and state, the *STAXI-II* (Spielberger 1999) measuring aggressivity score, the '*Empathy Quotient*' (Baron-Cohen and Wheelwright 2004) measuring social abilities and emotional reactivity, and the *BIG Five Inventory 10 items* (Rammstedt and John 2007) assessing 'Extraversion', 'Agreeableness', 'Conscientiousness', 'Neuroticism', and 'Openness' scores.

### Stimuli

Two types of stimuli were used in the study: emotional static faces and emotional videos.

Concerning the emotional static faces, ten different individuals expressing each six emotions (i.e., happy, fear, anger, sadness, disgust and neutral expression) were selected from the Ebner database (Ebner et al. 2010). The faces selected were young adults from category B of the database. Half of the individuals were young women and the other half were young men. Stimuli were presented in the center of the screen on a grey background and subtended a visual angle of  $6.4^\circ \times 10^\circ$ .

The emotional videos were selected from the Film-Stim database (Schaefer et al. 2010) that provided high resolution stimuli. A pre-test was conducted on 17 videos selected from the database. We chose two videos for anger and sadness, three for happiness, fear and disgust and four for neutrality. We only used 30 seconds of the video's original duration (see Table 1). All videos were evaluated by ten individuals who were requested to identify the emotion presented to them and to indicate the intensity for them on a 5-point rating scale (ranging from low intensity 1 to high intensity 5). We then selected six videos, one for each emotion, with a mean percentage of correct emotion identification of 98% ( $\pm$ 4) and a mean intensity score of 4.14 ( $\pm$ 0.33).

**Table 1** Details of the videos viewed by the participants

Emotions	Videos	Extract
Happy	Life is beautiful	A joyful little boy finds his mother at the exit of a concentration camp liberated by the US Army
Angry	Seven	Upon learning of his wife's death, a man goes furious at his murderer
Disgust	Trainspotting	A man is rummaging in the dirty water of an unsanitary toilet and then dives into the toilet bowl
Fear	Scream	A panicked young woman tries to escape from a hallway with few exits
Sad	Dangerous minds	A class of teenagers learns of the death of one of their classmates
Neutral	The Lover	A young girl leaving high school gets into a car driven by a chau.eur

## Data collection

A force platform (AMTI : AccuSway+®) was used to analyse the medio-lateral (ML) and antero-posterior (AP) displacements of the CoP. Data were collected at a frequency of 100 Hz. Faces and videos were projected on a Dell screen with a resolution of 1920 × 1200 pixels, placed at a distance of 1 meter from every participant and positioned at eye height.

## Procedure

The experimental task consisted of a passive viewing task: participants were instructed to remain standing when looking at the stimuli while their posture was recorded. The experiment was performed in a quiet room with a constant luminosity. The participants were submitted to 12 blocks (2 types of stimulus × 6 emotions). For the six blocks presenting emotional static faces, one block consisted of the presentation of the ten individuals expressing the same emotion. Each face appeared for 3 s and the order of appearance of the faces was randomized. The six other blocks then presented the six selected 30-s emotional videos, one block per emotion. The participants first viewed either the six blocks of faces or the six blocks of videos but the order of the emotion for each type of stimulus was pseudorandomized across subjects.

After the written consent form was signed, participants were placed on a force platform with their feet hip-width apart and their arms positioned along the body to maintain a comfortable posture. The position of each foot was marked on the platform to ensure the reproducibility of the posture. Then, participants were submitted to twelve experimental trials. One trial included the presentation of a white fixation cross on the screen center for 2 s followed by one of the twelve emotional blocks and by a 20 s empty gray screen. During this inter-trial interval, participants were instructed to categorize the emotion perceived using the predefined list of the six possible expressions, and to rate the intensity of that emotion on a 5-point scale (except for the neutral expression). A break of 15 min was included at the end of the sixth block during which the self-report measures were completed. The postural data were not recorded during the inter-trial intervals.

## Statistical analysis

To quantify postural performance, we analyzed the total sway path length of the CoP displacements (in mm), the mean position of the CoP on the antero-posterior axis (CoP-Y, in mm) and the standard deviation of the mean CoP-Y (SD-Y in mm). The length and the SD-Y can be used as a measure of postural immobility. The mean CoP-Y provided

information about the displacement toward, or away from, the stimuli, and may therefore be considered as an index of the action tendencies.

Postural parameters data were initially checked for normal distribution using the Shapiro-Wilk test. Our datasets were distributed normally with the exception of the SD-Y variable, which significantly deviated from a normal distribution. The CoP-Y and the length were analyzed using 2 (emotional static faces and emotional videos) × 6 (joy, fear, anger, sadness, disgust and neutral expression) separate repeated measures analyses of variance (ANOVAs). Huynh–Feldt corrections were employed to adjust to the violation of the sphericity assumption in testing repeated measures effects. To provide clarity, the uncorrected degrees of freedom were reported, with the *p* value associated with the Huynh–Feldt adjustment. Planned comparisons were used for paired comparisons. The effects of facial expression and stimulus type on the SD-Y were assessed using the Friedman test. Friedman post hoc were used for paired comparisons. To further explore the relationship between individual traits and postural parameters, Spearman correlations were computed. All the analyses were performed using R studio and JASP. A significance level of *p* = 0.05 was used for all statistical analyses.

## Results

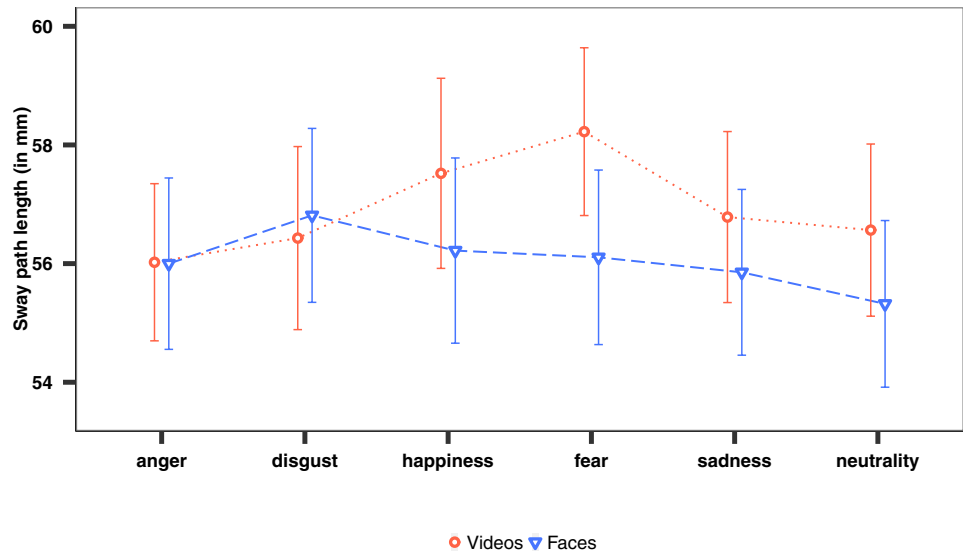
As the participants were likely to move on the medio-lateral and antero-posterior axes during the presentation of the initial fixation cross, the data were baseline-corrected. All trials started from the same (0.0) coordinate at the beginning of the emotional stimuli presentation. It is worth noting that the order of presentation of the blocks did not have any effect on postural parameters nor did they interact significantly with the stimulus type and the emotions for any of the analyzed postural parameters.

### Postural stability

The ANOVA performed on the total sway path length did not show any effect of emotions ( $F(5, 275) = 1.95$ ,  $p > .05$ ), but a marginal effect of stimulus type ( $F(1, 55) = 3.79$ ,  $p = 0.057$ ) indicating that the instability reflected by the increase in the sway path length seemed to be higher for videos (569.25 mm ± 10.45) than for faces (560.52 mm ± 10.38). Interestingly, the emotions \* stimulus type interaction was significant ( $F(5, 275) = 2.36$ ,  $p < 0.05$ ), see Fig. 1. Planned comparisons showed that the increase in the sway path length for videos compared to faces was only significant for the fear emotion ( $p < 0.005$ ). The differences in length between videos and faces for happy and neutrality failed to reach significance



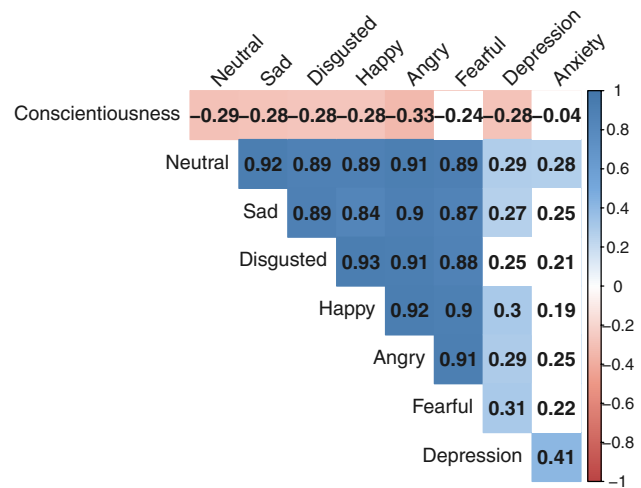
**Fig. 1** Mean and standard error for sway path length in videos and faces conditions for six emotions (anger, disgust, happiness, fear, sadness and neutrality)



( $p = 0.065$ ;  $p = 0.078$ ). Within the videos, several emotions differed significantly from each other. Both the happy and the fear videos differed from videos of anger, disgust, sadness and neutrality ( $p < 0.05$ ;  $p < 0.001$ ), with a higher length for happy and fear videos than for the other emotions. The happy and the fear videos did not differ from each other ( $p > 0.05$ ).

We further examined whether individual traits might modulate the postural stability of participants. To do this, we examined correlations between the total sway path length recorded in front of faces or videos with scores obtained from the different self-report measures. Significant correlations between the BDI, the BFI conscientiousness scores and the anxiety state were reported in Fig. 2 and in Fig. 3 showing correlation matrices obtained for the sway path length. These correlations underline the congruence of the postural behavior through emotions for faces and for videos. Hence, the more unstable participants were while being exposed to an emotion, the more unstable they were when faced with other emotions (all  $p < 0.001$ ). More interestingly, postural stability was deemed to be related to depressive symptoms, conscientiousness and anxiety state scores. Indeed, the fewer depressive symptoms participants had (BDI-II), the more stable they were in response to anger, fear, happy, sadness, neutral videos and faces, and in response to disgust videos and marginally for disgusted faces.

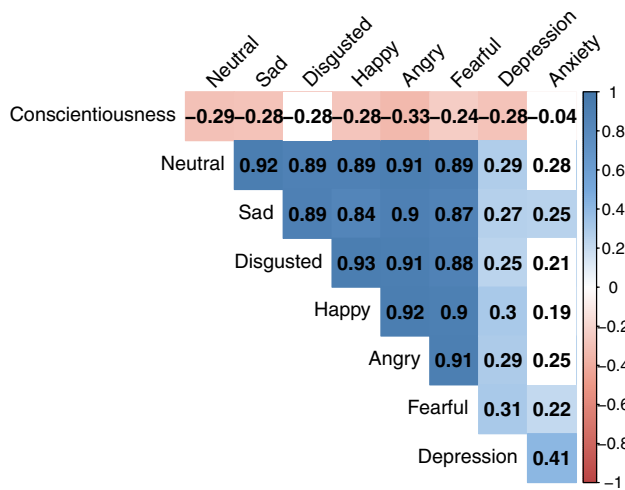
Furthermore, the more impulsive participants were (low BFI conscientiousness score), the more unstable they were when exposed to angry, happy, sadness, neutral videos and faces, or to disgusted faces and fear video. Finally, the higher the anxiety state score, the more unstable participants were in response to fear and sad videos, and marginally in response to angry and sad faces.



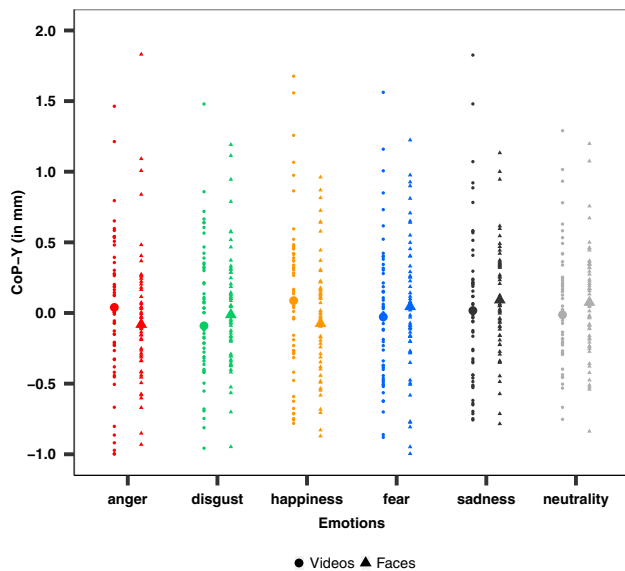
**Fig. 2** Spearman's correlations between sway path length in response to each emotional static faces condition (neutral, sad, disgusted, happy, angry and fearful) and some individual traits/emotional state (mild depressive symptoms, conscientiousness and anxiety state). The correlation coefficient is indicated in bold in the boxes, the colour gradient of the box corresponds to the strength of the correlation. A white box corresponds to a non-significant correlation

### Postural variations around the AP axis

As both stimuli characteristics and individual traits affected the overall postural stability, it remained to be seen whether these metrics would also affect the approach-avoidance tendencies indexed by the mean position of the CoP-Y. The ANOVA performed on the mean CoP-Y position did not show any significant effect due to emotion or stimulus type (all  $F_s < 1$ ) or any interaction between these two factors ( $F(5, 275) = 1.78, ns$ ). However, as shown in Fig. 4, this lack of effect may be explained by the variability between- and



**Fig. 3** Spearman's correlations between sway path length in response to each emotional videos condition (neutral, sad, disgusted, happy, angry and fearful) and some individual traits/emotional state (mild depressive symptoms, conscientiousness and anxiety state). The correlation coefficient is indicated in bold in the boxes, the colour gradient of the box corresponds to the strength of the correlation. A white box corresponds to a non-significant correlation



**Fig. 4** Mean and individual CoP-Y in videos and faces conditions for six emotions (anger, disgust, happiness, fear, sadness, neutrality)

within participants with approach (positive CoP-Y) and avoidance (negative CoP-Y) behaviours differing widely between emotions and stimulus type. Interestingly, some correlations between CoP-Y and individuals traits emerged. So, the higher the extraversion score (BFI Extraversion), the more participants moved away from fear video ( $r = -0.28, p < 0.05$ ) and angry faces ( $r = -0.36, p < 0.01$ ). In addition, the more emotionally unstable participants were

as indexed by high BFI neurotic score, the more they moved away from anger video ( $r = -0.26, p = 0.05$ ) and fearful faces ( $r = -0.29, p < 0.05$ ). Finally, the better the understanding of others' emotions (EQ Cognitive Empathy) and the higher the emotional responsiveness score (EQ Emotional Responsiveness), the more participants moved away from anger video ( $r = -0.29, p < 0.05$ ) and disgusted faces ( $r = -0.28, p < 0.05$ ), respectively.

The lack of overall effects on approach and avoidance behaviours may also be explained by the postural variations around the AP axis objectified by the SD-Y. The Friedman test did not reveal any effect due to emotions ( $p > 0.05$ ) but yielded some significant effect of stimulus type on SD-Y [ $\chi^2(1) = 7.14, p < 0.01$ ]. SD-Y was significantly higher for videos ( $3.84 \text{ mm} \pm 1.46$ ) compared to faces ( $3.72 \text{ mm} \pm 1.73$ ). Furthermore, consistent with the results on the mean CoP-Y, the better the understanding of other people's emotions (EQ Cognitive Empathy), the greater the instability was around the AP axis in response to fear video ( $r = 0.30, p < 0.05$ ) and in response to angry ( $r = 0.44, p < 0.001$ ) or to disgusted ( $r = 0.27, p < 0.05$ ) faces.

### Discussion

This study aimed to explore the impact of two types of stimulation (emotional videos and static emotional faces) and of basic emotions (happiness, anger, sadness, fear, disgust and neutrality) on postural stability and action tendencies. The originality of this study resides in the use of stimuli having different properties and conveying a large panel of emotions. Research on the subject has been mostly restricted to a limited number of emotions, which do not allow for a fine categorization of the impact of emotion on posture. Finally, a crucial aspect of our work lies in the study of potential modulations between emotions and posture, by considering stable individual personality' traits and emotional states. To study this, participants' postural oscillations were measured using a force platform while viewing emotional static faces and emotional videos. Questionnaires were used to assess the participants' personality traits and emotional state. Our results provide evidence of some effect of the stimulation type on global postural stability, with a higher length in response to videos, but less so to faces. This postural stability parameter correlated with some individual traits and emotional state. Conversely, contrary to our original hypotheses we did not observe any significant effects of the stimulus type or emotions on the mean CoP-Y position. This might be explained in part by the inter- and intra-individual dispersion, which we explored on the one hand through the study of the SD-Y showing a more significant postural instability in front of videos than faces and on the

other hand through the correlations with personality traits and emotional states.

Our results provide evidence that properties of the stimulus (videos *vs* faces) affect global postural stability. In fact, a higher length was observed in response to videos. Possible explanations for these discrepancies may be related to the presence of perceptual cues that can influence postural control, such as the presence of background noise, protagonists' voices, or camera movements. Raper and Soames (1991) reported an impact of the sound source on postural sway owing to the fact that the auditory field is a background conversation instead of being a pure tone. Stoffregen et al. (2007) observed a decrease in the variability of postural sway when viewing a moving target compared to a stationary target. In addition, it was shown that the pattern of eye movement was different when exploring dynamic scenes rather than static stimuli with longer fixation durations and larger saccade amplitudes (Smith and Mital 2013). This can therefore have an influence on posture (Rodrigues et al. 2013). However, these explanations are not totally satisfying in the context of our study since the difference in postural stability observed with videos, and in comparison with faces, was limited to fear and was marginal for the happiness emotion and the neutral expression.

The postural stability discrepancies between videos and faces could also be explained by the fact that complex and dynamic stimuli may lead to more unstable postures (Laurens et al. 2010). Indeed, the processing of a complex stimulus involves increased attentional demand, which may induce a decrease in the cognitive capacities available for postural stability, and thus lead to more postural oscillations (Huxhold et al. 2006). In addition, films may lead to greater motor and emotional engagement of the viewer. This phenomenon may be akin to the emotional contagion, which can be defined as an affective state that matches other people's emotional display (Hess and Blairy 2001). Several studies have reported an increase in brain activations dedicated to mirror neurons or greater emotional contagion in response to dynamic emotional faces compared to a neutral condition, or to static faces (Hess and Blairy 2001; Trautmann et al. 2009). The observer's involvement may also vary on the direction of the emotion. These elements support Frijda's 'environmental expectation' hypothesis (Frijda 1953). Emotional facial expressions and the direction of those emotions towards an observer or their environment, are crucial clues since they simultaneously allow for the evaluation of others' intentions and the detection of external clues that may be favorable to the observer or may constitute a threat. The increased postural instability in response to the fear video relative to the fearful faces seems to be consistent with these hypotheses. Thus, a fearful face with a direct gaze indicates that the threat potentially comes from the observer, which does not constitute a threat to himself. Conversely, the fear

video introduced a young woman running away, repeatedly looking behind her. The threat would come directly from the environment and could potentially be a threat to the viewer. In this context, participants experienced first-person action. This may explain why our results do not match those of D'Attilio observing a freezing behaviour in response to images of attacks where the participant remains a spectator of the scene (D'Attilio et al. 2013). In accordance with our results on happiness, several authors have also observed some emotional contagion in response to videos clips and especially in response to happiness (Hess and Blairy 2001; Harada et al. 2016). A decrease of the length were observed on the other emotions, which is consistent with several studies reported a decrease in some postural parameters (such as area, length, speed or SD-Y) in front of pictures or videos of attacks, mutilation and sadness (Azevedo et al. 2005; Facchinetti et al. 2006; Stins and Beek 2007; D'Attilio et al. 2013; Hagenars et al. 2014).

In addition, some links between individual traits and global posture could be established. More specifically, several correlations were found between sway path length and presence of mild depressive symptoms, conscientiousness and anxiety state. A low score on the depression scale predicted better postural stability in almost all conditions. Although we did not include participants with depression, this observation is consistent with Radke's idea of an association between depressive symptoms and behavioural adjustment difficulties in response to emotional expressions (Radke et al. 2014). The set of stimuli in our study involves a social dimension (faces, conversations, interaction between different protagonists), inducing an attentional cost all the more important in participants whose social sphere is impacted. Aligned with this phenomenon, our results also emphasized that individuals with low conscientiousness score (i.e., more impulsive individuals) were more unstable (except for fearful faces and disgust video). Fearful faces and disgust video may have induced some freezing effect in these participants, as several studies focusing on responses to unpleasant stimuli have demonstrated in recent years (Azevedo et al. 2005; Stins and Beek 2007; Hagenars et al. 2014). Finally, individuals with high anxiety-state level were more unstable when exposed to sad or fear videos and to neutral, angry or sad faces. A similar study also established a link between the anxiety state of the participants and the increase in postural instability parameters such as surface area and length (Ohno et al. 2004). Other studies have shown that anxious participants would pay more attention to facial expressions than non-anxious participants (Li Wanyue 2019) and would avoid eye contact (Green and Guo 2018). Correlations between the anxious state and the emotion of sadness can be explained by the ambivalent nature of sadness. Indeed, sadness can be perceived as an emotion that must be avoided by some individuals. In other contexts, sadness may



be perceived as a form of psychological distress, generating empathy and a tendency to approach, as well as expressions of physical pain (Gea et al. 2014). In anxious individuals, the emotion of sadness can therefore lead to a cognitive and postural conflict leading them to either approach the face to help the person or, on the contrary, to avoid it, thus affecting their postural stability. The increase in postural instability in response to the fear video and angry faces, which may be the most 'threatening' conditions for anxious participants, further supports the 'environmental expectation' hypothesis. Finally, participants with high anxiety-state scores appeared to be unstable in response to neutral faces. Tronick's research on still faces showed that a neutral expression may conceal some negative meaning (Tronick et al. 1998). Hence, these different elements question the potential effect of the neutral condition as a control condition.

Considering the impact of stimulus type and emotions on postural variations around the antero-posterior axis, this study did not identify any effect of these factors on the mean CoP-Y position. These results are in line with previous studies showing little or no effect of emotions on CoP-Y (Azevedo et al. 2005; Stins and Beek 2007; Horslen and Carpenter 2011). Stins and Beek (2007) reported a modest forward shift of the CoP-Y in front of neutral and unpleasant images and no effect for pleasant pictures. Azevedo et al. (2005) and Horslen and Carpenter (2011) did not observe an emotions effect on the CoP-Y in front of pleasant and unpleasant stimuli. However, posturographic responses to emotional pictures/videos are rather inconsistent across studies. These inconsistent results may be attributed to the diversity of methodological resources such as stimulus types (static faces, dynamic faces, IAPS pictures, videos), stimuli exposure durations, postural tasks (passive viewing, lateral movement, maintaining a forward posture). While some authors addressed the avoidance of images of mutilation in participants (Hillman et al. 2004; Lelard et al. 2014), others observed the avoidance of pleasant, unpleasant (i.e. mutilation) and neutral pictures (Perakakis et al. 2012). Eerland et al. (2012) reported some approach behaviours during passive viewings of pleasant images and noted avoidance of unpleasant images (i.e. sad and scared people) as participants made some lateral moves. Finally, Gea et al. (2014) identified some approach behaviours in response to happy dynamic faces. The absence of approach or avoidance behaviours through the examination of the CoP-Y in our study may be partially explained by the presence of inter- and intra-individual dispersion. The effect of the type of stimulation on SD-Y partly supports this hypothesis. Indeed, a variability around the mean position of the CoP-Y was observed (SD-Y), which was significantly greater with videos than with faces. This effect appeared consistent with the increase in the attentional cost when the stimulus is more complex, in this case videos compared to faces. The effect of

stimulus type or emotions on the mean CoP-Y position may have been masked by substantial inter-individual postural variability on the Y-axis. On the other hand, the existence of correlations between directional postural parameters (i.e. CoP-Y and SD-Y) and some individual traits point out to variabilities in individuals. Extraversion and neuroticism scores were negatively correlated with mean CoP-Y position in response to several conditions. Extraversion refers to being sociable, optimistic, active and is related to potential rewards. Conversely, individuals with a high neurotic score seem to be anxious, hypersensitive to negative/stressful events and would rather activate avoidance, withdrawal or flight behaviours. The higher the extraversion score of the participants, the more they moved away from the fear video and angry faces. Also, a high score for neuroticism predicted avoidance of the anger video and fearful faces. In addition, the more emotionally responsive (i.e., emotionally sensitive) participants were, the more they moved away from disgusted faces. The emotion of disgust is associated with a potential threat to the viewer and may therefore lead to an avoidance response (Sawchuk et al. 2002). Finally, the higher the cognitive empathy score (indicating a good understanding of emotions), the more participants moved away from anger videos and oscillated around the Y-axis in response to fear video, angry and disgusted faces.

## Conclusion

This study aims to deepen the knowledge of the effects of stimulus type and emotions on postural stability and action tendencies taking into account individuals' traits and emotional states. This study also demonstrates that postural stability is impacted by the properties of stimuli (emotional videos vs emotional static faces) and the emotion conveyed by those stimuli. Similarly, it emphasizes the role of individual traits as potential modulators of postural stability, such as mild depressive symptoms and conscientiousness as well as the individual's own emotional states, such as their state of anxiety. No effect of stimulus type or emotions on approach and avoidance action tendencies could be observed. As suggested by Stins and Beek (2007) study, one hypothesis that may explain the absence of emotions effect on action tendencies in our study could be that passive viewing of images / videos is only weakly coupled to posture. Alternatively, this may also be due to variations in postural oscillations around the antero-posterior axis, which proved to be more significant in response to videos than to faces. In addition, individual traits such as extraversion, neuroticism and empathy appeared to modulate the participants' approach and avoidance tendencies. According to the Perception-Valuation-Action model (Ochsner and Gross 2014), the valuation stage depends on several factors,

including the individual's personality traits and emotional state, which play a key role in action tendencies.

These findings point out the importance of considering various factors when examining postural control such as certain stimulus properties (videos vs faces), fine categorization of emotions, individual traits and emotional states. Several questions remain unanswered at this point. Further work therefore needs to be done to investigate the impact of other factors on postural control. The environment, in particular, is deemed to play an essential role in the interpretation of emotions and contextual clues such as the interpersonal distance that may affect postural control. Adding an additional clue such as the congruence between the emotion carried by others and their approach or avoidance movement could trigger stronger action tendencies in the observer.

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### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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