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Observing Peripersonal Distance Regulation of Human Affect With the Embodied Distance Test

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We frequently regulate our distance from objects with silent automaticity. Various areas of psychology have studied how we regulate space, though issues with measurement have obscured a grounded interpretation of many findings, as is particularly evident in the long tradition of research on personal space. The Embodied Distance Test (EDT) was developed in response to these longstanding issues in the measurement of spatial behavior and experience in humans, providing a replicable and extensible method for interdisciplinary use. Through calculating difference between predetermined image presentation locations to the participant's later placement locations of the same stimuli, the procedure uses a fairly simple method for indexing spatial distortion. We demonstrate reliable distortion of images of human affect in peripersonal space. Furthermore, we explore empirically-measured differences between explicit and implicit versions of the task which support theoretical concerns regarding the first-person experience of peripersonal space.

Keywords: peripersonal space, embodied cognition, psychological distance, situated cognition, nonverbal behavior

Our bodies seem to automatically adjust and readjust to the space we share with important people and things in our lives (Bargh & Chartrand, 1999). In fact, our sense of space and distance is so automatic and basic, its expression seems to weave throughout many such complex and interesting phenomena such as emotion, the sense of self, and interpersonal relationships. Considered from the third-person perspective, the distance from a body to surrounding objects is simply the measured distance between two objects. In contrast, the first-person perspective – the perspective of experience – shows that distance reflects aspects of the person's whole life situation and is influenced by a host of motivational, emotional, and cognitive processes (Balcetis & Dunning, 2010; Harber, Yeung, & Iacovelli, 2011; Liberman & Trope, 2008). The phenomenologist and philosopher, Maurice Merleau-Ponty, made a strong case for the basic importance of distance in psychology ("depth"):

> More directly than other dimensions of space, depth forces us to reject the preconceived notion of the world and rediscover the primordial experience from which it springs; it is, so to speak, the most 'existential' of all dimensions, because...it is not impressed upon the object itself, it quite clearly belongs to the perspective and not to the things. (1962/2002, p. 298.)

In this quote, Merleau-Ponty addresses the 'existential' nature of depth, highlighting his observation that the first-person experience of space differs qualitatively from the way in which space is typically conceived

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in science; not just in terms of the shape of the space, but in the way the person's perspective is intimately involved in its basic structure. This philosophical position seems to offer a way of understanding deep methodological problems in the tradition of research on interpersonal spatial behavior.

The "stop-distance" task is a foundational method which has been traditionally used in studies of interpersonal spatial behavior (Hayduk, 1978). In this task, participants are explicitly told to inform the experimenter when an approaching confederate experimenter "begins to make the subject feel uncomfortable" (Hayduk, 1978, p. 118). With this experimental situation, the participant is fully involved in the intentions of the experiment and readily gives a consciously-controlled, explicit, verbal indication of their spatial preference.

In contrast to this explicit method are implicit tasks like the chair placement or selection techniques (Hayduk, 1978). In these measures, participants are asked to "pull up a chair" or "take a seat," unaware that the location they choose is covertly measured by the experimenter. In these tasks, participants implicitly indicate their distance preferences through their bodily arrangement within the situation. Measures of this kind are valued as they measure spatial regulation without invoking the complicating factor of the participant's reflective awareness. In this vein, implicit measures are thought to indicate a more "real life" meaning of interpersonal space (Hayduk, 1983, p. 293). We find here that the distinction between implicit and explicit methods in the tradition of interpersonal space research is crucial in impacting spatial perspective. However, these distinctions were often not recognized and may have contributed to confusion across findings as, while they have been taken to measure the same phenomena, they have a rather low intercorrelation (Hayduk, 1978, 1983).

Thus, the equivalence of explicit and implicit distance in the tradition of interpersonal space research may posit a common experiential space across kinds of measurement. Instead, such differences of measurement may alter the perspective of the subject upon the spatial situation in a fundamental way by mixing kinds of first- and third-person perspective experiences in the participants themselves. Further research is needed in order to empirically specify

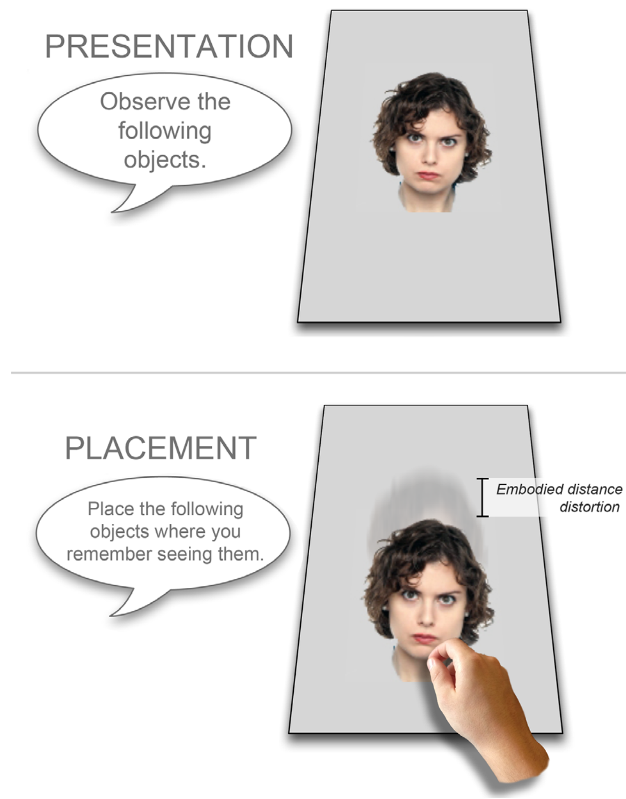

Figure 1a. Walkthrough of the presentation and placement procedure used for the EDT implicit task.
Note. The figure portrays a participant's interaction with a given stimulus. This stimulus would be encountered as one in a series during both the presentation and the placement phases of the procedure. All images were presented in full color.

how it is that the experience of interpersonal space can "belong to the perspective" (Merleau-Ponty, 1962/2002, p. 298). In what follows, we propose a measure called the Embodied Distance Test (EDT) and use it to observe such differences in spatial experience. The EDT closely tracks implicit expressions of distance while maintaining the experimental control necessary for research in cognitive and affective neuroscience.

Method

Participants

All 119 participants were undergraduate students enrolled in an introductory Psychology course participating for course credit. The participants were 60.2% female with the average age of 20.47 (SD

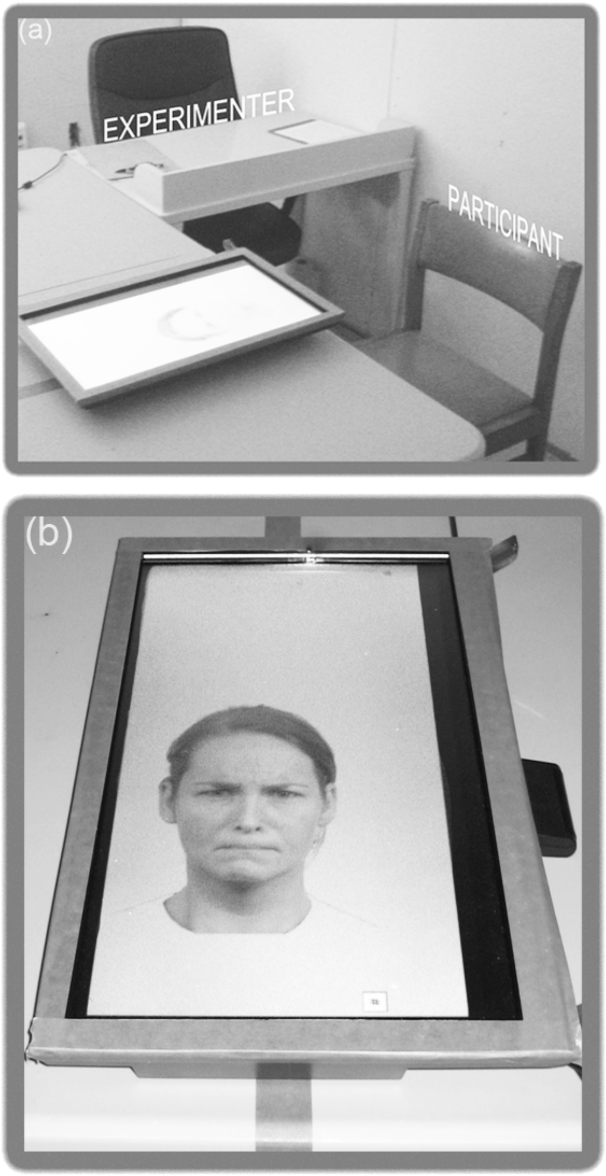

Figure 1b. Overview (a) and participant first-person perspective (b) of the touchscreen EDT used in Studies 2 and 3.

= 3.32). Participants primarily identified as Non-Hispanic White (77.8%). Participants also identified as Other/Not Listed (8.5%), Hispanic or Latino (6%), Black or African American (2.6%), Asian or Asian American (3.4%), American Indian or Alaskan Native (.9%), and one entry was missing. All participants were required to have 20/20 or corrected to 20/20 vision and native fluency in English.

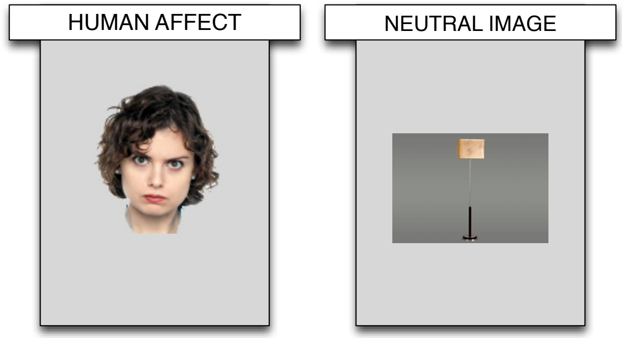

Figure 2a. Example stimuli used.
Note. Not actual Radboud Faces Database or International Affective Picture System images. All images were presented in full color.

Presentation and Placement

At the crux of the EDT method is the presentation-placement procedure. Figure 1a provides a visual walkthrough of this procedure from the participant's first-person point of view. During the presentation phase, a series of stimuli were presented at predetermined locations on a touchscreen surface while the participant was asked to simply observe these stimuli. Subsequently, participants were asked to place each stimulus, one at a time, where they remembered seeing it presented. In this version of the EDT, the stimulus is given at the bottom of the screen, nearest to the participant, for placement. Distance distortion is calculated by taking the difference between the predetermined presentation location and the participant-determined placement location such that negative values indicate distortion of distance toward the participant's body (i.e. Distortion = Placement – Presentation).

Physical Arrangement and Hardware

The EDT apparatus was composed of an Acer 23" T231H LCD touchscreen monitor and a 2.20 GHz AMD Athlon 62 X2 Dual Core Processor 4200+ with 3 GB of RAM running Windows 7. Participants used a stylus to touch the screen. The touchscreen monitor was placed flat on the table and participants sat in a chair at one side of the table. With this arrangement, the left edge of the touchscreen was near the torso of participants, with the right edge of the screen marking

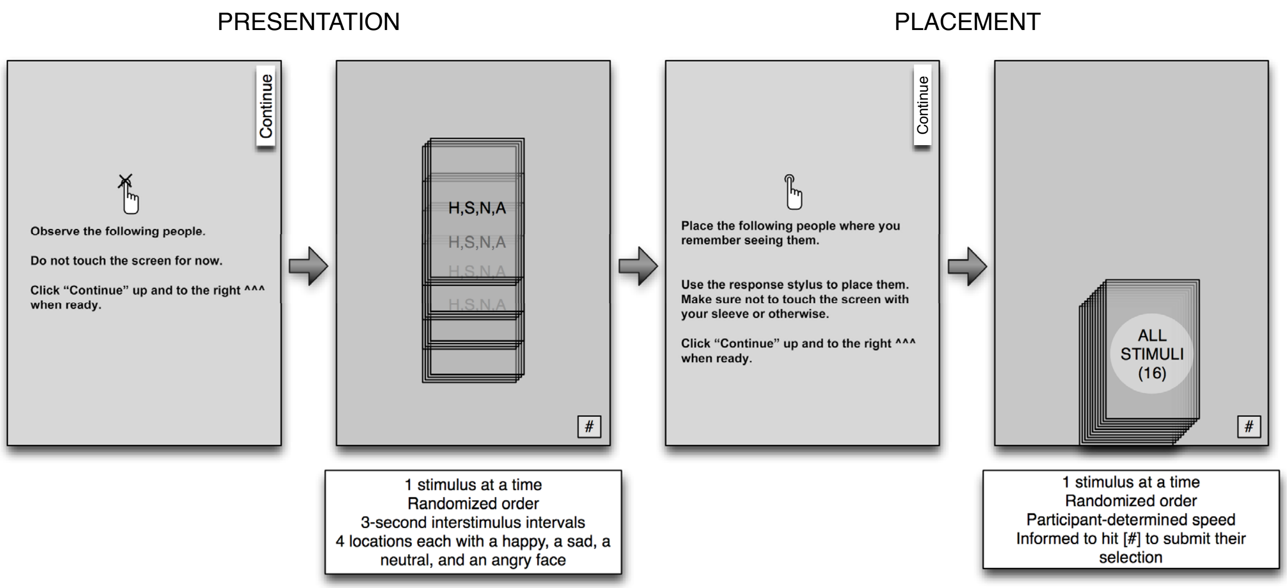

Figure 2b. Schematic of the EDT implicit procedure.

the farthest distance. The experimenter sat out of the participants' line of sight, behind a small desk to the right. Lighting and any visual aspects of experience were held constant across participants. Figure 1b shows the arrangement of the room and the first-person perspective of the participant when facing the screen.

Software and Stimuli

The EDT software was constructed through customized items in Medialab. Items were custom JavaScript-based HTML items, adapting the structure of an open-source Slider applet (Arvidsson, 2002). Stimuli were composed of neutral, nonhuman images (e.g., a lamp) from the International Affective Picture System (IAPS) database (*Mvalence* = 5.06, *SD* = .11; *Marousal* = 2.88, *SD* = .45) and standardized, high-resolution images of individuals demonstrating Facial Affect Coding System-directed affect from the Radboud Faces Database (Langner et al., 2010). The standardization of IAPS means allows for the comparison of our results with other publications using the IAPS database. An Adobe Photoshop CS5 macro cropped, resized, and rotated all images. In the case of the facial affect images a second Photoshop macro was developed to remove hard lines and recolor the background. Image size was standardized to 700 X 1000 pixels or 24.84 X 35.28 cm at 75 ppi resolution. The image alterations gave the stimuli a 'floating' effect on the screen and assured that there were no strong non-facial visual cues (see Figure 2a for an example). Overall, the software was programmed 'sideways', such that the right side of the monitor was farther from the participant. Figure 2a shows example human affect and neutral images in approximate proportions to the touchscreen surface. Locations of image presentation were made constant across types of stimuli.

Procedure

An experimenter greeted and consented the participants when they arrived at the laboratory. During the consent process, participants were told the experiment was "a study of spatial memory." No other indications of space or the hypotheses of the study were made. Participants were then asked to adjust their chair to the spot marked on the floor, informed that they would be using the touchscreen in the experiment, and asked to follow instructions as they appeared on the screen. During the touchscreen portion, participants proceeded through 5 blocks of 16 stimuli each beginning with a practice block. We describe the characteristics of each of these stages of the experimental procedure in detail below. Each

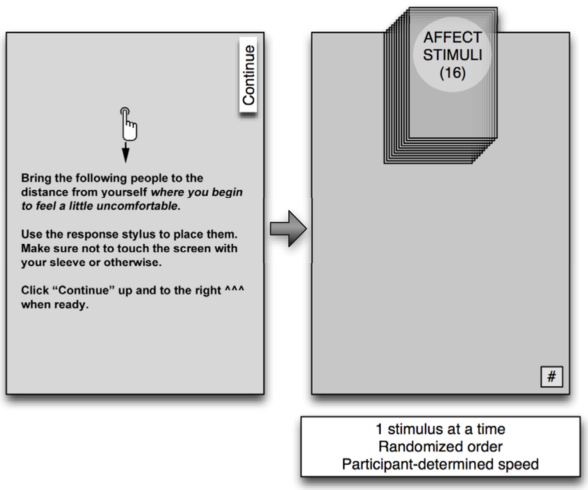

Figure 2c. Schematic of the explicit procedure.

block of the experiment employed one of two types of participant responses (implicit and explicit) and one of two kinds of stimuli (human faces or neutral objects). Instructions of the implicit responding mode of the EDT asked participants to place a series of previously observed stimuli where they remembered seeing them. This mode is of primary interest, as it sought to measure peripersonal distance distortions apart from the participant's direct, conscious knowledge. The explicit instructions, by contrast, directly asked participants to report their preferences for the spatial location of stimuli on the touchscreen surface. For all blocks of implicit responding, stimuli were presented for 3 seconds at one of four locations from the participant. See Figures 2b and 2c for schematic walkthroughs of the implicit and explicit procedures used throughout. Following completion of the touchscreen portion, participants were directed to complete a laptop-based self-report questionnaire in an adjacent room.

Practice: Block 1. Participants were asked to "observe the following people." After presentation of all stimuli, participants were asked to "place the following people where you remember seeing them" (see Figure 2b). One image of each affect (happy, sad, neutral, and angry) was presented at one of the four presentation locations in a randomized order. When later asked to place the images, participants moved the image itself from the bottom of the screen toward where they remembered seeing it and then clicked a box on the lower right corner (from the participant's perspective) in order to submit their response. Following this block, participants were asked if they had any questions about the procedure and were instructed to continue when ready.

Implicit response to human affect: Blocks 2 and 3. Following block 1 participants encountered the same standard presentation-placement arrangement with 16 new facial affect stimuli at the same four presentation locations. No longer naïve to the task, participants were now aware that they would need to place each stimulus from the outset. Each of the four kinds of affective stimuli (happy, sad, neutral, and angry) was presented at each of the four locations. Gender of the actor for each location was reversed across two randomly-assigned conditions, such that each gender was represented by each emotion at each location. All affect images featured novel actors to the participant and utilized Caucasian actors.

Implicit response to neutral images: Block 4. Block 4 followed the same structure of blocks 2 and 3, but used the set of 16 neutral IAPS images as stimuli. Each stimulus was presented at one of the same four locations utilized in previous blocks.

Explicit preference for human affect: Block 5. In the final block of stimuli, participants were asked to "bring each person toward you until you begin to feel slightly uncomfortable" in order to assess explicit preferences for the images. Here, 16 images, four of each affect, were presented at the far edge of the screen and participants moved the image to their desired location before submitting their choice by clicking a box on the right near edge of the monitor. See Figure 2c for a visual schematic of this process.

Results

Data collected from 119 participants yielded 9,520 distance observations (80 observations each). Of these observations 1.2% were invalid (N = 125) due to technological malfunction. These malfunctions were sporadic across cases in the database and did not seem to follow any clear trend. Given the large amount of observations per case and the flexibility of our data analytic method in managing missing data, this relatively small group of data was not of concern.

Table 1
Descriptive estimates of distancing effects in cm on the touchscreen surface.

Stimulus category	Mean	SE	df
Overall	-.82	.84	3.04
Angry[a]	-1.01	1.11	3.10
Happy[c]	-.59	1.11	3.10
Neutral[b]	-1.30	1.11	3.10
Sad[a,b]	-1.23	1.11	3.10

Note. Different superscript letters indicate significant differences between stimulus groups with Bonferroni correction for multiple comparisons.

Implicit Distance Behavior

We turn to an analysis of our guiding hypothesis that the EDT measure could detect reliable differences in distance distortion. Overall, participants placed human affect images .82 cm closer to their body than the location in the initial presentation. See Table 1 for descriptive statistics for each kind of affect.

Human affect: Blocks 2 and 3. First, we evaluated the effect of facial affect on distance distortion in Blocks 2 and 3. We performed a linear mixed effects model with fixed effects of affect (4 levels: happy, sad, angry, neutral), condition (2 levels: counterbalancing locations of male and female actors by emotion), block number (2 levels: Block 2 or Block 3), and two interactions: affect by block and affect by condition. Random effects in the model were participant (119) and presentation location (4).

Supporting our hypothesis for an affect-distancing effect, we found that the kind of expressed affect significantly impacted implicit distancing, $F(3, 3676) = 10.86$, $p < .001$ (see Table 2). Post-hoc Bonferroni corrected pairwise comparisons of the affect-distancing effect indicated that happy faces were distanced farthest from the body (*p*s < .003) while angry faces were distanced farther than neutral faces ($p < .04$), but not significantly farther than sad faces (though in that direction; $p = .12$). There were no significant differences in distancing between sad and neutral faces ($p = .60$). Block was also a significant effect in the model, indicating that stimuli in the second block was placed farther from the participant's body than during the first block, $F(1, 3676) = 11.02$, $p = .001$. Condition and both interactions were not significant in the model (*p*s > .2).

Neutral objects versus human affect. In order to explore the general distancing effects of different blocks, we built a linear mixed effects model with block (4 groups, blocks 1-4) as a fixed effect and participant (119) and presentation location (4) as random effects. We proceeded to construct a linear contrast, which tested the general effect of faces against the effect neutral IAPS stimuli (block 4 vs. blocks 2 and 3). There was a significant effect of stimulus category on calculated distancing such that faces, on the whole, were placed closer to the participant's body than neutral objects, $t(5588) = -9.50$, $p < .001$.

Exploration of Other Influences on Implicit Distancing Effects

The distancing effect from the presentation-placement method may have been influenced by alternative factors including autocorrelation of responses, whether accuracy was influenced by the presentation of stimuli early or late in order (i.e., primacy and recency effects on memory), and memory decay between presentation and placement phases of the blocks. We examined these effects on the standard EDT implicit version of using images of human affect (blocks 2 and 3).

Autocorrelation of responding. In order to examine potential autocorrelation effects, that one stimulus placement depends on the placement of prior stimuli, we produced autocorrelation and partial autocorrelation function (ACF and PACF) tables for the placement means. These functions indicated that there was no evidence of first nor higher-order autocorrelation or partial autocorrelations in participant placement, suggesting that consecutive placements were temporally independent, *p*s > .05.

Primacy and recency of memory encoding. One might predict that primacy and recency memory encoding may impact later distancing effect. In order to test this influence, we examined a linear mixed model with participant (119) and block (2) as random effects and presentation order as a continuous fixed effect. We found no evidence for an effect of presentation order (1-16) in the model, $F(1, 3283.92) = 4 * 10^6$, $p = .998$.

Table 2

Mixed effects model summary of the implicit distancing effects.

Fixed effects source	Numerator, Denominator df	*F*	*p*	Random effects parameter	Variance estimate	SE
Intercept	1, 3.07	.88	.42	Residual	1401428.68	32688.75
Affect	3, 3676.00	10.86	0.00	Presentation Location	767201.79	627619.59
Block (2 or 3)	1, 3676.00	11.02	0.00	Subject	255396.76	39130.84
Stimulus Location Condition (1 or 2)	1, 117.00	1.08	0.00			
Affect * Block	3, 3676.00	1.51	.21			
Affect * Condition	3, 3676.00	.30	.83			

Order of memory retrieval. We then examined the effect of placement order (1-16) as a continuous fixed effect in the model with participant (119) and block (2) as random effects. We found a significant effect of placement order in the model, $F(1, 3282.85) = 16.96$, $p < .001$, indicating that items placed later in the blocks were distanced farther from the participant's body. This corresponds with the overall effect of block order on distancing (later blocks were distanced farther) and seems to indicate an underlying artifact related to increased time in the experiment with increased distancing perhaps due to practice.

Explicit Preferences

We examined distance preferences by asking participants to "bring the people toward yourself until you begin to feel uncomfortable," an analogue to the predominantly verbal method in the personal space research literature. We examined differences in preferences across kinds of human affect by building a linear mixed effects model with participant (119) as a random effect and affect (4 levels: happy, sad, neutral, or angry) as a fixed effect. We found that different emotions were reliably preferred at different distances from the participants' bodies, $F(3, 1782) = 40.05$, $p < .001$. Post-hoc explorations indicated that angry and sad faces were preferred farthest away from the participant's body with neutral faces being preferred between those faces and happy faces preferred closest.

Comparison of Explicit and Implicit Responses to Human Affect

In order to statistically explore the differential distancing of affect images based on explicit preference and implicit movement, we compared distancing on the implicit version of the EDT task (blocks 2 and 3, combined) and the explicit version of the EDT task (block 5). First, we computed the z-score for within each version, creating a common metric. Then, we constructed a linear mixed effects model with fixed effects of EDT instructions (2 levels: implicit vs. explicit), affect (4 levels), and the interaction of EDT instructions and affect. As before, participant (119) was entered as a random effect. In a full-factorial model, we found a significant interaction effect between EDT version and affect, $F(3, 5586) = 25.75$, $p < .001$, indicating a large impact of task instruction on distancing between conditions based on affect. There was an overall effect of affect in the model, $F(3, 5586) = 10.78$, $p < .001$.

Discussion

Distancing in peripersonal space on the implicit version of the task was sensitive to different kinds of facial affect and different categories of stimuli, suggesting further potential of this new measure. We also determined how distancing on the explicit version, similar to the verbal reporting of personal space research, was distinct from distancing on EDT implicit version, similar to nonverbal tasks of personal space research. We explored the influence of other psychological processes on peripersonal space distortion, determining that response order impacted distancing such that those stimuli encountered later tended to be distanced further from the body. Regarding the impact of memory, we found that various indices of memory did not influence distortion. Overall, we confirmed that we could observe distortions of peripersonal space with the EDT across kinds of human affect, that all human affect images were reliably distorted toward the participants' body when compared to neutral nonhuman images, and that implicit and explicit modes of the EDT task (using human images across both) showed reverse spatial trends.

Our exploratory findings regarding specific distancing intensities across kinds of human affect on the implicit version of the task partially correspond with previous research. First, previous research has demonstrated the tendency for angry individuals to be experienced as closer to one's body (Dosey & Meisels, 1969; Wilkowski & Meier, 2010). Second, our findings correspond with similar findings which indicate that negative stimuli, while explicitly preferred away from the body, may actually be implicitly perceived as closer to the body than neutral or positive stimuli (Balcetis & Dunning, 2010; Coombes, Cauraugh, & Janelle, 2007).

Commensurability of measures has long been a problem in personal space research and looms over further progress in the study of spatial aspects of emotion and cognition. The flexibility of the EDT method responds to measurement distinctions which have historically "clouded" personal space research (Hayduk, 1978, p. 129) and provides a methodological link for the study of verbal experiences of space with nonverbal, embodied experiences. We anticipate that future research can benefit from the adjustable extensibility of the procedure: flexibility of stimuli, flexibility of spatial arrangement, and flexibility of instruction. The software can be modified to use any set of images at controlled presentation durations and can be synced with other media or intervention, e.g., sound and electric shock. Further, being a controlled, computerized task, instructions can be varied quite easily. The EDT procedure can account for relevant distinctions between measures and a clearer account of embodied and psychological distancing experience. The EDT complements previous methods of spatial measurement by providing a way for participants to spontaneously distance stimuli and by calculation of distancing, which involves both direction and degree. The EDT is limited in its scope of measuring meaningful peripersonal space distortion in that it necessarily requires participants to interact with images rather than tangible objects (e.g., human affect images rather than other humans). As such, interaction with objects is contained to the touchscreen surface, which inherently limits the possibilities of spatial closeness and distance. While it does appear promising for further research, the EDT also involves what appear to be practice effects, where the placement of later stimuli seem less prone to the influence of emotion.

Currently, much of the research on psychological distance relies on self-report measures via Likert scales, third-person perspective verbal reports of distance, or first-person perspective verbal reports. Some conceptual (Merleau-Ponty, 1962/2002) and empirical perspectives (Hayduk, 1983) indicate that nonverbal enaction of distance is, at least under some conditions, functionally distinct from explicit verbal report of distance (cf. Balcetis & Dunning, 2010). Understanding the conditions under which the first-person experience of distance diverges from third-person measurement may indicate important aspects of the function of spatial experience – particularly in peripersonal space - for regulating emotion in day-to-day life.

Theoretical work from the field of phenomenology calls for reconceptualization of human behavior in terms of enactments of organism-environment relationships. For example, conceptualizing the brain as a mediating organ between our bodies and the world rather than the sole seat of cognition (see Fuchs, 2011), we can understand disjunctions between real space and remembered space as ways in which we manifest our bodily selves in our environments. Further, elements of embodiment have been identified as integral to the experience of the self and these advances have led to promising hypotheses about the nature of experiential space in constituting and maintaining psychopathology (Fuchs & Schlimme, 2009).

Merleau-Ponty (1962/2002) described the difference between perspectives on human perception in his discussion about the difference between breadth, the perception of distance between two external objects and depth, the perception of distance from the situated, first-person experience. He argues that this is due, in part, to the inherently spatial nature of having a body, which permeates all perception and action. Measurements of embodied space involve the participant in spatial interactions as they construct their sense of being an embodied self with silent automaticity. Examining embodiment, in part through the human regulation of embodied distance, can lead to a better empirical understanding of the characteristics of the individual's perceptual being-in-the-world among objects of experience (Heidegger, 1927/2008). Accordingly, the subject-object relationship itself might be considered more phenomenologically basic – and contain more explanatory power of behavior – than examining the characteristics of either in isolation (see Lenarčič & Winter, 2013). Spatial behavior provides a ground for testing more effectively the dynamics of these highly complex relationships through empirical means. With proper measurement techniques, these principles can be examined empirically and contribute toward understanding the phenomenology of verbal and nonverbal space, toward a richer picture of a second-person cognitive neuroscience.

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