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Mood induction through imitation of full-body movements with different affective intentions

Eva-Madeleine Schmidt[1,2,3] | **Rebecca A. Smith**[4] | **Andrés Fernández**[5] | **Birte Emmermann**[6] | **Julia F. Christensen**[1,2]

[1]Department of Cognitive Neuropsychology, Max-Planck-Institute for Empirical Aesthetics, Frankfurt am Main, Germany

[2]Department of Language and Literature, Max-Planck-Institute for Empirical Aesthetics, Frankfurt am Main, Germany

[3]Max Planck School of Cognition, Leipzig, Germany

[4]Institute of Neuroscience and Psychology, University of Glasgow, Glasgow, UK

[5]Centre for Vision, Speech and Signal Processing, University of Surrey, Guildford, UK

[6]Chair of Ergonomics, Technical University of Munich, Munich, Germany

Correspondence
Julia F. Christensen, Max-Planck-Institute for Empirical Aesthetics, Grüneburgweg 14, Frankfurt am Main 60322, Germany.
Email: julia.christensen@ae.mpg.de

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Abstract

Theories of human emotion, including some emotion embodiment theories, suggest that our moods and affective states are reflected in the movements of our bodies. We used the reverse process for mood regulation; modulate body movements to regulate mood. Dancing is a type of full-body movement characterized by affective expressivity and, hence, offers the possibility to express different affective states through the same movement sequences. We tested whether the repeated imitation of a dancer performing two simple full-body dance movement sequences with different affective expressivity (happy or sad) could change mood states. Computer-based systems, using avatars as dance models to imitate, offer a series of advantages such as independence from physical contact and location. Therefore, we compared mood induction effects in two conditions: participants were asked to imitate dance movements from one of the two avatars showing: (a) videos of a human dancer model or (b) videos of a robot dancer model. The mood induction was successful for both happy and sad imitations, regardless of condition (human vs. robot avatar dance model). Moreover, the magnitude of happy mood induction and how much participants liked the task predicted work-related motivation after the mood induction. We conclude that mood regulation through dance movements is possible and beneficial in the work context.

KEYWORDS

affect, avatar, bodily expression, dance, embodiment, human–avatar interaction, mood regulation, movement

INTRODUCTION

Being able to regulate one's mood in everyday life has many benefits such as facilitating cognitive processes and enhancing psychological well-being (Jeon, 2017; Restubog et al., 2020; Rowe et al., 2007). Research has shown that there is a relationship between mood and cognitive processes like attention, information processing and judgement (Cacioppo & Gardner, 1999; Jeon, 2017; Vallverdú & Trovato, 2016). Positive affect increases cognitive flexibility and creative thinking and leads to a greater breadth of attentional allocation (Rowe et al., 2007). Negative affect stimulates mainly local processing (Jeon, 2017). These observations indicate that mood regulation (in both directions) can modulate how we interact with our environment and can influence our performance. Thus, leveraging mood regulation as an instrument to optimize cognitive processes has clear benefits for individuals, for instance, in the workplace. Nevertheless, ergonomics and human factors research have been focusing on effectiveness and efficiency, largely disregarding the influence of affect (Eccles et al., 2011; Jeon, 2017; McLoone et al., 2012).

Furthermore, it has been argued that the ability to regulate one's mood may mitigate negative mental health consequences of situations where we cannot rely on human proximity and physical contact for support in regulating our affective states (e.g. social isolation, travelling, a pandemic, etc.; Restubog et al., 2020). This calls for mood regulation strategies that do not depend on human proximity and, hence, attract attention to assistive software interfaces, or, for that matter, the avatars embedded in these technologies. This consideration dovetails with growing research efforts in human–machine interfaces and emotions applied to robots and software applications (Shibata et al., 1997; Vallverdú & Trovato, 2016).

These aspects emphasize the need for new strategies in the field of mood regulation and solutions that can support people in regulating their affective states in a purposeful way. This can be used for the targeted facilitation of cognitive processes at work or in the context of improving and/or maintaining personal psychological well-being in a situation of social isolation. Here, we propose to use full-body dance movements performed with different affective expressivity for mood regulation. If successful, such movements embedded in a technological tool (e.g. set-up in an app) may provide an efficient solution to the problems described above.

We follow the definitions proposed by Gross (2015), where affect refers to the superordinate category for valenced states, comprising emotions and moods. Moods are of longer duration and of less intensity than emotions (Gross, 1998, 2015; Larsen, 2000). Moods often do not refer to and are not directed towards specific objects or events, whereas emotions are often understood as having a defined cause and object of reference (Gross, 2015; Larsen, 2000; Manstead & Fischer, 2000). A shared characteristic of mood and emotions is expression. However, it is argued that moods are expressed more through the body, for example, through postural changes or full-body movements (Larsen, 2000). Because moods and emotions can be seen as two entities of the same superordinate category (affect), it is argued that they do not represent two entirely separate constructs but, in essence, have common characteristics (Larsen, 2000). For this reason, research on emotions is also referenced here to support the discussion of this topic, and affect is used as a superordinate concept of both constructs.

Mood regulation refers to the process of changing the valence of one's affective state to another, by choosing to engage in specific activities (Carver & Scheier, 1990; Manstead & Fischer, 2000). Common strategies for mood regulation are physical exercise, improved diet and pleasure-seeking (Gross, 2002; Larsen, 2000). Carver and Scheier (1990) assume that such behaviours can reduce discrepancies between a desired subjective state (set point) and the current state via a negative feedback loop. This theory is often limited to strategies focusing on one direction – from a negative to a positive mood (Manstead & Fischer, 2000) – neglecting the equally conceivable regulation towards a negative mood. A study on mood regulation should ideally test whether this theory applies to both directions of valence. Negative mood is not bad per se: some research shows that negative mood can, under some circumstances, enhance cognitive processes including focused information processing (Jeon, 2017) and creativity (Bledow et al., 2013).

Yet, it should be noted that in these experiments, the conclusion is often that negative mood should ideally be followed by a positive mood (Bledow et al., 2013).

By comparison, *emotion regulation* refers to the process by which individuals actively change their emotions, how they experience their emotions and how they express them. The most distinguished strategies for emotion regulation are situation selection, situation modification, attentional deployment, cognitive change and response modulation (Gross, 1998, 2015; Koole, 2009). In the context of this project, the method proposed (mood regulation via imitation of whole-body movements with different intended affective expressivity) is not directed toward specific objects or events, and, therefore, corresponds by definition to mood regulation.

In what follows, we will give an overview of the previous literature that leads us to the hypotheses of the current project. First, we assess previous findings on the relationship between affect and full-body movements and outline why we believe that movement may be used for mood regulation. We then discuss the advantage of dance as a special form of full-body movement with affective expressivity. Finally, we address research on human-machine interaction and avatars in the context of the above, when being embedded in a digital intervention tool.

Can performing movements with affective expressivity provide sufficient meaningful sensory input to the brain to change one's affective state, and, thus, be a promising approach to mood regulation? The following observations and theoretical accounts suggest that the answer to this question may be positive. Mood induction has a long tradition in experimental psychology (Gerrards-Hesse et al., 1994; Westermann et al., 1996; for a review see: Gilet, 2008) and previous work has provided valuable first results using emotion induction procedures (which are different from mood induction; we will elaborate on this difference later) to alter research participants' currently experienced emotions (Shafir et al., 2013, 2016). In Dialectical Behavioural Therapy (DBT) the imitation of facial expressions, such as smiling, is used as an interventional tool to promote emotion regulation. Building on the assumptions of DBT, Shafir and colleagues' work (2013, 2016) showed that the motor execution of emotional actions with full-body movements (e.g. jumping for joy, sinking to the floor in sadness) can make the expressor feel the corresponding affective state. While the execution of happy actions significantly enhanced positive affect, the performance of sad actions significantly increased sadness. As a result, the authors argue in favour of the possibility that affect regulation may be possible through the execution of full-body movements. The strength of the potential effect of such movements on the individual's affective experience was emphasized by the result from two other conditions in the same study: the mere imagination and observation of emotional actions enhanced the corresponding emotions in the person imagining or observing the emotional action (Shafir et al., 2013).

Darwin (1872/2009) famously identified a series of emotion-specific nonverbal body movements which are recognized by same-species individuals fast and universally, as part of the organism's survival strategy. Modern work from experimental psychology, including that of Wallbott (1998) has since reported that indeed distinctive patterns of movement and posture are associated with the expression of some emotions. However, in the realm of empirical research, much research has focused on facial expressions of affect and universals regarding such portrayals (Asthana & Mandal, 1997; Barrett et al., 2019; Cowen & Keltner, 2020; Ekman & Friesen, 1971; and discussed in: De Gelder, 2009). The past two decades have seen repeated calls to extend this work to the domain of full-body movement (De Gelder, 2006, 2009; Tamietto & De Gelder, 2010). Research using stimuli of full-body movements and postures of actors and actresses portraying various emotions, recorded on video or image, has shown that some portrayals are specific to at least some emotions and are recognized by human observers fast and universally (Atkinson et al., 2004). Further research has provided data to suggest that there are emotion-specific patterns in full-body movements. Dael et al. (2012) found that consistent patterns of bodily sensations are associated with distinct emotions, and Nummenmaa et al. (2014) found that distinct bodily sensations are associated with both basic and complex emotions. Research in modern neuroscience has informed several theories of human emotion, some of which emphasize the relation between body movements and affect. According to the theory of constructed emotion (Barrett, 2017), our emotions and moods are the result of concepts that are constructed in our brain to categorize, identify, and understand sensory inputs, including those that stem from proprioceptive and interoceptive feedback. Besides, the theory holds that the same interoceptive response may be categorized affectively in different ways, dependent on the situation and the cognitive evaluation that we make about the situation implicitly or explicitly in a top-down kind of way (Barrett, 2017; Barrett et al., 2019). The somatic marker hypothesis by Damasio et al. (2000) suggests that the same brain structures engaged in affective processing also are direct and indirect recipients of signals from the internal milieu, viscera, and musculoskeletal frame (hence, susceptible to modulations through full-body movement). The neural activation patterns of these structures represent the internal state of the organism by means of multidimensional maps. It is believed that these, in turn, represent unconscious affective states that guide behaviour and correlate with their conscious feeling of them (Damasio et al., 2000).

These conjectures have been interpreted to mean that emotions can be embodied through physical movements (Niedenthal, 2007; Nummenmaa et al., 2014), as it has been found that execution, observation (perception), and thinking about emotions comprises perceptual, somato-visceral, and motor re-experiencing (Niedenthal, 2007; also discussed in: Reed et al., 2020). Therefore, the, arguably, close connection between affect and body movements has repeatedly been stressed (De Gelder, 2009; Frijda, 1988; Nony, 1922; Shafir et al., 2013; Tomkins, 1995). This research from the past three decades in the field of emotion psychology and affective neuroscience provides the empirical basis for the proposal that there is a connection between how we feel and how we move our bodies. In our everyday life, our bodies move constantly in the context of social interactions and the dynamics usually increase when we are experiencing specific moods and emotions. Indeed, considerable evidence suggests that our affective states are related to physiological changes in our bodies (Barrett, 2017; Damasio et al., 2000; Kreibig, 2010; Niedenthal, 2007; Nummenmaa et al., 2014; for a review see: De Gelder, 2009). Nonetheless, the opposite process, how affective expressions – that we may willingly perform through full-body movements and posture – relate to how we feel, has received relatively little research attention (Shikanai et al., 2013).

Even though these findings suggest that there is a relationship between affect and full-body movements, it is still to be empirically established whether this connection between affect and its corporeal expressions through full-body movements can be used specifically for the modulation of sensory inputs – through full-body movements – to influence individuals' subjective affective states. *Power posing* is a position where the individual chooses to stand with their feet positioned beyond hip-width, arms spread out wide and above the head and chest puffed. This position is hypothesized to signal power to others, and through proprioceptive feedback, also to oneself. Research on power posing provides first results that proprioceptive feedback from our muscles in specific positions can influence our affective states. Besides, it has been shown that assuming this body position of power can impact behaviour positively (e.g. performance at a job interview [Cuddy et al., 2015], general mood [Cuddy et al., 2018; Nair et al., 2015; Welker et al., 2013] and improve well-being for patients in the clinical context [Weineck et al., 2020]). Assuming that this position has also been found to induce hormonal and visceral changes (Carney et al., 2010, 2015; Laborde et al., 2019; Minvaleev et al., 2004; Nair et al., 2015). Even though some studies could not replicate these findings (Davis et al., 2017; Smith & Apicella, 2017), and this research has given rise to some controversies (Cuddy et al., 2018; Simmons & Simonsohn, 2017), the evidence does suggest that musculoskeletal states influence affect via proprioceptive mechanisms (Minvaleev et al., 2004; Nair et al., 2015).

The above suggests that the targeted manipulation of sensory input through the movements we perform with our body (bottom-up), including *intending to make our movement look or feel like a specific affective state* (happy/sad; top-down) may be used for mood regulation. Applied to the workplace, for instance, this may be used to positively affect performance.

We will use mood induction, to extend the work by Shafir and colleagues reviewed above which suggests that performing full-body movements with affective expressivity may be a promising strategy for mood regulation. Mood induction employs techniques such as visual stimuli, autobiographical recall, situational procedures and music to induce specific affective states (Blatz, 1925; for a review see: Siedlecka & Denson, 2019). As Shafir and colleagues, we will be using full-body movements. However, instead of using different full-body *actions* to express different emotions (e.g. jumping for joy, sinking to the floor in sadness, etc.), we will use a procedure from the realm of dance practice. This procedure consists of using the same sequence of dance movements to express different emotions (Christensen et al., 2018; Christensen, Azevedo, & Tsakiris, 2021; Smith & Cross, 2021) and can be compared to repeating the same verbal sentence with different verbal affective expressivity by modulating how the sentence is pronounced. The advantage of this procedure is that individuals only need to learn one sequence which may be used for mood regulation in both directions (positive and negative). Besides, in keeping with our aim to help develop a mood regulation tool, *dancing* a movement may be more entertaining than performing simple emotional actions for mood regulation (e.g. sinking to the floor in sadness or jumping of joy). Thus, we will examine whether imitating short dance movement sequences with different affective expressivity (albeit without music in this case) from a teacher on a computer screen can be used as a strategy for mood regulation.

In addition, this project aims to explore a pertinent research question from the domain of human–machine interaction (more specifically, human–avatar interaction) which regards the usefulness of different visual presentations as 'teachers' or models to imitate such full-body movements from. The question of whether it makes a difference to human observers when imitating a human avatar or a robot avatar teaching these movements still requires further research (for first assessments of this question, see Blackler et al., 2019). Some research has found that dynamic facial expressions of emotions, for example, can elicit similar reactions in humans when performed by humans and human-like avatars (Johnson et al., 2018; Kegel et al., 2020; Moser et al., 2007).

The effectiveness of interventions with such avatars could be shown in a wide range of applications suggesting that avatars can be used as intervention tools. For example, An et al. (2013) found that an avatar-hosted behaviour change intervention led to positive changes in young adults with regards to health-related behaviours such as abstaining from smoking or exercising more. An intervention for children with autism spectrum disorder showed that a computer-based program with an avatar assistant led to positive effects on emotion recognition and social interaction skills (Hopkins et al., 2011). Compared to humans, computer-based systems with avatars as interaction partners for human offer the advantage of being constantly available and showing constant performance. Further, avatars can easily be adapted to users' specific needs and preferences. Therefore, investigating avatar-based stimuli or models to imitate mood induction through dance movements will offer additional insights into how the human-likeliness of such an avatar is related to its usefulness, its liking and the degree to which interactors are attentionally engaged.

Another variable of interest in the context of this work is motivation. Especially, in the workplace, motivation is an aspect that is of great importance. For instance, in two large samples ($N=826$ and $N=302$), researchers found that motivation positively influenced employee work performance and quality (Dysvik & Kuvaas, 2011; Kuvaas & Dysvik, 2009). To investigate whether the imitation of dance movements with affective expressivity modulates motivation, we will include a pre- and post-assessment of participants' level of motivation and include this variable for additional exploratory analysis.

Summing up, we hypothesize that if an individual first learns a movement sequence and then performs it repeatedly, intending different affective expressivity (i.e. happy or sad), this may contribute to regulate their mood. The ultimate goal is to provide the empirical basis for a dance-based online mood regulation tool which is to be grounded precisely on such a process. The focus will be on the induction of mood through full-body dance movements with affective expressivity, following the assumptions of the somatic marker hypothesis (Damasio et al., 2000), and related theoretical conjectures (Barrett, 2017; Minvaleev et al., 2004; Nair et al., 2015) positing that our affective states – also – arise from somato-visceral feedbacks from the movements of our bodies. Previous research has shown that the imitation of emotion-specific movements has led to the induction of the corresponding emotions (Shafir et al., 2013). We here hope to provide empirical evidence for these two research questions:

(i) Can different mood states be induced through the imitation of short sequences of dance movements with different intended affective expressivity?
(ii) Is there a difference in mood regulation when movements are imitated from a human dance avatar versus from a robot dance avatar?

Thus, we hypothesize that

Hypothesis 1. The imitation of dance movements with happy affective expressivity will lead to an increase in self-evaluated happy affective state (1-tailed prediction).

Hypothesis 2. The imitation of dance movements with sad affective expressivity will lead to an increase in self-evaluated sad affective state (1-tailed prediction).

Previous interventions with avatars as models to be imitated indicate that these can be a useful alternative to traditional human-to-human interventions and trainings (An et al., 2013; Hopkins et al., 2011; Rehm et al., 2016). However, research suggests that there is a difference between humans and robots in the context of dance (Blackler et al., 2019). Therefore, the third hypothesis is two-tailed.

Hypothesis 3. The effectiveness of affect induction is different between the human dance avatar and the robot dance avatar (2-tailed prediction).

Regarding motivation, there is not enough research in this specific realm to base a definite prediction on. We believe that whether work motivation is modulated by our experimental manipulation is likely to depend on the success of the mood induction (Hypotheses 1 and 2). Hence, we will address motivation as part of an exploratory analysis.

We will further assess how much participants like the different dance models, human avatar and robot avatar in the exploratory analysis.

METHODS

Participants

A total of 66 participants (46 female, 20 male) took part in the experiment. Participants were, on average, 36.33 years old ($SD = 13.94$, range 18–62). From the original sample, three participants were excluded due to technical problems with playing the videos ($n = 1$), high self-rated technical difficulty with the experimental procedure ($n = 1$) and non-response to mood induction (meaning that they showed no change in happy ratings after happy *and* no change in sad ratings after sad mood induction compared to baseline; difference = 0 or negative $n = 1$). The experiment took on average 19 min and participants were paid 7€ for their participation after completing the experiment. Sociodemographic data of the full sample is presented in Table 1. An overview of participants' responses to the study variables is presented in Tables S1–S3.

To determine the sample size of our two experimental groups (Visual Presentation: human avatar, robot avatar), two power calculations were performed using G*Power 3.1. (Faul et al., 2007). We based our estimates on the effect sizes of the only comparable study known to us (Shafir et al., 2013), in which very large effect sizes between $d = 1.069$ to $d = 1.664$ for t-tests were observed (calculated by the authors, based on the values reported in the source paper). Therefore, for our sample size calculation, we set the threshold of a large effect of $d = 0.80$ (Cohen, 2009; $d = 0.2$ is considered a small, $d = 0.5$ a medium and $d = 0.8$ a large effect size). As we planned to compare the group receiving the dance instructions from a human avatar with those who received them from a robot avatar, we conducted a sample size calculation for an independent samples t-test (effect size = .80, alpha = .05, power = .90). This gave a suggested sample size of 28 per group (total $N = 56$).

Second, because ANCOVA is a class of multilevel modelling (Gałecki & Burzykowski, 2013), we also calculated the sample size for multilevel modelling. There is no previous similar study to ours to base our effect size on that used multilevel modelling. Based on Cohen (2009), where $f^2 = 0.02$ is considered

TABLE 1 Sociodemographic characteristics of participants.

Baseline characteristic	Human avatar *n*	Human avatar %	Robot avatar *n*	Robot avatar %	Full sample *n*	Full sample %
Gender						
Female	20	60.61	26	78.79	46	69.7
Male	13	39.39	7	21.21	20	30.3
Education						
Lower secondary school (9 years)	1	3.03	0	0	1	1.54
Secondary school (10 years)	0	0	1	3.03	1	1.54
Vocational training	0	0	3	9.09	3	4.62
High school diploma	8	24.24	13	39.39	21	32.32
Bachelor's degree	10	30.3	8	24.24	18	27.69
Master's degree	14	42.42	8	24.24	21	32.31
Employment						
Student (school)	0	0	1	3.03	1	1.54
Vocational trainee	0	0	2	6.06	2	3.08
Student (university)	10	30.3	13	39.39	23	35.38
Part-time employed	8	24.24	4	12.12	12	18.46
Full-time employed	9	27.27	10	30.3	18	27.69
Self-employed	5	15.15	2	6.06	7	10.77
Retired	1	3.03	1	3.03	2	3.08
Dance experience						
Yes	16	48.48	18	54.55	34	51.52
No	17	51.52	15	45.45	32	48.48

Note: $N = 66$ participants were on average 36.33 years old. Of those who reported to have dance experience (both amateur and professional; $n = 34$), the dance experience was 10.4 years on average ($SD = 11.66$, range: 0.2–42).

a small, $f^2 = 0.15$ a medium and $f^2 = 0.35$ a large effect size, we, therefore, performed a second sample size calculation for linear multiple regression with only a moderate-high effect size (deviation from zero, effect size = .25, alpha = .05, power = .95, number of tested predictors = 2). This gave a suggested sample size of 65. Because we had two experimental groups, the sample contained a minimum of 66 participants.

People from 18 years old to the age of retirement (67 years), who were fluent in German, and without physical limitations in movement were invited to participate in the experiment. The criteria for data exclusion were participants' answers to a series of questions at the end of the experiment. These are questions about (1) technical issues (a multiple-choice question at the end of the experiment: 'Did the videos play alright [technically]'? 0 = *not at all*, 5 = *yes, no problems*; all participants rating three or under were excluded, and 'How difficult did you find this survey from a technical perspective?' 0 = *not at all difficult*, 5 = *very difficult*; all participants rating three or above were excluded), (2) not passed attention checks (a multiple-choice question: 'Please select the middle circle'. All participants that did not select the middle circle were excluded), and (3) non-compliance with the instructions led to exclusion (e.g. participants who did not execute the dance movements; this was checked by the experimenter via video chat during the session). (4) Non-responders to both mood inductions (meaning that they showed no change in happy ratings after happy *and* no change in sad ratings after sad mood induction compared to baseline, difference = 0 or negative) were excluded (Rottenberg et al., 2018). (5) The data were also checked for outliers which were excluded (we set the threshold *a priori* to a tolerance of +2 *SD*s for the motivation, liking, comfort, difficulty and initial affect ratings).

Stimuli

A total of 16 dance movement video clips of ~6-s length (eight counts in dance notation), performed by a professional dancer and recorded on video, were used as stimuli in this experiment. We set up the experiment with two different conditions to gauge our between-groups factor, Visual Presentation (the dance model that the participants will be asked to imitate during the experiment; two levels: human avatar, robot avatar). Thus, in Visual Presentation, (1) participants were asked to imitate a human avatar. In Visual Presentation, (2) participants were asked to imitate a robot avatar. The two Visual Presentations are illustrated in Figure 1a.

The stimuli were taken from the EMOKINE dance stimuli library (Christensen, Smith, et al., 2021; Christensen et al., under review). This dance movement library was created using motion capture technology and comprises nine dance movement sequences that were danced by one dancer who was filmed performing sequences of simple dance movements expressing different affective states (happiness, sadness, anger, fear, contentment and neutrality). Each sequence is available in the form of a learning video, where the dance model gives a verbal explanation for the respective sequence, plus six separate video clips, where a dancer danced each sequence intending to express the six emotions. In post-production, each video was created in four different Visual Presentations [robot avatar, full-light dancer with blurred face (human avatar), silhouettes and point-light displays].

In a series of experiments (Christensen et al., under review), it was established that human observers ($N = 120$) recognize the affective intentions expressed by the dancer in these stimuli for the expressive stimuli. The learning videos were, of course, not part of this emotion recognition norming experiments. We based the stimuli selection for our experiment on the observer emotion recognition data from these observer experiments (i.e. data from the Visual Presentations of the human avatar and the robot avatar).

We performed the following changes with regards to the original stimuli. We changed the stimulus colour of the human avatar and robot avatar videos (Visual Presentation) to black and white, as most stimuli in this field of research are black and white (as discussed in Christensen & Calvo-Merino, 2013; Christensen & Jola, 2015), and adjusted background avatar contrast ratio to improve the matching of the stimuli and avoid confounding effects regarding colour or contrast. We used a customized matlab script to obtain luminance properties of the stimuli which averaged the luminance score of each video frame. A t-test did not show any differences in luminance between our stimuli of Visual Presentations human avatar and robot avatar, $t(14) = -1.036$, $p = .318$.

In the learning video for sequence 2, a laugh was heard on the audio track (when the avatar says 'back to neutral'). This sound bit was cut out and replaced so the final stimulus was without laughter.

To gauge our factor Affective Expressivity (two levels: happy, sad), the affective intentions expressed by the dancer of these video stimuli (and which participants will be asked to imitate) were happy and sad affective expressivity. This choice of happy and sad affective expressivity was motivated by previous research that suggests that happiness and sadness are the affective states that are most frequently associated with visually rather specific kinematic parameters of full-body movements. These include clear variations in lateral and vertical extension of the body and the mean speed and acceleration of the movements, among other parameters (Bernardi et al., 2018; Gross et al., 2012; Kleinsmith & Bianchi-Berthouze, 2012; Poyo Solanas et al., 2020; Shafir et al., 2016). As this experiment is the first of its kind using this *same-sequence* approach instead of emotional *actions*, we used these two affective expressivities in full-body movement for which comparatively most empirical basis is available.

From the original dance movement library, sequences number six (from here on sequence 1) and eight (from here on sequence 2) were used for the present experiment. Sequence 1 was chosen because emotion recognition rates from the observer experiments of the source publication were similar for all three versions of the sequence (happy, sad, neutral; see Table 2 for an analysis of the original data from the source publication; Christensen et al., under review). For sequence 2, the recognition rates from the source publications differed between the happy, sad and neutral versions of the sequence (see Table 3 for an analysis of the original data from the source publication; Christensen et al., under review). Despite

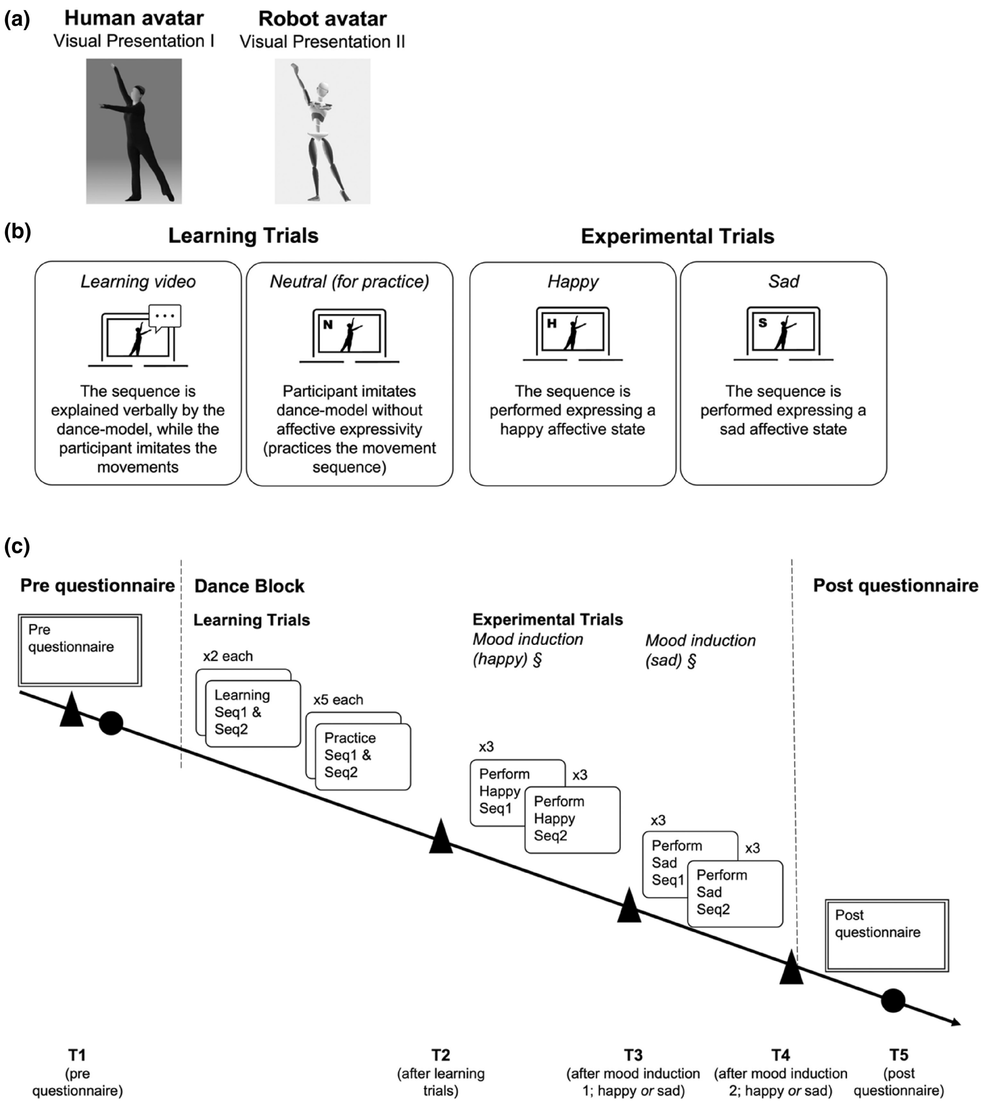

FIGURE 1 Stimuli and procedure. *Note*: Seq1 = Sequence 1, Seq2 = Sequence 2, § = counterbalanced order, ▲ = affect ratings, ● = motivation ratings, T = time point. (a) Visual presentations of stimuli: participants were asked to imitate either the human avatar (Visual Presentation 1, group I) or the robot avatar (Visual Presentation 2, group II). (b) Types of dance movement video clips per sequence: Participants imitated the learning (with verbal explanation) and practice (neutral expressivity) video clips for learning and practicing the sequences during the learning trials. For mood induction, the videos with happy and sad affective expressivity were used for the experimental trials. Stimuli were repeated more than once, and participants performed Σ26 trials in total (due to the futile nature of mood induction effects, low stimuli numbers in mood induction research are common; see, Teasdale and Russell [1983], who used 12 stimuli and Bigand et al. [2005] who used 27 stimuli; discussed in Marcusson-Clavertz et al., 2019). (c) Procedure: the experimental procedure followed the presented time sequence. In addition, to the affect ratings, represented by the ▲ in this figure, the pre-questionnaire contained motivation ratings. In the post-questionnaire, participants were asked to rate their motivation again. Attentional engagement, questions regarding exclusion criteria and further variables for the exploratory analysis including demographics were also part of the post-questionnaire but are not represented in this figure. T1 refers to the time point (T) of the pre-questionnaire, T2 to the time point where ratings were obtained after the learning trials, T3 to the time point where ratings were obtained after the first mood induction (which, due to the randomized order, can be after the happy or the sad mood induction), T4 refers to the time point where ratings were obtained after the second mood induction and T5 refers to the time point of the post-questionnaire.

TABLE 2 Results of Chi-square test examining emotion recognition rates for sequence 1.

	Human avatar		Robot avatar				
Intention	***N* incorrect**	***N* correct**	***N* incorrect**	***N* correct**	$X^2(1)$	*p*	Φ
Happy	21	12	21	12	0	1	0
Sad	7	26	8	25	0	1	0.04
Neutral	17	16	17	16	0.546	.46	0.12

Note: Data from the validation study (Christensen et al., under review), where $N = 120$ human observers rated which emotion the dancer intended to express in each stimulus; for the human avatar videos, and for the robot avatar video clips. Shown here is the rating data of the six stimuli of sequence 1 in both Visual Presentations. The two learning videos are not listed here because they were not part of the validation study. For the data from the validation study please see Zenodo: https://zenodo.org/record/7821844 (Zenodo DOI: https://doi.org/10.5281/zenodo.7821844). The software is available on Github: https://github.com/andres-fr/emokine. Comprehensive Readme files accompany the data and software.

TABLE 3 Results of Chi-square test examining emotion recognition rates for sequence 2.

	Human avatar		Robot avatar				
Intention	***N* incorrect**	***N* correct**	***N* incorrect**	***N* correct**	$X^2(1)$	*p*	Φ
Happy	16	15	13	18	0.259	.611	−0.1
Sad	9	22	18	13	4.199	.04	0.29
Neutral	12	19	13	18	0	1	0.03

Note: Data from the validation study (Christensen et al., under review), where $N = 120$ human observers rated which emotion the dancer intended to express in each stimulus; for the human avatar videos, and for the robot avatar video clips. Shown here is the rating data of the six stimuli of sequence 1 in both Visual Presentations. The two learning videos are not listed here because they were not part of the validation study. For the data from the validation study please see Zenodo: https://zenodo.org/record/7821844 (Zenodo DOI: https://doi.org/10.5281/zenodo.7821844). The software is available on Github: https://github.com/andres-fr/emokine. Comprehensive Readme files accompany the data and software.

this limitation, we chose these two sequences, because sequences 1 and 2 were the closest match numerically in terms of recognition rates.

Each of the two conditions of the factor Visual Presentation contained eight stimuli (the six stimuli represented in Tables 2 and 3, plus two learning videos; repeated several times each). Participants were shown the learning videos for each sequence to follow along. For practice purposes, two additional stimuli were shown of neutral expressivity (here, the dance model did not intend to express any emotion while dancing the sequence, and the neutrality of the affective expressivity had been confirmed in the norming study). Within each Visual Presentation, two dance-sequence stimuli were of happy affective expressivity (i.e. the dance model intended to express happiness while dancing the sequence) and two of sad affective expressivity (i.e. the dance model intended to express sadness while dancing the sequence). Figure 1b illustrates these different stimulus types in the order in which the participants saw the eight stimuli within each Visual Presentation: learning video, practice (neutral affective expressivity), happy affective expressivity and sad affective expressivity.

Please note that all stimuli were repeated more than once. Learning videos were repeated twice for each sequence (Σ4 trials), and practice videos were repeated five times each (Σ10 trials). The experimental trials were repeated three times for each sequence and affective expressivity (Σ12 trials). This number and/or duration of experimental trials was sufficient to produce mood induction in previous studies (see Teasdale and Russell [1983], who used 12 stimuli and Bigand et al. [2005] who used 27 stimuli and discussed in Marcusson-Clavertz et al., 2019). This means that all participants performed Σ26 trials in total. This paradigm design was based on the proposal by Cadopi et al. (1995) who also used this same-sequence approach in their experiment to teach their participants dance movement sequences (on average, their participants needed 5.38–7.38 trials to learn the sequences) to examine cognitive representations in modelling dance movements.

Manipulation check

At four time points (time points = T; T1, T2, T3 and T4) of the experiment (represented as ▲ in Figure 1c), participants were asked to rate their current affective state and specific emotions (this procedure is from here on called: affect rating). The items to be rated were (1) happy, (2) sad, (3) angry, (4) fearful, (5) surprised and (6) disgusted (in German: glücklich, traurig, wütend, verängstigt, überrascht, geekelt), as well as the general affect items (7) valence (scale from negative to positive; in German: sehr negativ gestimmt – sehr positiv gestimmt) and (8) arousal (scale from low to high; in German: sehr ruhig – sehr aktiviert/aufgeregt/angespannt; Schmidtke et al., 2014). Participants were asked to indicate how much each of these eight items describes their current affective state. Continuous scales were displayed next to the eight items (0 = *not at all*, 100 = *very much*), and a question was displayed: 'How do you feel right now?'. Even though the aim was to induce happy and sad moods, six additional affective states to those expressed in the videos were included to avoid demand effects (Shafir et al., 2013).

We used these eight affect ratings following the conjectures of several theories of human emotion. An advantage of utilizing basic emotions is that it facilitates the comparison of data from different studies and cultures (Barrett et al., 2019; Ekman & Friesen, 1971; Van Dyck et al., 2017). The number of distinct emotions used in affect ratings in studies varies. Some authors used more than 20 emotions (Cowen & Keltner, 2020), while other authors only refer to the five or six basic emotions such as happiness, sadness, fear, anger, disgust (and surprise; Atkinson et al., 2004; Barrett et al., 2019). Of course, referring to different *emotions* is accompanied by methodological limitations, as these emotion categories have been found to sometimes be confused or mixed (Eerola & Vuoskoski, 2011). However, assessing emotions on a continuum (on a scale from 0 to 100) may mitigate this disadvantage. In addition, we assessed valence and arousal to gauge participants' current affective state as part of each of the eight affect ratings. According to Russell (1980), there are two dimensions of affect: arousal and valence. Different discrete emotions can be assigned to an area within a space of these two dimensions. Combining valence and arousal assessments with the categorical assessments, we overcame the limitations of these dimension-specific affect expressions that have been shown to comprise a low degree of resolution and differentiation (Scherer, 2004). A higher methodological quality and an additional acquisition of knowledge was expected from a combination of distinctive and dimension-specific emotions.

Motivation assessment

With regards to our exploratory hypothesis about work motivation, we assessed participants' motivation (Dysvik & Kuvaas, 2011; Kuvaas & Dysvik, 2009). To gauge participants' current work motivation, along with how and whether their work motivation changes throughout the experiment, participants were asked the question 'What is your next work-related task/duty after completing this experiment?'. This question was explained verbally by the experimenter in the introduction (if participants, for example, students, do not have a work task they should think of a duty task, such as writing an essay or preparing a presentation). They were also asked to state *when* they will do this task, and *how motivated* they feel *right now* to do it. The first two items of the motivation assessment were open questions. The latter question about how motivated they feel right now to do that work-related task was responded on a 5-point Likert scale (0 = *not at all*, 5 = *very much*). These questions were asked twice during the experiment. The first motivation assessment was before the manipulation at T1 (before the learning trials) and the second one was repeated after the experimental trials at T5 (see Figure 1c). T1 refers to the time point (T) of the pre-questionnaire, T2 to the time point where ratings were obtained after the learning trials, T3 to the time point where ratings were obtained after the first mood induction (which, due to the randomized order, can be after the happy or the sad mood induction), T4 refers to the time point where ratings were obtained after the second mood induction, and T5 refers to the time point of the post-questionnaire.

Attentional engagement

This measurement of attentional engagement is not to be confused with the attention check, on the basis of which participants were excluded (see section 'Participants'). To check whether participants were attentionally engaged in the dance task, we embedded two distractors in the paradigm.

A distractor in this experiment was a 35 × 35 pixels circle with a colour similar to the background of the videos (#DCDBDC) that appeared in the upper right and left corners of the screen (at an angle of 30° and 150°, respectively, from the centre of the video clip and at a distance of 1% window width from the edge of the screen) to avoid habituation (as discussed in Van Moorselaar & Slagter, 2020; Wang et al., 2019). These colours were chosen based on the fact that high-salience visual cues receive more attention than those with low salience (Chen & Cave, 2006). Hence, the colour of the distractor was similar to the stimuli of the experimental task that participants are engaged in to not draw too much attention to it. The trials on which the distractors appeared were determined via random selection in Excel. Thus, in two of the trials (16.67% of the experimental trials; happy expressivity, sequence 2, repetition 1 and sad expressivity, sequence 1, repetition 3) the distractor was presented. After the experimental trials, participants were asked to indicate which of two symbols they saw (circle, triangle or none) and how confident they were about their answer on a continuum from 0 = *not at all confident* to 100 = *very confident*.

Classically, distractor cues are presented in the periphery of the participants' visual field, as they perform an experimental task. The time a visual peripheral cue should be displayed is commonly set to less than 100 ms (Cheal & Lyon, 1991; Estes & Taylor, 1964). However, a first pilot experiment with $N = 3$, revealed that none of the participants saw the distractor at a presentation time of 90 ms. A second pilot experiment with $N = 10$ participants (five of whom completed the questionnaire at home and five at the institute, all supervised via video chat as per methods) was conducted. Two (one at home, one at the institute) out of 10 participants saw the distractors with a duration of 110 ms; thus, distractor duration was fixed to 110 ms (see Figure 2).

We assumed that if a participant is attentionally engaged in the task, they will be less likely to notice the distractor. The amount of attention paid to a distractor can represent an objective measure of participants' engagement with a task. We determined that someone who rates they are 100% confident that they did not see the distractor is different from someone who is only 20% confident. We did not aim to exclude any participants based on this attentional engagement measure.

Pre- and post-questionnaires

We divided our assessments into a pre-questionnaire (at T1) and a post-questionnaire (at T5), which together sandwiched the mood induction (dance block; T3 and T4) between them. The pre-questionnaire contained the first affect rating and the questions assessing participants' motivation. In the post-questionnaire, motivation questions were asked again. At T5, the questions measuring attentional engagement were also asked. In addition, the post-questionnaire (at T5), contained a forced-choice question in which participants were asked to indicate whether they would prefer the human or the robot avatar ('If you were to do more practice rounds, which avatar would you prefer?'). Participants were asked to indicate on a continuum how comfortable they felt doing the movements ('How comfortable did you feel with performing the movements?' 0 = *not at all comfortable*, 100 = *very comfortable*), how difficult they found executing the movements ('How difficult were the dance moves for you?' 0 = *not at all difficult*, 100 = *very difficult*) and how much they liked the videos in general ('How much did you like the videos?' 0 = *Did not like at all*; 100 = *I liked them very much*). These variables contributed to the explorative analysis of the data.

The post-questionnaire (at T5) included questions regarding exclusion criteria (i.e. the four measures outlined in section 'Participants'), and we asked a question to assess the likelihood that participants would use the dance videos embedded in an app at the workplace ('How likely is it that you would use this tool if it were an app that you could use at your work place for a little break?' on a continuum 0 = *not at all likely*, 100 = *very likely*). The post-questionnaire (at T5), also contained demographic questions

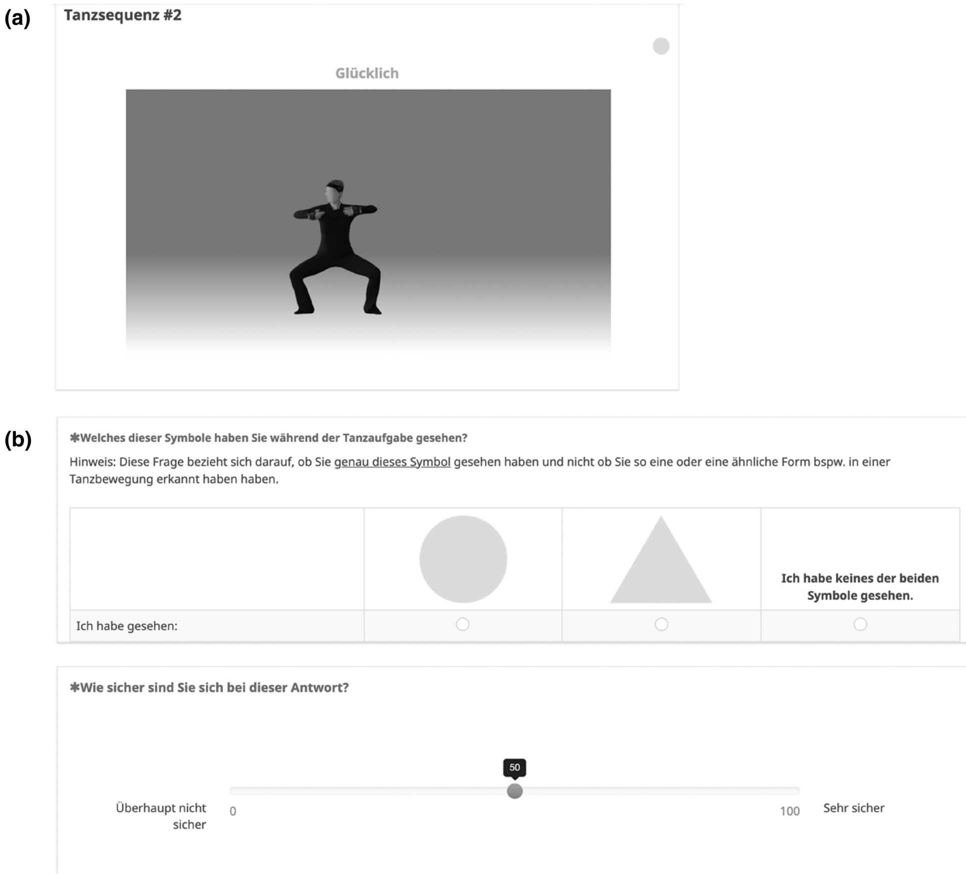

FIGURE 2 Distractor presentation in the survey. *Note*: (a) Presentation of a distractor during dance block: Picture a is an exemplary representation as occurred in one of the trials ('Tanzsequenz#2' = dance sequence 2, 'Glücklich' = happy). Participants saw which affective expressivity they were supposed to imitate above the video in blue. The distractor (a 35 × 35 pixels circle) was presented for 110 ms in two, i.e. 16.67%, of the experimental trials (happy expressivity, sequence 2, repetition 1 and sad expressivity, sequence 1, repetition 3) in the periphery of participants' visual field (at an angle of 30° and 150°, respectively, from the centre of the video clip and at a distance of 1% window width from the edge of the screen). The colour of the distractor was grey (#DCDBDC), similar to the background of the video clips. (b) Forced choice and confidence measure: The bold text with the asterisk represents the questions, grey texts below are hints to the question and underneath are the respective answer options (explained and translated hereafter). Participants were asked 'Which of these symbols did you see during the dance task?' (in German: 'Welches dieser Symbole haben Sie während der Tanzaufgabe gesehen?'), and they could either select a circle, a triangle or the option 'I have seen neither of these symbols' (in German: 'Ich habe keines der beiden Symbole gesehen'.). Participants were also asked to indicate on a continuum 'How confident are you in this answer?' (in German: 'Wie sicher sind Sie sich bei dieser Antwort?') from 0 = *not at all confident* (in German: „überhaupt nicht sicher") to 100 = *very confident* (in German: „sehr sicher"). We employed these questions to measure attentional engagement for additional informative value and the comparison of both Visual Presentations. We did *not* use it as an exclusion criterion.

including age, gender, highest education and current employment. Since dance experience may have modulated the results (Christensen et al., 2016; Kirsch et al., 2018; Van Dyck et al., 2017), a question asking about dance experience was also included ('How many years of dance experience do you have?').

Procedure

This experiment was set up in the online survey application LimeSurvey© with the dance video stimuli embedded. For experimental control, and to guarantee that dance movements are executed, the experimental sessions were conducted in a laboratory of the Max Planck Institute for Empirical Aesthetics, Frankfurt/M, Germany. Each participant was supervised by the main experimenter (located in a different room on the same premises to give the participant privacy during the movement execution) via video chat. The introduction to the experiment was done in person by the experimenter, before the participant was left alone in the laboratory for the task. While participants completed the experiment, the experimenter's camera was turned off, to avoid distraction and to minimize interaction (Wijenayake et al., 2020).

The general procedure of the study was divided into three parts: the pre-questionnaire at T1 (as part of the manipulation check, see section 'Manipulation Check', and motivation assessment, see section 'Motivation Assessment'), a dance block, in which participants learned and performed the trials (see section 'Stimuli'), interleaved with an affect rating after the learning trials (T2) each affective expressivity at T3 and T4, (happy, sad; see section 'Manipulation Check'), and the post-questionnaire at T5 (here, we assessed participants' work motivation again, see section 'Motivation Assessment', as well as their experience of the and their attentional engagement, and demographics data; see section 'Pre- and Post-Questionnaire').

In the dance block, participants first learned sequence 1 and then sequence 2. They watched and imitated the learning video of the respective sequence and repeated these twice each. Then, they practiced the respective sequence with the help of the videos with neutral affective expressivity. The program was set up so that participants repeated each of the two dance sequences five times each, for practice purposes.

To rule out that any effects in the experimental manipulation (i.e. affect ratings after dance blocks, see section 'Manipulation Check') could be attributable to the physical activity itself, we included one affect rating trial just after participants had practiced the neutral practice videos, and before they proceeded to the experimental trials with the videos expressive of affect (happy and sad; at T2). This is because it has previously been reported that negative affect and rumination can be reduced by engaging in physical activity, causing an increase in affect ratings per se (Bernardi et al., 2018). Therefore, it is important to assess mood after the neutral practice condition, as much as after the movement conditions with happy and sad expressivity (at T3 and T4). If the mood change was induced by the physical activity itself, there would be a significant difference between the affect ratings before and after the practice trials, but not between the practice trials and the experimental trials.

The order of the experimental trials of the dance block (i.e. imitating the videos expressive of happy and sad affect) was counterbalanced to minimize sequence effects. The order in which participants imitated sequences 1 and 2 did not change, to facilitate the task. Sad and happy trials were identical in structure: participants practiced both sequences with the corresponding affective expressivity three times each. Participants were aware of which affective expressivity they imitated, and the affect word (happy or sad) was displayed above the video in blue. They then did the affect ratings again, once after the happy trials and once after the sad trials (at T3 and T4). The dance block was followed by the post-questionnaire (at T5; see section 'Pre- and Post-Questionnaire'). This procedure is illustrated in Figure 1c.

In order to address the second research question about which Visual Presentation is more conducive to mood induction effects, participants were randomly assigned to one of two conditions. In one condition, group I, participants only saw videos of the human avatar as a dance model, and participants of group II saw videos of the robot avatar as a dance model (see Figure 1a). Both groups saw the happy and sad videos (see Figure 1b).

DATA ANALYSIS

The design had two within-subjects factors, Imitation (no/neutral[1] imitation, happy imitation, sad imitation) and Mood Dimension (happy, sad), and two between-subjects factors, Visual Presentation (human avatar, robot avatar) and Order (happy first, sad first). Order was a secondary factor that we

[1]The ratings for the comparison condition (i.e. no imitation or neutral imitation) were determined based on preliminary analyses. See section 'Data Management' about the 'Control for physical movement'.

only included to check for order effects, but we did not have any specific hypotheses regarding this factor.

The analysis regarding our exploratory hypothesis about motivation and liking was conducted separately.

Data management

To prepare the data for analysis, we followed these steps:

Dependent variables

The primary dependent variables were the happy and sad affect ratings at the different time points. Two additional dependent variables were computed for the subsequent analyses. Two magnitudes of change in affective state were computed: (1) magnitude of change for the happy mood induction (before–after happy imitation) and (2) magnitude of change for the sad mood induction (before–after sad imitation). Depending on the order in which participants imitated the happy and sad movements, the point of reference (before imitation) was either after the neutral imitation or after the sad imitation for the happy mood induction. Likewise, the point of reference for the sad mood induction either was after the happy imitation or after the neutral imitation. The reason for doing this is that the magnitude of the effect of the mood induction (neutral vs. happy/sad imitation) may impact the strength of any motivation change.

Attentional engagement variable

A new variable for attentional engagement based on participants' responses of whether they had seen the distractor (yes/no) was computed. The hypothesis-driven analyses were performed twice, once with and once without the participants who saw the distractor, to explore whether the mood induction only worked for those participants who did not see the distractor (and hence, supposedly were more engaged in the task).

Additional affect ratings

The additional affect ratings (anger, fear, surprise, disgust, arousal, valence) were included in the task with the sole objective to avoid dem. We conducted a separate repeated measures analysis of variance (RM ANOVA) to determine that there were no changes in the other affect scales before and after mood induction.

Control for physical movement

Physical movement alone can be enough to account for mood changes (Bernardi et al., 2018). This means that a difference in mood may be detected also in this sample between T1 (before any imitation) and T2 (after neutral imitation). To determine the point of reference for the following analyses (T1 or T2), we computed a *t*-test between the happy and the sad ratings between T1 and T2.

Dance experience

To ensure that the two groups did not differ in terms of dance experience, and because dance experience has previously been found to modulate affect ratings to dance movements (e.g. Christensen et al., 2018), a one-way analysis of variance (ANOVA) with years of dance experience as the dependent variable and the between-subjects factor Visual Presentation (two levels: human avatar, robot avatar) was run.

Mood induction analyses

Analysis 1

This analysis focused on the difference between no/neutral imitation (measured at T1/T2, depending on the results of the *t*-test described above), happy imitation (measured at T3 or T4 due to the randomized order of the mood inductions) and sad imitation (equally measured at T3 or T4). To exclude possible order effects (happy mood induction first as opposed to sad mood induction first), Order was included as a factor.

We conducted a $3 \times 2 \times 2 \times 2$ repeated measures analysis of covariance (RM ANCOVA) to investigate whether the happy mood induction led to higher happy affect ratings (Hypothesis 1), whether the sad mood induction led to higher sad affect ratings (Hypothesis 2) and whether the Visual Presentation influenced affect ratings (Hypothesis 3). Thus, the within-subjects factors Imitation (three levels: no/neutral imitation, happy imitation, sad imitation), and Mood Dimension (two levels: happy, sad) were included. The between-subjects factors were Visual Presentation (two levels: human avatar, robot avatar) and Order (two levels: happy mood induction first, sad mood induction first).

The covariates included to control for confounds were gender as a between-subjects factor (two levels: female, male) because previous work shows gender differences in attitudes towards dance (Sanderson, 2001), and age because the age of the participants was only delimited to a small extent, and some epidemiological assessments suggest that dancing frequency may be different for different age groups in Germany (SINUS-Institut, 2017). We also included several measures of participants' level of engagement with the task as covariates to check if they modulate the results as found previously (Christensen, Azevedo, & Tsakiris, 2021). These were operationalized as participants' ratings on Likert scales and continuous scales in the post-questionnaire: difficulty, comfort and liking of the task (see section 'Pre- and Post-Questionnaire'), as well as their attentional engagement (i.e. whether they detected the distractor circle [yes/no], and their level of confidence). The dependent variables were the affect ratings of our manipulation check.

Analysis 1 was repeated, but without the non-significant variables above.

Analysis 2

The above analysis with the magnitudes of change in affective state (see section 'Manipulation Check') as dependent variables and without the factor Imitation was repeated.

Motivation change and liking analyses

Analysis 3

We were particularly interested in the motivation level following mood induction because this would be relevant in an applied (e.g. work) context. However, as this is an exploratory analysis, and from a theoretical point of view neither the dependent variable nor the exact analysis could be determined *a priori*. Therefore, several different analyses were conducted to explore motivation.

The main analysis was a hierarchical multiple linear regression with the dependent variable motivation. The model included as predictors at level 1: Time Point (two levels: T1, at the start of the experiment, and T5, after mood induction), Visual Presentation (two levels: human avatar, robot avatar), magnitude of happy mood induction and magnitude of sad mood induction. At level 2, the exploratory predictors of attentional engagement, difficulty, comfort, liking, probability to use, age and years of dance experience were included.

A second model explored a different dependent variable (i.e. the difference in motivation ratings between T1 and T5 [difference = T1 − T5] or the motivation rating at T5). A correlation analysis was performed between these two possible dependent variables and the relevant predictors (magnitude of happy mood induction, magnitude of sad mood induction, attentional engagement, difficulty, comfort, liking, probability to use, age and years of dance experience) before conducting the main analysis. The dependent variable with the highest number of correlations was chosen. Based on this, a hierarchical multiple linear regression with the dependent variable motivation was conducted. As predictors, the theory-based predictors Visual Presentation, magnitude of happy mood induction and magnitude of sad mood induction at level 1 were included. The predictors for level 2 were selected based on whether they correlated with the dependent variable or not.

Analysis 4

To examine which avatar type (human or robot) participants preferred and to explore whether that depended on the condition participants were assigned to, we conducted a logistic regression. The single factor was Visual Presentation and the dependent variable was the dichotomous answer of preference for one of the two models (human or robot avatar). A one-way ANOVA with the between-subjects factor Visual Presentation (human avatar, robot avatar) was also conducted to explore whether subjective liking ('How much did you like the videos?' [0 = *not at all*, 100 = *very much*]; dependent variable) differed between the two Visual Presentations.

RESULTS

Results from all analyses set out in our analysis plan are reported here. We submitted introduction, methods and analysis plan to the journal, went through peer review and received an in-principle-acceptance (IPA) prior to collecting any data. All analyses that are reported here were planned *a priori.*

Additional affect ratings

To examine whether there were changes in the additional affect ratings (anger, fear, surprise, disgust, arousal, valence) before and after mood induction an RM ANOVA (see section 'Data Analysis – Additional affect ratings') was computed. This analysis showed a significant main effect of Mood Dimension, $F(5, 325) = 108.9$, $p < .001$, partial $\eta^2 = .63$ and a significant interaction between Mood Dimension and Time Point, $F(5, 325) = 3.558$, $p = .004$, partial $\eta^2 = .05$. An analysis of the contrasts demonstrated that fear ratings were significantly higher at T1 ($M = 12.73$) than at T4 ($M = 7.15$), with a difference of 5.58 points ($SE = 2.59$), $p = .032$, $r = .11$. Valence ratings were significantly higher at T1 ($M = 62.88$) than at T4 ($M = 55.05$), with a difference of 7.83 points ($SE = 2.59$), $p = .003$, $r = .16$. The remaining Mood Dimensions showed no significant difference between T1 and T4.

Control for physical movement

To test whether there was an effect of physical movement on the happy and sad affect ratings and to determine the point of reference for our following analyses a dependent *t*-test comparing T1 and T2 for happy and sad affect ratings was run (see section 'Data Analysis – Control for physical movement'). There was a significant difference in happy ratings between T1 and T2, $t(65) = -2.8$, $p = .007$, $d = 0.26$, and a significant difference in sad ratings between T1 and T2, $t(65) = 3.12$, $p = .003$, $d = 0.22$. Hence, there was an effect of physical movement: participants became happier and less sad after the learning trials (T2) compared to the beginning of the experiment (T1). Happy and sad ratings at T2 (after neutral imitation) were, thus, used as the comparison measurement for the hypothesis-driven analyses.

Dance experience

To investigate whether the two groups differed in terms of dance experience and, thus, to exclude that dance experience altered the affect ratings, a one-way ANOVA with years of dance experience as the dependent variable and the between-subjects factor Visual Presentation (see section 'Data Analysis – Dance experience') was conducted. There was no significant effect for Visual Presentation, $F(1, 64) = 0.973$, $p = .328$. The groups did not differ in terms of dance experience, for which we did not regard this variable in the subsequent hypothesis-driven analyses.

Mood induction analyses

A 3 × 2 × 2 × 2 RM ANCOVA with the within-subjects factors Imitation (neutral imitation, happy imitation, sad imitation) and Mood Dimension (happy, sad), and the between-subjects factors Visual Presentation (human avatar, robot avatar) and Order (happy imitation first, sad imitation first; see section 'Data Analysis – Analysis 1') was conducted. Several covariates were included to test for gender, age and engagement effects. The dependent variables were the affect ratings. This analysis tested Hypothesis 1 and Hypothesis 2. We found a significant main effect of the factor Mood Dimension rating scale, $F(1, 62) = 141.147$, $p < .001$, partial $\eta^2 = .69$; ratings on the happy mood scale ($M = 65.3$, $SE = 2.1$) were higher than the ratings on the sad mood scale ($M = 19.8$, $SE = 2.1$). There were no main effects of Imitation condition, $F(2, 124) = 1.547$, $p = .217$, nor of Visual Presentation, $F(1, 54) = 0.300$, $p = .586$, nor of Order, $F(1, 54) = 0.408$, $p = .526$. In accordance with our hypotheses, there was a significant interaction between Imitation and Mood Dimension, $F(2, 124) = 53.867$, $p < .001$, partial $\eta^2 = .46$. None of the covariates were significant: gender ($p = .054$), age ($p = .54$), difficulty ($p = .807$), liking ($p = .836$), comfort ($p = .461$), liking ($p = .673$), attentional engagement (detection the distractor: yes/no; $p = .052$), attentional engagement (level of confidence of detecting distractor; $p = .783$). To follow up the interaction, planned Tukey post-hoc comparisons with Bonferroni correction were conducted. These showed that after imitating happy movements, participants' ratings on the happy mood dimension rating scale were higher ($M = 71.3$, $SE = 2.48$) than after imitating sad movements ($M = 55.2$, $SE = 2.48$). Conversely, after imitating sad movements, participants' ratings on the sad mood dimension rating scale were higher ($M = 32.3$, $SE = 2.48$) than after imitating happy movements ($M = 11.8$, $SE = 2.48$). There was also an interaction between Order, Imitation, and Mood Dimension, $F(2, 124) = 3.844$, $p = .024$, partial $\eta^2 = .06$.

This analysis was repeated excluding the Visual Presentation factor and the covariates because these variables had not shown any significant effects in the first analysis. As before, there was a significant main effect of Mood Dimension, $F(2, 64) = 139.983$, $p < .001$, partial $\eta^2 = .69$; but no main effect of Imitation, $F(2, 128) = 1.586$, $p = .209$, nor of Order, $F(1, 64) = 0.431$, $p = .514$. There were again significant interactions in the same direction, between Imitation and Mood Dimension, $F(2, 128) = 53.851$, $p < .001$, partial $\eta^2 = .46$ and between Order, Imitation and Mood Dimension, $F(2, 128) = 3.739$, $p = .026$, partial $\eta^2 = .06$.

As a control procedure, analysis 1 was repeated once more, including only the participants who did not see the distractor ($n = 52$; i.e. participants who, according to our predictions, were most engaged in the task and, therefore, did not see the distractor). This analysis was conducted to examine whether the attentional engagement of participants influenced the mood induction (see section 'Data Analysis – Attentional engagement variable'). As before, results showed that there was a main effect of Mood Dimension, $F(2, 48) = 123$, $p < .001$, partial $\eta^2 = .72$, a significant interaction between Imitation and Mood Dimension, $F(2, 96) = 50.577$, $p < .001$, partial $\eta^2 = .51$ and a significant interaction between Order, Imitation and Mood Dimension, $F(2, 96) = 3.405$, $p = .037$, partial $\eta^2 = .07$. The precise results of the contrasts of these analyses are reported in Table S4. No differences in results were found compared to the analyses with the full data set.

To explore this interaction with Order, two follow-up analyses were conducted.

First, the above analysis was repeated twice (without the factor Order), first with the participants who did the happy imitation first and then with those who did the sad imitation first. In the analysis with the participants who did the *happy* imitation first, as before, we found a main effect of Mood Dimension, $F(1, 32) = 45.27$, $p < .001$, partial $\eta^2 = .59$. A post-hoc Tukey test showed that happy ratings ($M = 64.4$) were significantly higher than sad ratings ($M = 19.6$), with a difference of 44.9 points ($SE = 5.02$; $p < .001$, $r = .845$). There was no main effect of Imitation, $F(2, 64) = 1.176$, $p = .315$, but again, a significant interaction between Imitation and Mood Dimension, $F(2, 64) = 28.6$, $p < .001$, partial $\eta^2 = .47$. For contrast analyses of the interaction, see Table S5. In the analysis with the participants who did the *sad* imitation first, we again found a main effect of Mood Dimension, $F(1, 32) = 143.8$, $p < .001$, partial $\eta^2 = .82$ and no main effect of Imitation, $F(2, 64) = 0.635$, $p = .533$. Happy ratings ($M = 66.3$) were significantly higher than sad ratings ($M = 19.9$), with a difference of 46.3 points ($SE = 3.2$), $p < .001$, $r = .931$. The interaction between Imitation and Mood Dimension was significant as well, $F(2, 64) = 28.86$, $p < .001$, partial $\eta^2 = .47$. For contrast analyses of this interaction, see Table S6.

Second, another analysis was conducted to explore the effect of the Order in which participants did the mood induction conditions (happy first, sad first) on the mood induction. A 2 × 2 RM ANOVA with the within-subjects factors Time Point (two levels: pre-imitation, post-imitation) and Mood Dimension was conducted. In Analysis 1, we compared the mood induction effects to the same point of reference (neutral imitation) for all participants. We used the factor Time Point in this analysis to account for the different points of reference of participants. For participants who had the happy mood induction first, the point of reference *pre-imitation* was the happy rating after the neutral imitation. For participants who had the sad mood induction first, their point of reference *pre-imitation* for the happy mood induction was the happy rating after the sad mood induction. We found a significant main effect of Time Point, $F(1, 65) = 39.86$, $p < .001$, partial $\eta^2 = .38$, of Mood Dimension, $F(1, 65) = 118.6$, $p < .001$, partial $\eta^2 = .65$, and there was a significant interaction between Time Point and Mood Dimension, $F(1, 65) = 7.742$, $p = .007$, partial $\eta^2 = .11$.

This interaction was followed up by analyses of contrasts. The interaction between Time Point and Mood Dimension is represented in Figure 3.

In general, happy mood ratings ($M = 65.9$) were significantly higher than sad mood ratings ($M = 22.8$), with a difference of 43 points ($SE = 3.14$), $p < .001$, $r = .862$. Mood ratings after the mood inductions (post-imitation; $M = 51.8$) were significantly higher than before the mood inductions (pre-imitation; $M = 37$), with a difference of 14.8 points ($SE = 2.09$), $p < .001$, $r = .66$. Regarding happy and sad mood ratings separately, *happy* mood ratings were significantly higher post-imitation ($M = 71.3$) than pre-imitation ($M = 60.5$), with a difference of 10.8 points ($SE = 2.62$), $p < .001$, $r = .35$. *Sad* mood ratings were significantly higher post-imitation ($M = 32.3$) than pre-imitation ($M = 13.4$) with a difference of −18.9 points ($SE = 2.62$), $p < .001$, $r = .548$. These results are in line with Hypothesis 1 and Hypothesis 2.

As part of analysis 2 (see section 'Data Analysis – Analysis 2'), a 2 × 2 × 2 RM ANCOVA was conducted, similar to analysis 1, but with the *magnitudes of change* (= ratings *before* *minus* *after* the respective mood induction) in affective state as the dependent variable, and without the factor Imitation (because this is already accounted for in the calculation of the magnitudes of change). There was a significant main effect of Mood Dimension rating scale, $F(1, 62) = 8.316$, $p = .005$, partial $\eta^2 = .12$, of Order,

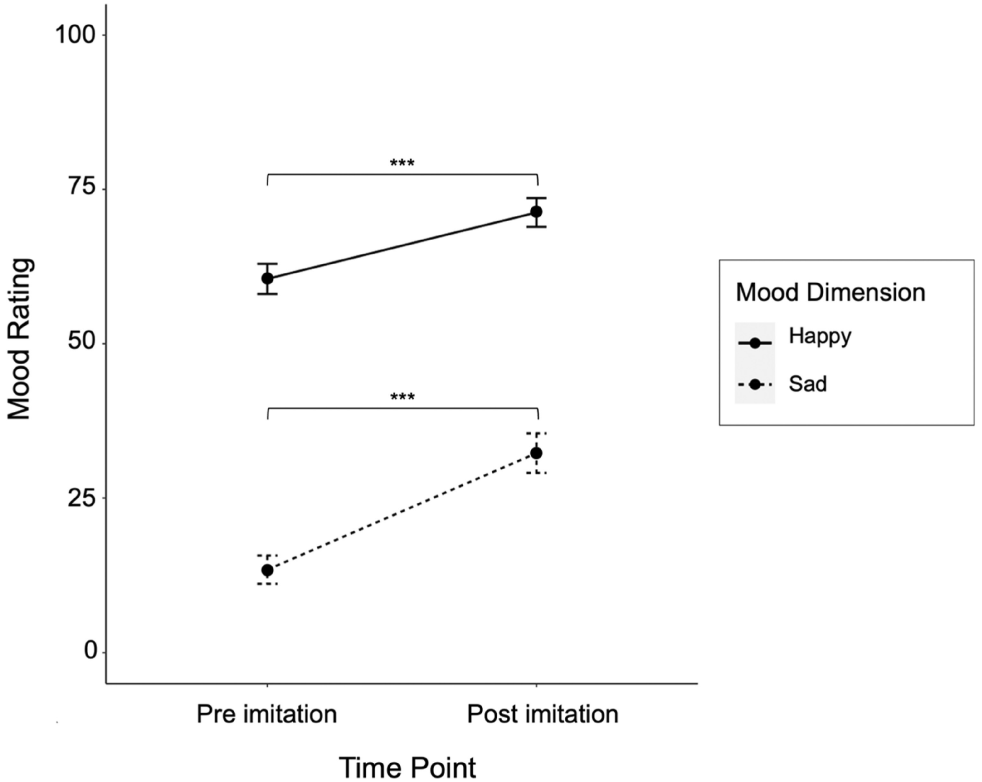

FIGURE 3 Changes in mood ratings as a function of time point and mood dimension. *Note*: $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$. Depicted in the graph are the happy and sad mood ratings as a function of the within-subjects factors Time Point and Mood Dimension. Please note that pre-imitation may correspond to after neutral imitation *or* after happy/sad imitation, depending on the order in which participants did the mood inductions. Participants rated their happy and sad affective states before each mood induction (before imitation) and after imitating the dance movements with happy and sad affective expressivity (post-imitation). Happy ratings were significantly lower pre-imitation than post-imitation, with a difference of −10.8 points ($SE = 2.62$), $p < .001$. Sad ratings were significantly lower pre-imitation than post-imitation, with a difference of −18.9 points ($SE = 2.62$), $p < .001$.

$F(1, 54) = 9.691$, $p = .003$, partial $\eta^2 = .15$ and of gender, $F(1, 54) = 4.172$, $p = .046$, partial $\eta^2 = .07$. We did not find a main effect of Visual Presentation, $F(1, 54) = 1.078$, $p = .304$ nor of the other covariates. There was a significant interaction between Mood Dimension rating scale and Order, $F(1, 62) = 7.643$, $p = .008$, partial $\eta^2 = .11$.

The analysis was repeated without the factors that did not show significant effects (i.e. Visual Presentation, age and engagement variables).

There was a significant main effect of Mood Dimension, $F(1, 64) = 8.568$, $p = .005$, partial $\eta^2 = .12$: the magnitude of the happy mood induction ($M = 9.04$) was significantly smaller than the magnitude of the sad mood induction ($M = 17.15$), with a difference of −8.11 points ($SE = 2.77$), $p = .005$, $r = .344$. There was also a significant main effect of Order, $F(1, 63) = 9.408$, $p = .003$, partial $\eta^2 = .13$: the magnitude of the mood induction was smaller for participants, who did the happy imitation first ($M = 7.48$), than for those who did the sad imitation first ($M = 18.72$), with a difference of −11.2 points ($SE = 4.51$), $p = .015$, $r = .299$. There was no main effect for gender, $F(1, 63) = 3.14$, $p = .08$.

There was a significant interaction between Mood Dimension and Order, $F(1, 64) = 7.939$, $p = .006$, partial $\eta^2 = .11$. The contrast analysis of the interaction showed that the magnitude of the happy mood induction was smaller for participants who did the happy imitation first ($M = -0.477$), than for those who did the sad imitation first ($M = 18.566$), with a difference of −19.04 points ($SE = 5.29$), $p < .001$,

$r = .331$. There was no significant difference between participants, who did the happy imitation first and those who did the sad imitation first for the magnitude of the sad mood induction ($p = .518$).

Motivation change analyses

According to our approved analysis plan, two linear regressions were conducted to investigate whether work-related motivation changed after mood induction.

A first hierarchical linear regression included the predictors Visual Presentation (human avatar, robot avatar), Time Point (T1, T5), magnitude of happy mood induction, and magnitude of sad mood induction at level 1. At level 2, the following exploratory predictors were included: attentional engagement (whether or not participants saw the distractor), difficulty (perceived difficulty of dance movements from 0 to 100), comfort (felt comfort during performance of movements from 0 to 100), liking (of the videos from 0 to 100), probability of use (likelihood to use dance movements as a tool from 0 to 100), age and years of dance experience (see section 'Data Analysis – Analysis 3').

The level 1 model was not significant, $F(3, 62) = 0.485$, $p = .379$ with an R^2 of .123 (adjusted $R^2 = .015$), indicative for a low goodness-of-fit according to Cohen (2009). The level 2 model was significant, $F(5, 60) = 2.368$, $p = .011$. The R^2 for this model was .422 (adjusted $R^2 = .178$), indicative for a low goodness-of-fit according to Cohen (2009). Only the coefficient Liking of the respective avatar ($B = 0.530$, $SE\ B = 0.124$, $\beta = .445$, $p < .001$) showed a significant effect for the level 2 model, while there were no significant effects for the predictors Visual Presentation ($p = .587$), Time Point ($p = .984$), magnitude of happy mood induction ($p =$. 345), magnitude of sad mood induction ($p = .126$), attentional engagement ($p = .461$), difficulty ($p = .439$), comfort ($p = .622$), probability to use ($p = .678$), age ($p = .285$) and years of dance experience ($p = .656$). This means that the more participants liked the videos while performing the task, the more their motivation increased afterwards. Detailed results of this regression are depicted in Table 4.

The first linear regression analysis included Time Point as a predictor of motivation ratings after mood induction. Because this motivation change analysis is exploratory, we then conducted a second hierarchical regression with a different set of predictors. We computed two possible dependent variables: (1) the motivation rating at T5 and (2) the magnitude of motivation change between T1 and T5. From a theoretical point of view, we could not determine which of the two should be chosen. The motivation rating at T5 is a direct indicator of the level of motivation at a specific point in time, while the magnitude of motivation change between T1 and T5 reflects the change in motivation over time. However, in the context of work, it can be argued that what matters most is the motivation outcome rather than the change. Therefore, we considered both variables and presented their respective results to provide a comprehensive view of the data. We conducted a Spearman's correlation between these two variables and the other predictors (magnitude of happy mood induction, magnitude of sad mood induction, attentional engagement, difficulty, comfort, liking, probability of use, age and years of dance experience) to determine which of the two possible dependent variables we should include into the second linear regression. These correlations are illustrated in Table 5.

As illustrated in the correlation matrix, the correlation coefficients were higher for the computed variable magnitude of motivation change than for motivation ratings at T5. The magnitude of motivation change was therefore used as the dependent variable for the subsequent analysis.

The second hierarchical linear regression was conducted with the predictors Visual Presentation, magnitude of happy mood induction and magnitude of sad mood induction at level 1. At level 2, the predictors comfort and years of dance experience were included. The other predictors were not included as these did not correlate with the dependent variable (see Table 5). The level 1 model was significant, $F(3, 62) = 3.841$, $p = .014$ with an R^2 of .157 (adjusted $R^2 = .116$), indicative for a moderate goodness-of-fit according to Cohen (2009). The level 2 model was significant, $F(5, 60) = 2.621$, $p = .033$, and the R^2 for the level 2 model was .179 (adjusted $R^2 = .111$), indicative for a moderate goodness-of-fit according to Cohen (2009). The coefficient magnitude of happy mood induction ($B = 0.392$, $SE\ B = 0.132$, $\beta = .393$,

TABLE 4 Spearman's correlations for study variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Difference in motivation	—											
2. Motivation at T5	.173	—										
3. Magnitude of happy mood induction	.352**	.045	—									
4. Magnitude of sad mood induction	.030	−.080	.347**	—								
5. Attentional engagement (correct/incorrect)	.027	−.055	.242	.084	—							
6. Attentional engagement (certainty)	−.031	−.050	.051	−.046	.292*	—						
7. Difficulty	−.195	−.062	−.094	−.064	−.090	−.030	—					
8. Comfort	.247*	.267*	.191	.101	.009	.017	−.681***	—				
9. Liking	.176	.443***	.186	.126	−.009	.031	−.299*	.443***	—			
10. Probability to use	.186	.202	.242*	.273*	.012	−.119	.105	.184	.305*	—		
11. Age	−.056	−.019	−.041	.074	−.118	−.043	.029	.124	−.200	.191	—	
12. Years of dance experience	.327***	.050	.269*	.063	−.021	−.196	−.391**	.346**	−.007	.270*	.051	—

Note: $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$. Difference in motivation = difference of motivation ratings between T1 and T5 (difference = T1 − T5). Motivation at T5 = motivation ratings at T5, after the mood inductions. Magnitude of happy mood induction = change of happy affect ratings (before–after happy imitation). Magnitude of sad mood induction = change of sad affect ratings (before–after sad imitation). Attentional engagement (correct/incorrect) = indicates whether participants had or had not seen the distractor (yes/no). Attentional engagement (certainty) = certainty ratings of participants responses to whether they had seen the distractor. Difficulty = response to the question 'How difficult were the dance moves for you?' Comfort = response to the question 'How comfortable did you feel with performing the movements?' Liking = response to the question 'How much did you like the videos?'. Probability to use = response to the question 'How likely is it that you would use this tool if it were an app that you could use at your work place for a little break?' Overview of correlations of the two variable differences in motivation and motivation at T5 and the relevant predictors (the further variables presented in this table) to determine the dependent variable for the subsequent analysis (see section 'Data Analysis – Analysis 3'). Significant correlation coefficients were higher for motivation at T5 than for difference of motivation. Thus, motivation at T5 was used as the dependent variable for the subsequent analysis.

TABLE 5 Spearman's correlations for study variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Difference in motivation	—											
2. Motivation at T5	.173	—										
3. Magnitude of happy mood induction	.352**	.045	—									
4. Magnitude of sad mood induction	.030	−.080	.347**	—								
5. Attentional engagement (correct/incorrect)	.027	−.055	.242	.084	—							
6. Attentional engagement (certainty)	−.031	−.050	.051	−.046	.292*	—						
7. Difficulty	−.195	−.062	−.094	−.064	−.090	−.030	—					
8. Comfort	.247*	.267*	.191	.101	.009	.017	−.681***	—				
9. Liking	.176	.443***	.186	.126	−.009	.031	−.299*	.443***	—			
10. Probability to use	.186	.202	.242*	.273*	.012	−.119	.105	.184	.305*	—		
11. Age	−.056	−.019	−.041	.074	−.118	−.043	.029	.124	−.200	.191	—	
12. Years of dance experience	.327***	.050	.269*	.063	−.021	−.196	−.391**	.346**	−.007	.270*	.051	—

Note: *$p < .05$, **$p < .01$, ***$p < .001$. Difference in motivation = difference of motivation ratings between T1 and T5 (difference = T1 − T5). Motivation at T5 = motivation ratings at T5, after the mood inductions. Magnitude of happy mood induction = change of happy affect ratings (before–after happy imitation). Magnitude of sad mood induction = change of sad affect ratings (before–after sad imitation). Attentional engagement (correct/incorrect) = indicates whether participants had or had not seen the distractor (yes/no). Attentional engagement (certainty) = certainty ratings of participants response to whether they had seen the distractor. Difficulty = response to the question 'How difficult were the dance moves for you?' Comfort = response to the question 'How comfortable did you feel with performing the movements?' Liking = response to the question 'How much did you like the videos?' Probability to use = response to the question 'How likely is it that you would use this tool if it were an app that you could use at your work place for a little break?' Overview of correlations of the two variables difference in motivation and motivation at T5 and the relevant predictors (the further variables presented in this table) to determine the dependent variable for the subsequent analysis (see section 'Data Analysis – Analysis 3'). Significant correlation coefficients were higher for difference of motivation than for motivation at T5. Thus, magnitude of motivation change was used as the dependent variable for the subsequent analysis.

$p = .004$) showed a significant effect for the level 2 model, while the other predictors showed no significant effect: Visual Presentation ($p = .338$), magnitude of sad mood induction ($p = .113$), comfort ($p = .222$) and years of dance experience ($p = .929$). A higher magnitude of the happy mood induction was related to a higher difference between motivation ratings at T1 and T5. Detailed results of this regression are depicted in Table 6 and Figure 4.

Summing up, these two exploratory analyses suggest that increases in work-related motivation can be caused by engaging in something that we like and that the magnitude specifically of happy mood induction through movement determines the magnitude of this work-related motivation change.

Subjective preferences: liking analyses

To explore participants' subjective preferences for the dancer models of the model that they were asked to imitate (human avatar vs. robot avatar), a logistic regression was performed. Visual Presentation was the predictor. The dependent variable was the dichotomous preference rating [after the task, participants

TABLE 6 Results of hierarchical linear regression with magnitude of motivation change as dependent variable.

	B	*SE B*	*β*	*p*
Level 1				
Constant	1.474	3.947		.710
Visual presentation	−5.431	4.631	−.138	.245
Magnitude of happy mood induction	0.409	0.131	.410**	.003
Magnitude of sad mood induction	−0.158	0.105	−.197	.139
Level 2				
Constant	−6.955	7.692		.370
Visual presentation	−4.602	4.769	−.117	.338
Magnitude of happy mood induction	0.392	0.132	.393**	.004
Magnitude of sad mood induction	−0.176	0.109	−.220	.113
Comfort	0.128	0.103	.159	.222
Years of dance experience	−0.023	0.259	−.012	.929

Note: $R^2 = .015$ for Level 1, $R^2 = .178$ for Level 2 ($p = .011$). *$p < .05$, **$p < .01$, ***$p < .001$.

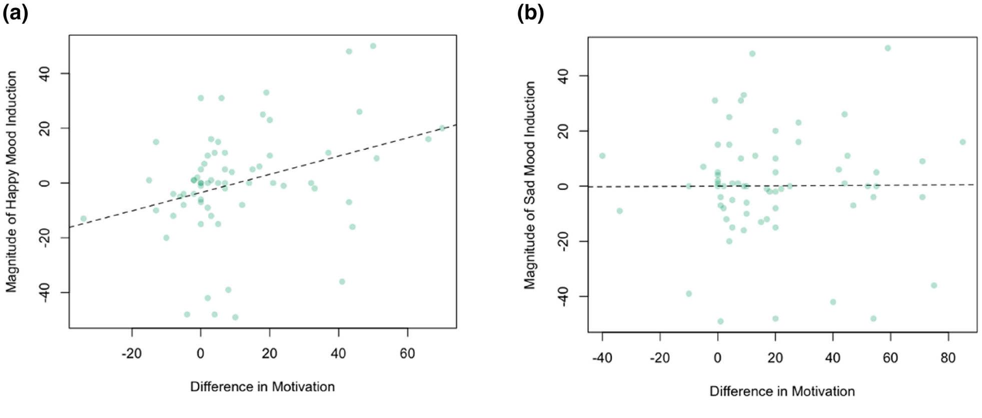

FIGURE 4 Correlation between motivation and magnitude of happy and sad mood induction. *Note*: Correlations between the difference in motivation (difference of motivation ratings between T1 and T5; difference = T1 − T5) and the magnitude of the (a) happy mood induction (change of happy affect ratings; before–after happy imitation) and (b) sad mood induction (change of sad affect ratings; before–after sad imitation).

were asked to make a forced choice between which of the two avatar types (human or robot) they would prefer for a hypothetical second practice round; see section 'Data Analysis – Analysis 4']. The regression model was not significant, $\chi^2(64) = 0.717$, $p = .397$. The type of dancer model participants had been asked to imitate in the task (human or robot avatar) did not significantly predict their preference for either of the models after the task ($B = 0.012$, B $SE = 0.014$, $p = .406$). The R^2 was .017, indicative for a low explanatory quality.

To examine whether participants' subjective liking of the videos ('How much did you like the videos?') differed between the two groups imitating the different dancer models, a one-way ANOVA was conducted. There was no statistically significant difference in liking ratings for the two Visual Presentations (human avatar or robot avatar), $F(1, 64) = 1.701$, $p = .197$.

DISCUSSION

The aim of this experiment was to assess the usefulness of online dance movement imitation as a mood regulation tool. Our results support previous predictions on the relation between affective states and full-body movement: the imitation of dance movements with a happy intention induced happy mood and the imitation dance movements with a sad intention induced sad mood. Both mood inductions were successful, regardless of the dancer model (human avatar or robot avatar) that participants had been asked to imitate. We further found that the magnitude of the happy mood induction and the degree to which participants liked the task predicted work-related motivation after mood induction.

Shafir et al. (2013, 2016) have argued that affect regulation may be possible through the execution of full-body movements. Research on power posing has suggested that musculoskeletal states influence affect via proprioceptive mechanisms (Minvaleev et al., 2004; Nair et al., 2015). Our results are in line with these previous findings. They also complement the theory that our affective states are related to physiological changes in our bodies (Barrett, 2017; Damasio et al., 2000; Jiang et al., 2021; Kreibig, 2010; Niedenthal, 2007; Nummenmaa et al., 2014; for a review see: De Gelder, 2009). Our affective state is not only reflected in our body; also the reverse is true: executing or dancing specific movements with affective expressivity can change one's affective state.

To further investigate mood induction effects, we computed the magnitude of change in happy and sad ratings before and after mood induction. This analysis of the magnitude of change of both mood inductions showed that the magnitude of the happy mood induction was smaller than the magnitude of the sad mood induction. Increases in work-related motivation may be related to how well the happy mood induction works.

These findings are of importance in the workplace, where mood regulation may be used to facilitate cognitive processes (Jeon, 2017; Rowe et al., 2007), and in other situations, where we may not be able to rely on human proximity and physical contact to regulate our mood. In this context, assistive software interfaces may represent a promising tool for mood regulation. Embedding avatars as dance models to imitate offers a series of advantages compared to human dance models. Therefore, we compared the effects of mood induction under two avatar conditions (human avatar and robot avatar). Blackler et al. (2019) argued that there is a difference between humans and robots in the context of dance. Contrary to our expectations, we did not find any differences between the human avatar and the robot avatar with regard to the effectiveness of the mood inductions. As already argued by some authors, avatars seem to represent a possible alternative to traditional human-to-human interventions for mood induction techniques (An et al., 2013; Hopkins et al., 2011; Rehm et al., 2016). This study highlights that this may be regardless of their human resemblance. However, a descriptive analysis of which of the avatars participants would have preferred for a consecutive practice round evidenced that a larger number of people preferred the human avatar ($n = 52$), as opposed to the robot avatar ($n = 13$).

We further investigated the effect of mood induction on motivation because motivation has been found to be an important contributing factor to work performance and quality (Dysvik & Kuvaas, 2011; Kuvaas & Dysvik, 2009). We did not find any difference in motivation ratings before and after the mood induction. Previous research found positive correlations between positive affect and motivation (Ceci & Kumar, 2016). Our results confirm this because a higher magnitude of the happy mood induction was associated with higher motivation change. We also found that the more participants liked the respective avatar they saw, the more motivated they became after mood induction. In a nutshell, these results suggest that doing something you like increases your motivation for something else. Since motivation can be an important variable for work performance, these results highlight the importance of how much an individual likes the avatar they are interacting with.

Our results support that mood regulation via online dance movement imitation as a mood regulation tool seems possible and may provide advantages in terms of cognitive processes, such as focused information-processing (Jeon, 2017) and creativity (when followed by a positive mood: Bledow et al., 2013; Hao et al., 2017). Not to be neglected, however, is that participants generally indicated a low probability of use ($M = 39.02$; scale from 0 to 100).

Despite the positive results of this study, we would like to discuss seven limitations in relation to this study design.

First, the results of this study provide some evidence to suggest that proprioceptive feedback from our body provides sufficient input to our brain to change our affective state. Nevertheless, we cannot be sure about attributing the effects of the mood induction solely to the movement mood induction. Participants were aware of which affective expressivity they imitated as the affected word (happy or sad) was displayed above the video. This could have caused demand effects because labelling an emotion in mood induction paradigms has been shown to activate implicit emotion regulation (Torre & Lieberman, 2018). It is, thus, possible that the repeated mood measurements attenuated the induced sad mood effect through implicit emotion regulation (Gillies & Dozois, 2021). On the contrary, it is also argued that in power posing awareness can cause effects to be less strong (as discussed in: Carney et al., 2015). Hence, although this is a different research question, the relationship between awareness and the strength of effects in mood induction via movement mood induction should be addressed in further studies. To establish a clear relationship between full-body movement and affect, an additional condition in which participants only see the affective word and do not perform or see any movement would be a possible control for this possible confound.

Second, several authors emphasize that within the context of mood induction, self-reports are susceptible to demand effects (Gilet, 2008; Marcusson-Clavertz et al., 2019; Westermann et al., 1996; Zimmermann et al., 2003). Nevertheless, we decided to use self-reports because they are often used in mood induction paradigms (Shafir et al., 2013).

Third, we only measured mood once after each mood induction to assess the effects of our experimental trials. We, therefore, cannot make any claims about the duration of the effects. Previous studies found that induced mood effects did not last longer than 4 min (Gillies & Dozois, 2021). To evaluate the usefulness of such a tool, for example, in the workplace, it would be interesting to explore how long the induced mood effects last.

Fourth, the magnitude of the happy mood induction was smaller than the magnitude of the sadness mood induction. This may be because happiness ratings were relatively high at baseline ($M = 69.64$) in comparison with after the happy mood induction ($M = 71.26$). It is conceivable that a positive interaction with the experimenter led to these initial high happiness ratings (this aspect was mentioned by several participants, but the exact number was not documented). This could have led to ceiling effects, which are commonly found in happy ratings (Suzuki et al., 2006). Further research may examine this paradigm for mood induction minimizing the interaction with the experimenter to a maximum, as other research has suggested that contextual variables can modulate the extent to which dance induces positive mood changes (Zajenkowski et al., 2015). Besides, it is argued that a positive (happy) mood is more difficult to induce than negative (sad) mood (Gilet, 2008). This could explain that, even though the happy mood induction *did* work it was less strong in comparison to the sad mood induction. A combination of different mood induction techniques could possibly enhance the effectiveness of the happy mood induction, as this has led to more successful mood induction results in past studies (Gilet, 2008; e.g. Mayer et al., 1995). The movements also differed in terms of their speed of execution. The dance videos with happy affective expressivity were on average 22.53% (≙13.25 s/stimli) shorter than those with sad affective expressivity despite the same movement sequence being performed. This may have resulted in increased difficulty, especially for those with little or no dance experience. It is possible that fewer resources were available for expressing the happy affective state due to the task being more difficult (as discussed in Hajcak et al., 2010). This assumption may be supported by the fact that we found a positive correlation between dance experience and the magnitude of happy mood induction. Finally, it should be mentioned that the fact that the recognition rate of the emotion of the happy stimuli had not been recognized above chance level in the validation study of the stimuli library could also explain the smaller magnitude of the difference for the happy condition, as compared to the sad condition.

Fifth, another important aspect of empirical dance research is the presence/absence of music in stimuli materials. For the sake of experimental control, dance movements and music are often studied separately at first, to, eventually, combine them in a next step. Music and movement alone can impact mood (Westermann et al., 1996), and previous research has shown that mood-congruent music and dance may have a statistically superadditive effect on observer responses (as found in Christensen et al., 2014). A review of our participants' comments evidenced that some ($n=9$) would have liked to imitate the dance movements with accompanying music. In this first study of its kind, the stimuli were presented without music because we were interested in exploring the influence of expressive *movement* on mood. In the next step, the separate but interrelated effect of movement and music on mood should be systematically investigated and described for the development of dance-based mood induction tools.

Sixth, we are aware that we can only conjecture about the effects of this mood induction on cognitive processes, and ultimately workplace performance because we did not assess these variables directly. Research from workplace productivity commonly assesses workplace motivation through specific questionnaires such as the Work Extrinsic and Intrinsic Motivation Scale (for a review see: Tremblay et al., 2009) and performance by measuring to which degree a person meets a combination of cost, flexibility, speed, dependability and quality objectives (Slack et al., 2010; for a review see: Tangen, 2003). However, our motivation assessment was specifically designed to mirror this type of research in that, in a first step, we asked participants to (1) define the next task they were having to undertake in their day and (2) rate their motivation to perform that task. This procedure ensured some real-life applicability.

Seventh, our study included only two visually very different types of dance avatars, one human with blurred face and the other Xsens proprietary software avatar. We did not find differences between the two avatars in terms of the effectiveness of mood induction. However, participants ($n=4$) commented that the human avatar was very stylized and did not look very human-like. This was possibly due to the blurred face as well as the dancer's all-black clothing. To capture more accurately how the variable of an avatar's human-like appearance affects mood induction, this aspect should have been included as a separate question in the experimental design. Alternatively, a human avatar, whose human features are better recognizable, should have been used. We realize that we cannot generalize about the effectiveness of these two avatars for mood induction, as this would require a series of comparisons where such avatars vary parametrically. It should further be emphasized that the wording of the question 'How much did you like the videos?' was vague because we did not want to draw attention to the 'avataryness' of the model, as an implicit measure of the liking and engagement with the model. However, on the other hand, this vagueness also means that the results concerning the liking variable should be interpreted with caution and supported with further evidence. For example, Johnson et al. (2018) found that the recognition of emotions expressed by an avatar improves as a function of the number of interactions a human has with the avatar.

Finally, it was not investigated whether avatars per se are an effective alternative to human dance models. The focus was on how the human-likeliness of the avatar's appearance affects mood induction. In future research, more varied (parametrically controlled) presentation styles could be implemented, and participants were asked to rate the videos in terms of anthropomorphism (the human-likeness). Since avatars offer benefits, such as being constantly available and showing constant performance, further research should equally address whether there is a difference in the effectiveness of mood induction when participants imitate an avatar compared to a human.

CONCLUSION

This study was the first of its kind to assess mood induction through full-body movements – and in particular, dance – using a same-sequence approach, that is, the same movement but with different affective expressivity was used for the induction of happy and sad mood. Our results confirmed this approach to be successful and highlight the relationship between movement and affect as well as the importance of dance as an effective method for mood regulation. Overall, these results show that dance videos can be used as a tool not only for increased physical activity and motivation (Lin, 2015) but also for targeted mood regulation.

This study also addressed whether imitation of dance movement sequences could be used as a tool for mood regulation at the workplace. We found that the magnitude of the happy mood induction and the subjective preference for an avatar were positively related to our measure of work motivation. We also provided the first evidence that the human-likeness of the avatars used in our study did not impact the effectiveness of mood induction.

AUTHOR CONTRIBUTIONS

Eva-Madeleine Schmidt: Conceptualization; data curation; formal analysis; investigation; methodology; visualization; writing – original draft; writing – review and editing. **Rebecca A. Smith:** Data curation; methodology; visualization; writing – review and editing. **Andrés Fernández:** Data curation; methodology; resources; software; writing – review and editing. **Birte Emmermann:** Conceptualization; methodology; writing – review and editing. **Julia F. Christensen:** Conceptualization; data curation; formal analysis; funding acquisition; methodology; project administration; resources; supervision; visualization; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The full data set and analysis code are available on the OSF: https://osf.io/v5k7j/?view_only=09523320bd184bbb971c01dba1daf5f8. Zenodo DOI: https://doi.org/10.5281/zenodo.7821844. The software is available on Github: https://github.com/andres-fr/emokine.

ORCID

Eva-Madeleine Schmidt https://orcid.org/0000-0002-1013-7583
Rebecca A. Smith https://orcid.org/0000-0002-3422-1894
Andrés Fernández https://orcid.org/0000-0003-3830-3595
Birte Emmermann https://orcid.org/0000-0002-2101-4554
Julia F. Christensen https://orcid.org/0000-0003-0381-5101

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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