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Understanding components of embodiment: Evidence from the mirror box illusion

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A R T I C L E I N F O

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A B S T R A C T

Past studies have examined embodiment in the rubber hand illusion, using principal components analysis (PCA) to identify factors from questionnaire responses during synchronous and asynchronous stroking. To better understand the phenomenology of embodiment, we used PCA in the mirror box illusion to examine performance across conditions that varied in movement synchrony to examine multisensory integration and movement type to vary the amount of multisensory congruence. We found three dissociable components in all conditions: embodiment, deafference and attentiveness. We also examined how these embodiment ratings varied across the four conditions. As hypothesized, embodiment ratings were highest for synchronous movement, with feelings of deafference highest for asynchronous movement. Furthermore, there was a movement by timing interaction, such that sliding resulted in greater differences in synchronous versus asynchronous ratings than tapping. These results suggest that embodiment or deafference can be changed as a function of the amount of multisensory congruence.

1. A psychometric approach to the mirror box illusion

Body ownership illusions like the rubber hand illusion (Botvinick & Cohen, 1998) provide a unique opportunity to examine how we can experience ownership over an object that is not part of our body (Armel & Ramachandran, 2003; Ehrsson, Holmes, Passingham, 2005). For this illusion to occur, participants view a rubber hand while one of their own hands is occluded from view. An experimenter then synchronously strokes both the viewed rubber hand and the participant's hidden, true hand. The visuotactile congruence between the seen strokes on the rubber hand and the felt strokes on their own hand creates sufficient multisensory integration to elicit embodiment of the rubber hand. When stroking is performed asynchronously (i.e., visuotactile incongruence) the rubber hand is not embodied, providing a control condition. From these body ownership illusions, we can observe what aspects of experience characterize embodiment as a participant's perception of their body shifts from a veridical body part to a fake body part (e.g., a rubber hand). Introspective self-report provides an opportune approach to understand the phenomenology of embodying a non-veridical body part.

To directly measure participant experience using introspective self-report, a psychometric approach can be used. With a psychometric approach, questionnaire data can be used to determine the underlying structure of experience by examining the latent groupings of questionnaire items (i.e., factor extractions from covariance matrices) using principal component analysis. Factors that are consistently and robustly extracted are then considered differentiable aspects of the participant's experience of the phenomenon. Longo et al. (2008) presented 131 participants with the rubber hand illusion using both synchronous and asynchronous stroking

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conditions and then asked them twenty-seven questions about their experience. This psychometric approach allowed for distinct factors of body experience to be identified by principal components analysis and examined whether these experimentally derived factors matched with hypothesized theoretical constructs of body ownership. They reported that participant experience consisted of four main components: 'embodiment', 'loss of own hand', 'movement', and 'affect', with an additional component 'deafference' forming during asynchronous stroking only.

Embodiment of the rubber hand was characterized by feeling ownership over the rubber hand, i.e., that it was part of their body, and that it was in the same location as their occluded hand. Embodiment is the most archetypal and central phenomenon in the rubber hand illusion and explained the largest portion of the variance in the questionnaire. A secondary component analysis was done on 'embodiment' questions, and three nested factors were identified: 'ownership', 'location', and 'agency'. These separated the experience of embodying the rubber hand into three distinct phenomena: perceiving the rubber hand as part of the body, in the same location as their occluded hand, and as a controllable object. The secondary primary component 'loss of own hand' was characterized by participants perceiving that their occluded, actual hand was out of their control, lost, or had disappeared. The third component 'movement' was characterized by perceiving both the occluded hand as moving towards the location of the rubber hand, and the rubber hand moving towards the occluded hand (even though no movement occurred). The 'affect' component simply regarded whether the participants either enjoyed or were surprised by their experience of the illusion. Lastly, the 'deafference' component was only extracted during asynchronous stroking conditions and was characterized by perceiving abnormal sensations from the occluded hand such as numbness or pins and needles sensations.

Romano, Maravita and Perugini (2021) followed up on these findings with a much larger sample to examine factors of embodiment, while examining the relationship between these embodiment factors and individual personality traits. They found that the best solution was a three-component structure consisting of rubber hand embodiment, disembodiment of the actual hand, and one related to physical sensations. Using an analysis that examined factors when selecting more than three components, the authors were not able to replicate the subcomponent structure for ownership identified by Longo et al. (2008). The only clear factors that emerged with more factors were loss of own hand and movement factors (part of disembodiment) and affect (which was part of movement). Finally, they found a significant relationship between the embodiment factor and participant self-esteem and empathy. High self-esteem and perspective taking, along with low personal distress and fantasy ratings predicted high embodiment ratings.

A second method that can be used to examine body ownership is the mirror box illusion (Medina, Khurana & Coslett, 2015; Wittkopf, Lloyd & Johnson, 2017; Liu & Medina, 2017, 2018; Katsuyama et al., 2018; Crivelli et al., 2021; Iida, Saito & Ota, 2021). In the mirror box illusion, participants place both their hands into a box separated by a mirror that occludes one hand. Both hands are placed at different distances from the mirror. Participants then view a reflection of their own hand in a mirror that is in a different location than their actual, occluded hand, creating an initial conflict between information from vision and proprioception regarding hand position. Participants are then instructed to synchronously tap with both hands while viewing the reflected hand in the mirror, creating visual, tactile, and motor congruence between the viewed reflection and their actual hand. When the illusion is successful, participants will experience a shift in the perceived location of their hidden hand such that they report feeling it at the location of the mirror-reflected hand. This perceived binding of the visual and proprioceptive estimates often results in feelings of ownership of the reflected hand (as opposed to a rubber hand in the RHI). In asynchronous movement conditions in which the hands tap out of phase, this creates incongruent multisensory information. Prior studies using the mirror box illusion (McCabe, 2005) and similar virtual reality illusions (Newport, Pearce & Preston, 2010; Newport & Gilpin, 2011; Kannape et al., 2019; Reader & Ehrsson, 2019) have shown a striking decrease in perceived ownership of the hand during multisensory disintegration. This decrease in ownership has been associated with both psychophysiological changes (decreased skin conductance response) and activity in multisensory brain regions (Gentile, Guterstam, Brozzoli & Ehrsson, 2013).

Both the rubber hand and mirror box illusion are similar in that both involve either multisensory integration and perceived ownership of the illusory hand, or multisensory disintegration due to visuoproprioceptive segregation. The mirror box illusion has two distinct advantages in eliciting embodiment compared to the rubber hand illusion: the reflected hand is photorealistic and minimizes any differences between the participant's body and the non-veridical body part (i.e., reflected hand); and synchronous tapping involves additional aspects of agency and movement that are not typically involved in the rubber hand illusion (though see Kalckert & Ehrsson, 2012 for an exception). The importance of these advantages is demonstrated in Wittkopf, Lloyd. and Johnson (2017), which used a mirror box illusion variant where visuomotor congruence was created by participants clenching and unclenching their fists as they viewed a reflected hand. The reflected hand was viewed in three different conditions: normal reflection, magnified reflection, and minified reflection. As expected, perceived embodiment of the mirror was increased by the visuomotor congruence, but interestingly altering the reflected hand (i.e. magnify/minimize) lowered subjective embodiment. Combined, this is evidence that the verisimilitude of the reflected hand, both from its viewed size and movement, is crucial for eliciting strong embodiment.

Previous research using the mirror box illusion has found that subjective measures of embodiment (i.e. questionnaires) are related to objective measures of embodiment such as proprioceptive drift (Medina, Khurana & Coslett, 2015). In this study, a variant of the mirror box illusion was used where participants would either tap the midline mirror (or a wooden block with a mirror surface) synchronously, asynchronously, or not move at all. Embodiment of the mirror was measured using both proprioceptive drift and a modified subset of questions from Longo et al. (2008). Subjective measurements of embodiment significantly predicted objective measure of proprioceptive drift.

Using a psychometric approach similar to Longo et al. (2008) and Romano, Maravita and Perugini (2021), we presented participants with the mirror box illusion under different conditions (synchronous and asynchronous movement), followed by a questionnaire regarding their experience. From this, we used principal components analysis (PCA) to examine the phenomenological structure of the mirror box illusion. Second, incongruence in the mirror box illusion is caused by differences in perceived movement of the seen and felt hand, whereas these differences are related to perceived sensation in the rubber hand illusion. Furthermore, one can alter the amount of visuomotor incongruency by varying the size of the movement. Previous studies (McCabe et al., 2005; Foell et al., 2013) developed a large body-sized mirror variant of the mirror box illusion with participants making congruent or incongruent full arm movements. In these studies, participants experienced several abnormal body percepts linked to deafference. One possibility is that these reports of deafference were related to the increase in visuomotor incongruence with full arm movements as compared to incongruence for only the finger or hand in a more typical mirror box experiment. Therefore, we examined whether changes in visuomotor incongruence altered the experience of the mirror box illusion. To do this, we introduced a motor condition where participants synchronously or asynchronously slid their hands against the base of the mirror box, as opposed to simply tapping a finger. Using component loadings derived from the PCA analyses, we then examined how incongruence and the amount of movement altered different aspects of embodiment. As sliding involved larger movements compared to tapping (as well as more tactile stimulation), we hypothesized this would lead to an interaction where sliding would elicit greater embodiment versus tapping in the synchronous condition (i.e., sensorimotor congruence) and greater deafference for sliding versus tapping in the asynchronous condition (i.e., sensorimotor incongruence).

2. Methods

2.1. Data sharing

All research protocols, program scripts, raw data, and statistical analyses can be found at https://osf.io/cm84n/?view_only=ef9a29516b95447fa36f4f69dc1c3cf6.

2.2. Participants

We tested one hundred participants (38 male, mean age = 19.2, 11 left-handed) that were recruited from the General Psychology participant pool at the University of Delaware. This study was approved by the University of Delaware Institutional Review Board. All participants gave informed consent before the experiment began and were offered course credit as compensation for their time. Participants were excluded from analyses if the tester reported that they did not properly follow instructions (e.g., repeatedly looked away from the mirror) or the session was prematurely ended. Two participants were excluded from the experiment.

2.3. Apparatus/Setup

The mirror box had a flat wooden base (36″ long × 16″ wide) and held an acrylic mirror (16″ wide × 12″ tall). The mirror's slot was centered on the base (i.e. 18″ from either edge) creating two equal sections of the box (18″ long × 16″ wide each). The reflective side of the mirror always faced the participant's right hand (i.e., left hand occluded; see Fig. 1.1).

Fig. 1.1. Image of the mirror box. Caption: The mirror box apparatus and the hand posture for the tapping and sliding conditions.

2.4. Procedure & design

Before the experiment began, participants took off all rings, bracelets, and any other items that made their right hand visually distinct from their left hand. Participants placed both hands into the two compartments of the mirror box, with their left hand occluded from view and right hand reflected in the mirror. The participant's occluded left hand was placed ten inches away from the mirror divider, while their right hand was placed six inches away from the mirror divider. Participants were instructed to move their chair to be able to comfortably view the reflected hand in the mirror while having no view of their occluded left hand or other body parts in the mirror.

This experiment, coded in E-Prime 3.0, was a two (movement: tapping or sliding) by two (synchrony: synchronous or asynchronous movement) design. In tapping blocks, participants tapped their index fingers to the beat of a metronome (160 bpm) either synchronously (i.e., both fingers performing the same movement in time) or asynchronously (i.e., one finger moving up while the other moved down). In sliding blocks, participants placed their palms against the base of the mirror box and slid their hands synchronously (i.e., both medially, so the reflected hand moved like the hidden hand) or asynchronously (i.e., one hand sliding medially towards the mirror and the other laterally away). Participants were instructed to slide their hands along the wooden base without touching the mirror divider or moving off the base. A metronome was also used to help pace their movements (60 bpm). Synchronous blocks created visuomotor congruence, as the movements performed by the participant's hidden hand matched the movements in the mirror-reflected hand. Asynchronous blocks created visuomotor incongruence as there was a mismatch between the movement of the hidden hand and what was seen from the reflected hand. Participants were monitored during each block to ensure proper movements were being made. Each tapping block was done twice (two synchronous, two asynchronous) and alternated in an ABBA/BAAB order between participants. After the four tapping blocks, one of each sliding block was done (one synchronous, one asynchronous) and alternated in a CD/DC order between participants.

In each block, the movement was performed for sixty seconds. Then, participants removed their hands from the box and responded to thirty questions on a 100-point visual analog scale (VAS). A visual analog scale was used instead of a Likert scale as previous research has shown VAS scales are less vulnerable to confounding factors and have better reproducibility (Pfennings, Cohen, van der Ploeg, 1995; Grant et al., 1999; Voutilainen et al., 2016). Question order was randomized between blocks and participants. There were minor differences between the wording of the tapping and sliding block questions to adapt to the different movements that were being performed. All questions are shown in the first column of Appendix A and are marked with 'A' if they were exclusively used for the tapping conditions and 'B' if they were used exclusively for the sliding conditions.

2.5. Questionnaire design

To develop a robust self-report questionnaire, initial items were adapted from Botvinick & Cohen (1998), Longo et al. (2008), and Foell et al. (2013). To encapsulate the possible experiences participants may have, thirty items were designed to cover a wide range of themes and possible constructs. Using a wider array of questions helps minimize the effect of experimenter choice on factor loadings. All questions were designed to apply to the mirror box illusion and were worded to minimize any semantic confusion in question items, biased wordings (e.g., using possessives as perceived ownership is being measured), and to minimize artificial inflation of factors from closely related questions (e.g., having both a normal and reverse-scored item in the questionnaire). Standardizing wording was emphasized as terms like "felt like, seem like, or is" vary in whether it is factual or subjective, which could allow for different participant interpretations and criterion in the context of experiencing the illusion. Additionally, previous questionnaires have used terms like "true" or "real" that may be interpreted as factual questions as opposed to questions about the participant's experience of body ownership. To reduce potential bias, we standardized terminology such that the hand seen in the mirror was called the "reflected hand", and the one connected to their body behind the mirror was called the "hidden hand".

2.6. Principal component analyses

Principal component analyses were completed using a direct oblimin rotation. For deciding the best solution, we selected the components determined using parallel analysis, along with examining scree plots and all eigenvalues > 1. In the factor extraction matrix, each value represents the correlation between the question and the component(s) the question loads on to. Negative loadings represent a negative relationship between the question's value and the component (e.g. a question on feeling joyful would load negatively in a component on depression). Loadings were suppressed under 0.3 and were considered complex loadings if they were 0.3 or above in two or more factors, and non-informative complex loadings (i.e., equal in multiple factors) were removed (Hair, Black, Babin, Anderson, & Tatham, 2006; Nunnally & Bernstein, 1994).

Second, to examine how these components break down in each condition, we used the Bass-Ackward procedure (Goldberg, 2006). In this procedure, we identify the correlations between component loadings going from the n-component solution to the n + 1-component solution, starting with our best solution going up to 7-component models (in which all eigenvalues > 1). This allowed us to examine how components break down across conditions. All Bass-Ackwards plots and descriptions are shown in the supplemental section. Finally, to examine structural similarity across synchronous and asynchronous conditions, we used Tucker's Phi coefficient, a measure of factor similarity (Lorenzo-Seva & Ten Berge, 2006).

3. Results

Separate principal component analyses were run for each condition to investigate the structure of the phenomenological experience of the mirror box illusion: synchronous tapping, asynchronous tapping, synchronous sliding, and asynchronous sliding. All thirty question items were included in each principal component analysis, with each trial separately entered into the analysis. PCA analyses were conducted in JASP 0.15, with Tucker's phi calculated using the psych and GPArotation packages in R 4.1.2. Scree plots for each PCA are shown in the supplemental section.

3.1. Tapping PCA

In the synchronous tapping condition, seven component eigenvalues were>1, and the parallel analysis suggested three components. We selected a three-component solution that extracted three components which together accounted for 43.3% of the variance in the data (see Table 1.1). We titled the first component embodiment of the reflected hand (i.e., mirror hand), and this component accounted for 20.7% of the variance. This component was characterized by perceiving that the reflected hand was part of the participant's body, the reflected hand was in the same location and had replaced their real hand, and that motor and sensory phenomena were experienced from the reflected hand. The second component accounted for 15.3% of the variance and was titled deafference. Questions in the deafference component were characterized by abnormal sensations, particularly of the hidden hand, such as their hand feeling cold, numb, or generally strange or not normal sensations. Embodiment and deafference were consistently the top two eigenvalue factors (except for asynchronous sliding where deafference were third). The third factor was titled attention and explained 7.3% of the variance. This factor included questions on attention to the task and was also negatively associated with enjoyment of the task (those who were distracted or less attentive found the task less enjoyable).

In the asynchronous tapping condition, there were eight eigenvalues>1, and the parallel analysis suggested four components. On

Table 1.1
Synchronous & asynchronous tapping component extractions.

#	Questionnaire Item	Tapping Sync			Tapping Async		
		Emb.	Deaff.	Atten.	Deaff.	Emb.	Atten.
1	It felt like the Hand behind the Mirror was replaced by the Hand in the Mirror.	**0.782**	0.01	−0.009	0.161	**0.766**	0.068
2	The Hand in the Mirror felt like it was part of my body.	**0.751**	−0.024	−0.055	−0.038	**0.738**	−0.099
3	The sensation of tapping seemed to come from the Hand in the Mirror.	**0.734**	0.093	0.012	0.139	**0.72**	−0.13
4	The Hand in the Mirror felt like it was my Hand.	**0.711**	−0.067	−0.096	−0.098	**0.831**	−0.059
5	It felt like I was looking directly at my Hand, rather than a reflection.	**0.672**	0.016	0.071	0.063	**0.714**	0.09
6	When I looked into the mirror I felt like I was seeing the other side of the box.	**0.656**	0.046	0.011	0.082	**0.74**	0.094
7	The Hand in the Mirror felt like it was in the same location as the Hand behind the Mirror.	**0.611**	−0.128	0.034	−0.052	**0.508**	0.205
8	I felt like I was tapping the wood with the Hand in the Mirror, not with the Hand behind the Mirror.	**0.582**	0.173	0.121	0.218	**0.588**	0.111
9	I felt like I could have moved the Hand in the Mirror without moving my right hand.	**0.551**	0.062	0.136	**0.319**	**0.389**	0.007
10	Whenever I saw the Hand in the Mirror tap the box I expected to feel the wood beneath my finger.	**0.522**	−0.087	−0.078	0.177	0.234	−0.154
11	I felt as if I was causing the movement I saw in the mirror.	**0.446**	−0.21	−0.289	−0.4	**0.475**	−0.08
12	The Hand in the Mirror moved just like I wanted it to, as if it was obeying my will.	**0.43**	−0.278	−0.174	−0.473	**0.491**	−0.014
13	It felt like the Hand behind the Mirror disappeared.	**0.379**	**0.373**	0.048	**0.405**	**0.304**	0.111
14	It felt like I couldn't locate the Hand behind the Mirror.	**0.329**	**0.507**	0.098	**0.701**	0.102	−0.002
15	I felt strange sensations in either hand during the trial.	0.035	**0.802**	−0.047	**0.715**	0.123	0.044
16	I had pins and needles sensations in the Hand behind the Mirror.	−0.045	**0.77**	−0.071	**0.682**	−0.045	−0.044
17	The Hand behind the Mirror felt numb.	0.047	**0.733**	0.016	**0.705**	0.088	0.115
18	My hands felt normal.	−0.018	**−0.692**	0.039	**−0.697**	−0.075	−0.038
19	Where I felt the sensation of tapping seemed to move during the trial.	−0.137	**0.661**	−0.066	**0.572**	0.138	−0.018
20	The Hand behind the Mirror felt cold.	−0.115	**0.655**	−0.08	**0.599**	0.068	−0.083
21	The Hand behind the Mirror felt like it was moving closer to the Hand in the Mirror.	0.075	**0.616**	0.067	**0.527**	0.11	−0.002
22	Tapping my hands was difficult.	−0.134	**0.553**	0.192	**0.645**	−0.209	0.113
23	During the block I felt the urge to move the Hand behind the Mirror.	0.127	**0.521**	0.063	**0.486**	0.091	−0.02
24	The Hand in the Mirror felt outside of my control.	0.081	**0.381**	0.284	**0.642**	−0.135	0.021
25	I found the experience surprising.	0.285	**0.358**	−0.144	**0.422**	0.194	−0.393
26	My eyes wandered during the trial.	0.009	−0.111	**0.832**	−0.058	0.136	**0.827**
27	I looked at the Hand in the Mirror for the entire trial.	0.068	0.059	**−0.801**	0.011	0.012	**−0.778**
28	I felt distracted during the trial.	0.054	0.079	**0.785**	0.103	−0.057	**0.782**
29	I found the experience enjoyable.	0.12	−0.113	**−0.4**	−0.139	0.182	**−0.452**
30	It felt like I had three hands.	0.132	0.256	0.281	**0.545**	0.034	−0.175
	Eigenvalue	6.211	4.596	2.179	7.512	3.744	2.286
	Percent of Variance Explained	20.7%	15.3%	7.3%	25.0%	12.5%	7.6%

Note: Components are arranged from greatest to lowest eigenvalue, and include 'Embodiment' (Emb.), 'Deafference' (Deaff.), 'Attending' (Atten.) Loading greater than |0.3| are bolded.

inspection of the scree plots, there was a clear gap between the third and fourth components, with the fourth component being very close to the simulated 95th percentile eigenvalue. Our chosen solution was a PCA analysis extracted three components which together accounted for 45.1% of the variance in the data (see Table 1.1). Solutions with additional components, are shown and discussed in the Supplemental section (see Bass-Ackwards analyses). Similar to the synchronous tapping condition, the extracted components represented embodiment, deafference, and attentiveness, though the first component for asynchronous tapping was deafference which accounted for 25.0% of the variance. This was followed by embodiment (12.5%) and attentiveness (7.6%).

Examining factor loadings in the two tapping conditions, there seemed to be a clear relationship between embodiment components, as loadings>0.3 were the same for both synchronous and asynchronous tapping conditions for nearly all questions. To quantify the similarity across the structures for synchronous and asynchronous tapping, we calculated Tucker's phi coefficient. Tucker's phi is used to evaluate the similarity of component loadings across PCA solutions from different samples (Lorenzo-Seva & Ten Berge, 2006). Generally, Tucker's phi coefficients from 0.85 to 0.90 suggest fair similarity, 0.90–0.95 high factor similarity, and > 0.95 nearly identical factors. Using the three-factor solutions for the tapping conditions, we found high Tucker's phi coefficients for loadings across the embodiment (0.96) and deafference (0.95) factors; though we only found a moderate coefficient for the attentiveness factor (0.73).

3.2. Sliding PCA

In the synchronous sliding condition, there were six components with eigenvalues > 0. The parallel analysis identified a four-factor solution. On inspection of the scree plots, there was a clear gap between the third and fourth components, with the fourth component being very close to the simulated 95th percentile eigenvalue. Therefore, we selected a three-component solution which together accounted for 54.9% of the variance in the data (see Table 1.2). Similar to the two previous tapping conditions, the experience of the

Table 1.2
Synchronous & asynchronous sliding component extractions.

#	Questionnaire Item	Sliding Sync			Sliding Async		
		Emb.	Deaff.	Atten.	Emb.	Deaff.	Atten.
1	It felt like I was looking directly at my Hand, rather than a reflection.	**0.915**	0.067	−0.17	**0.769**	0.043	−0.075
2	The Hand behind the Mirror felt like it was moving identically to the Hand in the Mirror.	**0.884**	−0.012	0.07	**0.57**	0.001	0.078
3	The Hand in the Mirror felt like it was my Hand.	**0.883**	0.012	−0.125	**0.8**	−0.236	−0.058
4	The Hand in the Mirror felt like it was part of my body.	**0.858**	0.022	−0.018	**0.793**	−0.14	−0.027
5	I felt as if I was causing the movement I saw in the mirror.	**0.853**	−0.15	−0.064	**0.605**	**−0.326**	−0.112
6	The Hand in the Mirror moved just like I wanted it to, as if it was obeying my will.	**0.835**	−0.187	−0.065	**0.621**	**−0.346**	−0.013
7	The Hand in the Mirror felt like it was in the same location as the Hand behind the Mirror.	**0.799**	0.005	0.03	**0.723**	0.137	0.129
8	I expected the Hand behind the Mirror to be performing the same action I saw in the mirror.	**0.754**	−0.047	0.102	**0.492**	0.255	−0.062
9	When I looked into the mirror I felt like I was seeing the other side of the box.	**0.704**	0.121	0.161	**0.709**	0.073	0.159
10	It felt like the Hand behind the Mirror was replaced by the Hand in the Mirror.	**0.581**	0.27	**0.33**	**0.711**	0.184	−0.048
11	The Hand in the Mirror felt outside of my control.	**−0.56**	**0.432**	0.225	**−0.309**	**0.561**	0.095
12	I felt like I was sliding against the wood with the Hand in the Mirror, not with the Hand behind the Mirror.	**0.538**	0.165	0.169	**0.668**	**0.337**	−0.071
13	I felt like I could have moved the Hand in the Mirror without moving my right hand.	**0.528**	0.226	**0.352**	**0.74**	0.031	0.086
14	The sensation of sliding seemed to come from the Hand in the Mirror.	**0.526**	0.193	**0.424**	**0.613**	**0.383**	−0.03
15	It felt like the Hand behind the Mirror disappeared.	**0.446**	**0.436**	0.268	**0.42**	**0.441**	0.017
16	I found the experience enjoyable.	**0.389**	−0.087	0.182	**0.328**	−0.106	**−0.426**
17	I felt strange sensations in either hand during the trial.	0.088	**0.78**	−0.273	0.094	**0.65**	0.127
18	The Hand behind the Mirror felt numb.	0.003	**0.717**	−0.088	0.175	**0.625**	0.236
19	I had pins and needles sensations in the Hand behind the Mirror.	0.108	**0.7**	−0.159	0.094	**0.446**	0.202
20	The Hand behind the Mirror felt cold.	−0.059	**0.698**	−0.001	0.102	**0.48**	0.096
21	My hands felt normal.	0.221	**−0.662**	0.021	0.039	**−0.727**	−0.031
22	It felt like I couldn't locate the Hand behind the Mirror.	0.157	**0.643**	**0.333**	0.199	**0.513**	−0.095
23	The sensation of sliding seemed to change during the trial.	−0.094	**0.621**	−0.203	0.119	**0.599**	−0.109
24	During the block I felt the urge to change the movement of the Hand behind the Mirror.	−0.23	**0.555**	0.078	0	**0.71**	−0.066
25	I found the experience surprising.	0.067	**0.462**	0.227	−0.017	**0.481**	**−0.479**
26	Sliding my hands was difficult.	−0.298	**0.462**	−0.312	−0.137	**0.594**	−0.132
27	It felt like I had three hands.	**−0.347**	**0.364**	0.018	−0.151	**0.447**	−0.017
28	I looked at the Hand in the Mirror for the entire trial.	0.069	−0.103	**0.792**	0.005	0.048	**−0.837**
29	My eyes wandered during the trial.	0.088	0.07	**−0.738**	0.021	−0.029	**0.782**
30	I felt distracted during the trial.	0.142	0.28	**−0.704**	0.009	0.123	**0.782**
	Eigenvalue	9.090	4.963	2.436	7.399	4.375	2.500
	Percent of Variance Explained	30.3%	16.5%	8.1%	24.7%	14.6%	8.3%

Note: Components are arranged from greatest to lowest eigenvalue, and include 'Embodiment' (Emb.), 'Deafference' (Deaff.), 'Attentiveness' (Atten.) Loading greater than |0.3| are bolded.

synchronous sliding condition consisted of embodiment (30.3% of the variance), deafference (16.5%), and attentiveness (8.1%) components. In the asynchronous sliding condition, the oblimin rotation extracted six eigenvalues > 1, with a parallel analysis suggesting a four-component solution. Upon inspection of the scree plot, we selected a three-component solution which together accounted for 47.6% of the variance in the data (see Table 1.2). As in the synchronous sliding condition, the experience of the asynchronous sliding condition consisted of embodiment (24.7% of the variance), deafference (14.6% of the variance) and attentiveness (8.3% of the variance). Examining the relationship between structures in synchronous and asynchronous sliding conditions using Tucker's phi, we found a similar pattern as observed with tapping. Examining across these factors, Tucker's phi was very high for both embodiment (0.94) and deafference (0.93), though not for attentiveness (0.74). These results suggest that the deafference and embodiment factors are similar across conditions.

3.3. Question response comparisons

While investigating the structure of the phenomenological experience of the mirror box illusion was our primary goal, we also sought to investigate how agreement on these questions changed based on the synchrony of the performed motor movements (synchronous vs. asynchronous) and the salience of the motor movement (tapping vs. sliding). Given the high Tucker's phi coefficients for embodiment and deafference, we focused on these components for this analysis. To accomplish this, we calculated each extracted component's value by multiplying the response by the loading coefficient from the principal component analyses, then summing these responses. This was performed separately for each of the four conditions. Following this, a MANOVA was run on these component scores with the grouping variables of timing type (synchronous, asynchronous) and motor movement type (tapping, sliding) as independent variables. All means and standard deviations for all questionnaire items, separated by condition, are included in Appendix A.

The omnibus MANOVA revealed a significant interaction between timing type and movement type $F(1, 388) = 6.19$, $p = .002$, $\eta_p^2 = .016$. The main effects of timing type, $F(1, 388) = 32.50$, $p < .001$, $\eta_p^2 = .151$, was also significant; though there was no main effect of movement type were significant $F(1, 388) = 1.80$, $p = .167$, $\eta_p^2 = .005$. Given the significant omnibus test, the individual ANOVAs for each component were examined.

Of greatest interest was the 'embodiment' component, which explained the highest amount of variation across all four conditions and involves the most characteristic aspects of the mirror box illusion (i.e. ownership over the reflected hand). A significant interaction was found between the timing type and the movement type, $F(1, 388) = 6.71$, $p = .010$, $\eta_p^2 = .013$. The main effect of timing was significant, $F(1, 388) = 110.6$, $p < .001$, $\eta_p^2 = .218$, while the main effect of movement type was not significant, $F(1, 388) = 2.84$, $p = .093$, $\eta_p^2 = .006$. As expected, embodiment was higher in synchronous (70.7) versus asynchronous (51.6) movement conditions. The significant interaction was because the difference between synchronous and asynchronous component scores was greater in the sliding movement condition (+23.8) compared to the tapping movement condition (+14.4).

For the deafference component, we found a main effect of timing, $F(1, 388) = 18.2$, $p < .001$, $\eta_p^2 = .044$, but no main effect of movement type, $F(1, 388) = 0.51$, $p = .474$, $\eta_p^2 = .001$. Deafference component scores were greater in the asynchronous condition (47.5) compared to the synchronous condition (41.2). There was also a significant interaction between timing and movement type, $F(1, 388) = 4.57$, $p = .033$, $\eta_p^2 = .011$, as the difference between synchronous and asynchronous movement conditions was greater in the sliding (−9.5) versus tapping (−3.2) conditions.

4. Discussion

This is the first attempt at elucidating the structure of the mirror box illusion's phenomenology using a psychometric approach. For all conditions, we found that the experience of the illusion broke into three primary factors, embodiment, deafference, and attention. For embodiment and deafference, the primary components related to body ownership, these factors were quite consistent across movement conditions providing additional evidence for their existence. Examining how embodiment and deafference ratings changes as a function of movement timing and type, we found the expected effect of greater embodiment (and less deafference) with synchronous versus asynchronous movement; and that these effects were exacerbated in the sliding versus tapping movement conditions.

4.1. Factor analysis for the mirror box illusion

Previous examinations of the rubber hand illusion using principal components analysis have found varying results. In the original study using the psychometric method for examining the rubber hand illusion, Longo and colleagues (2008) found evidence for four components: embodiment, loss of hand, movement, and affect; with a fifth component (deafference) that emerged for asynchronous stimulation only. More recently, Romano, Maravita & Perugini (2021) identified a three-component solution for both synchronous and asynchronous stroking with embodiment, disembodiment (a combination of the loss of hand and movement components in the Longo et al. (2008) solution), and a third component related to the physical sensations. For our mirror box experiment, our selected best solution was a three-component model that consisted of questions related to embodiment, deafference, and attention to the task. These three components were observed in both synchronous and asynchronous conditions, with high correlations in loadings across the two conditions. This suggests that these are relatively stable factors.

As expected, embodiment consistently explained the most variance and characterized the most recognizable experiences of the mirror box illusion, such as perceiving the reflected hand as part of one's own body. The questions associated with embodiment include both questions similar to those reported for embodiment in the rubber hand illusion (reporting that the hand in the mirror felt like "my hand" or "part of my body") and questions more specific to the mirror box illusion (i.e., feeling like their own hand was replaced by the hand in the mirror, or that they were looking directly at their own hand). We note that the questions from the rubber hand illusion with high loadings for embodiment in both Longo et al. (2008) and Romano, Maravita & Perugini (2021) ("it seemed like the rubber hand belonged to me", "it seemed like the rubber hand was my hand", "it seemed like the rubber hand was part of my body") all had high loadings for our analogous mirror box embodiment questions ("The Hand in the Mirror felt like it was part of my body", "The Hand in the Mirror felt like it was my Hand."). Along with this, there were also mirror box specific questions that highly loaded onto embodiment, including "It felt like the Hand behind the Mirror was replaced by the Hand in the Mirror." and "The sensation of tapping seemed to come from the Hand in the Mirror." These responses may all relate to the experience of full embodiment that occurs when the visuoproprioceptive mismatch is resolved in favor of the mirror hand. This experience is often described as a sense that the mirror image of the hand feels like their actual hidden hand, similar to the "visual capture" reported in prism adaptation studies (e.g., Hay, Pick & Ikeda, 1965).

The second major component was deafference, which was identified in all four principal components analyses and had a consistent structure across asynchronous and synchronous movement conditions. The questions with the highest loadings for deafference related both to the deafference factor in Longo et al., 2008 and the physical sensations factor in Romano, Maravita & Perugini (2021), with questions regarding the hand feeling "numb" and having "pins and needles". Other questions regarding anomalous sensations in the hand had high loadings to this deafference factor, including feeling "strange sensations in either hand", the mirror hand feeling cold, and (reverse coded) the hand feeling normal. Furthermore, other questions also loaded onto this deafference factor, including ones regarding a feeling of having three hands, an inability to locate the hand, and surprise. We found that our deafference factor appeared in all conditions, whereas this only emerged in asynchronous conditions in Longo et al's (2008) rubber hand illusion manuscript. The discrepancy between information from vision and other modalities is much greater in the mirror box illusion than the rubber hand illusion, likely making these deafferent sensations more salient and more clearly discriminable from other factors.

4.2. Response ratings

Aside from the structure of the mirror box illusion, we were also interested in how the rating of these components varied based on the presence of sensorimotor congruence and the salience of the participant's motor movement. As hypothesized, embodiment was found to be significantly higher in synchronous conditions as sensorimotor congruence facilitates the integration of the reflected hand into the participant's body schema. Timing type (i.e. synchrony/asynchrony) interacted with motor movement condition (tapping/sliding), and as we hypothesized the salient motor movement in the sliding condition amplified the difference in embodiment between synchronous and asynchronous movement.

We also found a similar effect for deafference, with more deafference in the asynchronous condition versus the synchronous condition, and an interaction such that the effect of movement timing on deafference was greater in the sliding versus tapping conditions.

In past studies, sensorimotor incongruence in asynchronous movement conditions have led to an increase in deafferent sensations. Furthermore, large movements in the mirror box have been shown to elicit anomalous sensations in asynchronous conditions. For example, McCabe and colleagues (2005) had participants make congruent or incongruent hand or arm movements in a large mirror box, and participants reported sensations related to pain, temperature change, and the existence of additional limbs more often with the mirror versus a control whiteboard condition (see also Foell et al., 2013). Our observed movement timing by movement type interaction suggests that differences in the amount of sensory incongruence may influence both the sense of embodiment and deafference. When tapping, the only movements being made are in the index finger, whereas in the sliding condition, the entire arm is being moved. These results suggest a mechanism that weights the amount of sensorimotor congruence (or incongruence) and modulates the sense of embodiment (or deafference) based on the amount of congruence.

4.3. Comparison to prior PCA studies on embodiment

Although a direct comparison is not possible due to differences in the questions asked, it is worthwhile to examine the commonalities and differences between our factor structure and those found in previous studies using the rubber hand illusion. In Longo et al.'s (2008) principal component analysis, four components were extracted: Embodiment of the rubber hand, loss of own hand, movement, and affect. The largest component for both the rubber hand illusion and the mirror box illusion was embodiment and had analogous questionnaire items characterized by ownership over a non-veridical body part (i.e., rubber/reflected hand), and feeling that tactile percepts originated from the non-veridical body part. We also found a primary factor related to embodiment.

There were, however, some distinctions between the structure of the rubber hand illusion and the mirror box illusion. Deafferent sensations, while analogous to the deafference component reported in Longo et al. (2008), emerged in both asynchronous and synchronous conditions and was consistently among the highest eigenvalue components. It is possible that the stronger sensory evidence in the mirror box illusion, provided by the visually identical reflected hand and motor movement, led to greater variance in the perception of deafferent sensations causing it to emerge as a central dimension in all conditions. However, it is important to note that on average participants did not report experiencing deafferent sensations (e.g., numbness, change in temperature) even in the asynchronous conditions, while in Longo et al. (2008) the deafference mean was above neutral. Possibly, our questionnaire even with our more expansive questions regarding abnormal sensations did not accurately capture the experience of deafferent sensations, and future research should seek to understand the quality of deafference and disembodiment.

Longo et al. (2008) also reported an agency component (i.e., control of the non-veridical body part) that was composed of two questions in their secondary principal component analysis on the embodiment component. Similar questions regarding agency were used in our questionnaire and agency was not extracted as a primary component. Furthermore, examining the Bass-Ackwards plots, clearly identifiable components for agency appeared in a variable manner, emerging from the deafference component at various points in the analyses. This is surprising as the motor movements used in the mirror box illusion (tapping, sliding) were hypothesized to elicit a greater sense of agency for participants. While agency failing to load as a primary component is in line with the findings of Longo et al. (2008), these agency questions only loaded within the embodiment component once. This provides mixed evidence for agency's role in the experience of the mirror box illusion as it was not found as a primary component or as a subsidiary component within embodiment.

Additionally, analogous questions were used from the location component reported in the secondary principal component analysis in Longo et al. (2008). These questions loaded strongly within the embodiment component as seen in Longo et al. (2008), but as they did not extract as a unique factor within any principal component analysis, we did not consider them as a distinct component of experience. A secondary principal component analysis was not pursued to maintain data-driven component extraction and to minimize the risk of artificial components extracting due to the similarity of question wording (e.g., two of the three location questions having nearly identical wording).

Our solutions did share a factor structure that was more similar to Romano, Maravita & Perugini (2021), as we both utilized three-factor solutions with the two primary factors being both embodiment and deafference. This may be due to methodological similarities, as we used oblimin-rotated solutions versus varimax rotations used by Longo et al. (2008). The major difference was the separation of "disembodiment" and "physical sensations" factors in Romano, Maravita & Perugini (2021) that we did not observe in our mirror box analysis. The physical sensations factor in Romano, Maravita & Perugini included questions on the touch of the paintbrush being "pleasant", feeling touch where they saw the touch, and anomalous sensations (such as pins and needles, and numbness). The disembodiment component was related to the hand having "disappeared", being "out of my control", and the sense of being unable to move the hand. In our mirror box solutions, these factors were all related to deafference. We suggest that this may be due to the strength of the mirror box illusion. Synchronous movements may result in high amounts of normal physical sensations and a strong sense of embodiment, whereas asynchronous movements may result in high feelings of disembodiment and consistent, anomalous physical sensations. Our design may not have had enough cases of moderate incongruence that could lead to a separation of these two factors, as found by Romano, Maravita & Perugini (2021). Additional research manipulating the amount of incongruence could explore this further.

5. Conclusions

Altogether, our results provide evidence for two major phenomenological aspects related to the mirror box illusion: embodiment related to synchronous performance and multisensory integration, and a sense of deafference related to incongruence between vision and other senses (proprioception, touch, motor outflow). These components share similarities to those observed in the rubber hand illusion, suggesting that body ownership illusions have some common underlying structure to their experience, though we note that other body ownership illusions, particularly larger scale illusions like the 'body-swap illusion' need to be tested to generalize this further (Petkova & Ehrsson, 2008; Guterstam & Ehrsson, 2012).

CRediT authorship contribution statement

William T. Leach: Conceptualization, Methodology, Software, Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Jared Medina:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Questionnaire item means and standard deviations by condition

		Synch. Tapping		Asynch. Tapping		Synch. Sliding		Asynch. Sliding	
#	Item	Mean	St.d	Mean	St.d	Mean	St.d	Mean	St.d
1	The Hand in the Mirror felt like it was part of my body.	73.90	19.02	55.88	23.6	79.09	23.73	54.86	30.42

(continued on next page)

(*continued*)

#	Item	Synch. Tapping		Asynch. Tapping		Synch. Sliding		Asynch. Sliding	
		Mean	St.d	Mean	St.d	Mean	St.d	Mean	St.d
2	The Hand in the Mirror felt like it was my Hand.	74.90	20.35	60.83	24.31	80.80	21.54	54.01	32.78
3	It felt like I was looking directly at my Hand rather than a reflection.	70.66	21.48	52.88	24.61	80.32	23.24	53.46	32.22
4	When I looked into the mirror I felt like I was seeing the other side of the box.	74.92	19.66	53.41	24.06	77.59	24.48	49.72	31.15
5	The Hand in the Mirror felt like it was in the same location as the Hand behind the Mirror.	70.26	21.65	56.44	21.78	75.39	26.63	41.38	31.43
6A	The sensation of tapping seemed to come from the Hand in the Mirror.	68.02	21.01	52.19	24.59	–	–	–	–
6B	The sensation of sliding seemed to come from the Hand in the Mirror.	–	–	–	–	70.68	28.33	55.95	29.47
7A	I felt like I was tapping the wood with the Hand in the Mirror.	63.37	23.42	48.76	24.47	–	–	–	–
7B	I felt like I was sliding against the wood with the Hand in the Mirror.	–	–	–	–	64.18	30.71	48.13	31.28
8	I felt like I could have moved the Hand in the Mirror without moving my right hand.	54.27	24.00	43.47	22.76	57.70	31.08	49.48	30.69
9	It felt like the Hand behind the Mirror was replaced by the Hand in the Mirror.	67.86	21.19	50.38	24.28	68.63	28.19	49.49	32.69
10	I had pins and needles sensations in the Hand behind the Mirror.	27.18	27.14	26.83	26.15	27.29	29.00	28.67	30.87
11	I felt strange sensations in either hand during the trial.	43.15	27.44	45.08	27.96	40.46	31.23	45.52	32.00
12	The Hand behind the Mirror felt numb.	37.81	26.92	37.38	26.93	31.48	27.99	36.43	32.13
13	The Hand behind the Mirror felt cold.	31.01	26.43	30.88	24.2	26.63	23.71	28.60	28.40
14	My hands felt normal.	52.82	27.60	47.81	28.44	56.14	28.92	39.59	31.73
15	It felt like I couldn't locate the Hand behind the Mirror.	51.17	23.40	51.21	25.78	48.11	30.97	53.41	30.05
16	The Hand in the Mirror felt outside of my control.	35.07	21.31	46.97	25.82	33.34	26.99	57.22	31.43
17	It felt like the Hand behind the Mirror disappeared.	50.96	25.32	42.92	23.74	53.54	32.21	41.47	31.05
18A	During the block I felt the urge to move the Hand behind the Mirror.	56.30	26.48	57.86	22.96	–	–	–	–
18B	During the block I felt the urge to change the movement of the Hand behind the Mirror.	–	–	–	–	52.55	34.05	65.70	29.95
19A	Tapping my hands was difficult.	30.30	25.70	43.06	28.76	–	–	–	–
19B	Sliding my hands was difficult	–	–	–	–	33.14	27.70	52.43	33.36
20A	Where I felt the sensation of tapping seemed to move during the block.	45.19	23.31	53.5	24.83	–	–	–	–
20B	The sensation of sliding seemed to change during the trial.	–	–	–	–	49.02	29.07	59.29	26.64
21A	The Hand behind the Mirror felt like it was moving closer to the Hand in the Mirror.	41.46	24.33	40.44	24.27	–	–	–	–
21B	The Hand behind the Mirror felt like it was moving identically to the Hand in the Mirror	–	–	–	–	76.70	25.47	38.01	33.58
22	It felt like I had three hands.	31.76	27.03	41.43	29.98	28.95	27.72	52.54	34.55
23	I felt distracted during the trial.	29.58	21.25	31.59	22.66	23.18	25.85	22.82	25.44
24	My eyes wandered during the trial.	27.33	23.31	30.59	22.11	22.50	29.31	19.86	24.35
25	I looked at the Hand in the Mirror for the entire trial.	83.24	19.98	78.96	20.6	86.09	20.02	82.59	21.14
26	I found the experience surprising.	63.94	20.2	62.78	22.28	65.02	26.94	66.55	25.12
27	I found the experience enjoyable.	60.92	22.44	56.58	24.59	62.64	24.52	56.00	26.15
28	The Hand in the Mirror moved just like I wanted it to as if it was obeying my will.	72.13	20.27	57.8	23.58	71.38	27.02	44.48	32.60
29	I felt as if I was causing the movement I saw in the mirror.	78.59	14.63	66.38	20.09	75.57	21.43	55.90	30.36
30A	Whenever I saw the Hand in the Mirror tap the box I expected to feel the wood beneath my finger.	73.81	19.17	66.8	22.02	–	–	–	–
30B	I expected the Hand behind the Mirror to be performing the same action I saw in the mirror.	–	–	–	–	81.18	17.55	66.75	28.11

Appendix B. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.concog.2022.103373.

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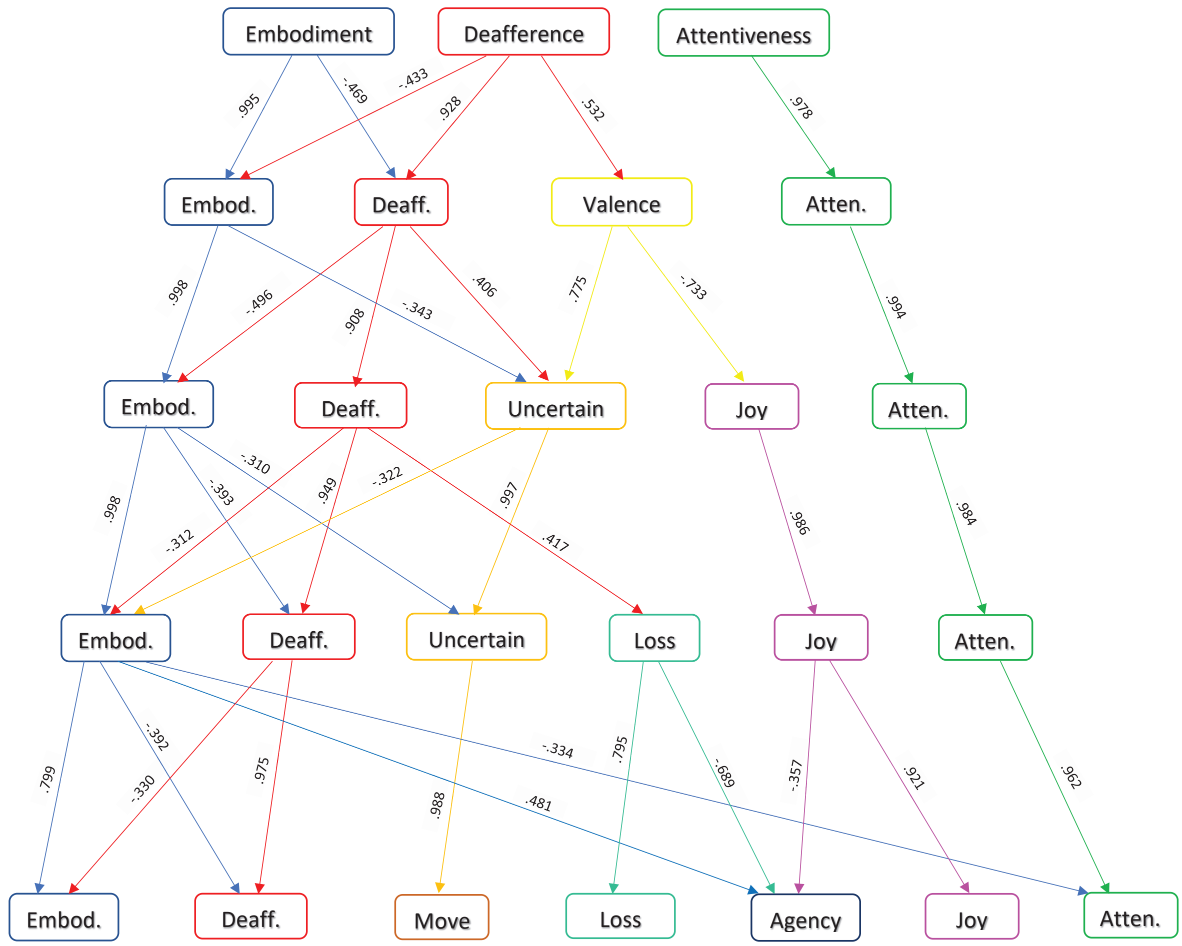
Supplemental Section A – Bass-Ackwards plots

Synchronous tapping

For the Bass-Ackwards analysis, the three-component factors (ownership, deafference, attention) maintained high correlations ($r > .9$) with the four-component solution, along with the addition of a fourth factor related to affect (finding the task difficult and not enjoyable). With a five-component solution, the original three-component factors (ownership, deafference, attention) remained with high correlations ($r > .9$), along with a component on affect (although this was related to positive aspects, i.e., finding the task enjoyable and not difficult). A fifth factor emerged related to uncertainty regarding perceived hand position. Using a six-component solution, the five previous factors were all highly correlated between the five- and six-component solutions ($r > .94$), with the addition of a new factor primarily related to agency over (cause of movement, mirror hand "obeying the will", control of the mirror hand) and location of the hand (couldn't located the hand behind the mirror, felt like the hand behind the mirror disappeared). Adding a seventh component resulted in a split of the agency/location component from the six-component solution, generally along the lines of agency and location.

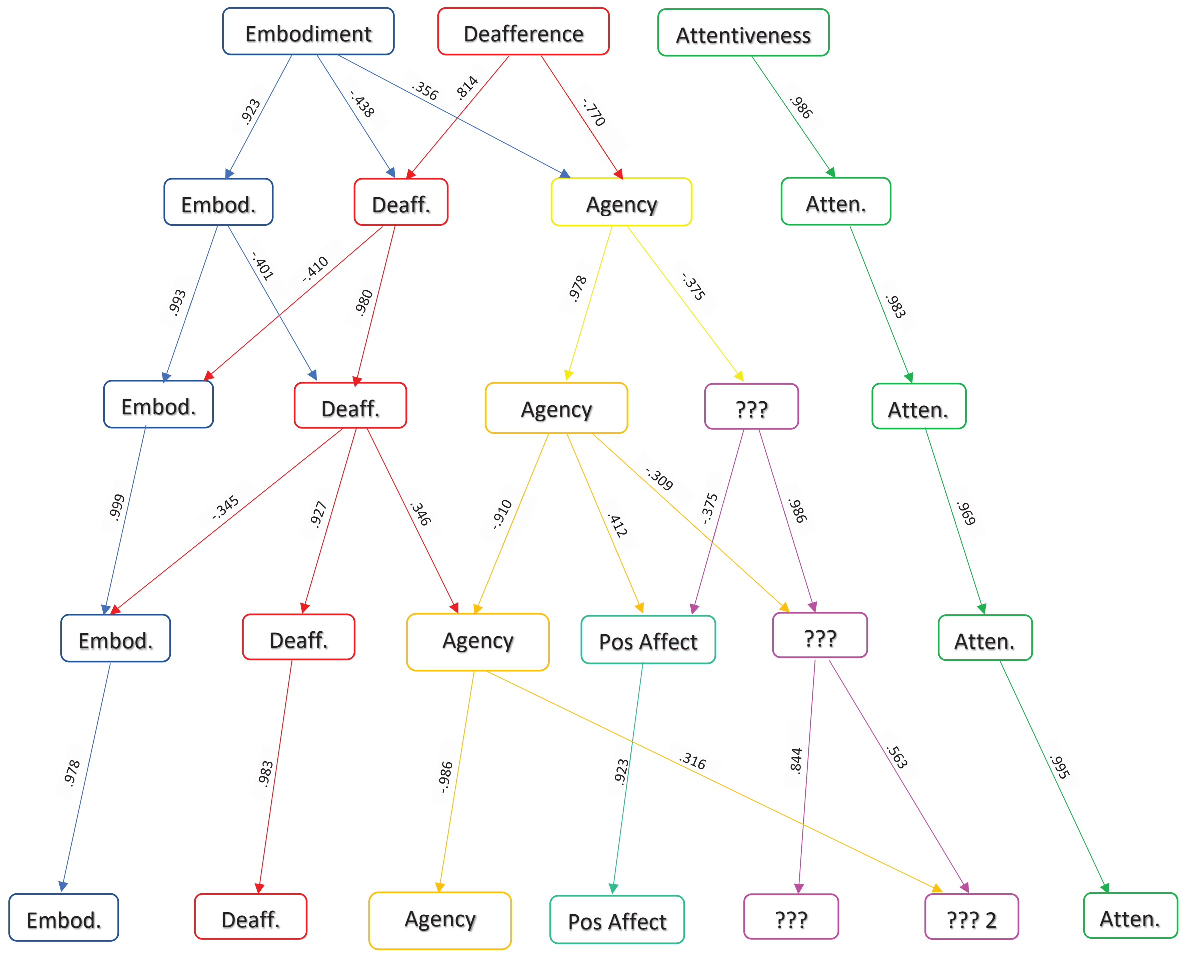
Supplemental Figure 1A – Synchronous tapping Bass-Ackward plot



Asynchronous tapping

Using the Bass-Ackward procedure, the four-component solution involves the same factors as the three-component solution, with high correlations (rs > .8). In addition, a new factor that is highly negatively correlated with deafference (-.77) and mildly correlated with embodiment (.35) emerged. These questions relate somewhat to agency (with responses on the hand moving “just like I wanted it to”, control, and causing the seen movement), though also including a few responses related to task difficult and enjoyment. There was a strong correlation between component ratings in the four and five factor solutions for embodiment, deafference, agency, and attention (rs > .97), along with the addition of a fifth factor that was difficult to define. The six-component solution had high correlations with factors in the five-component solution (rs > .9), with the addition of a factor on positive affect (finding the task enjoyable and surprising). The seven-component solution had high correlations with the factors in the six-component solution (rs > .8), with a seventh difficult to define component.

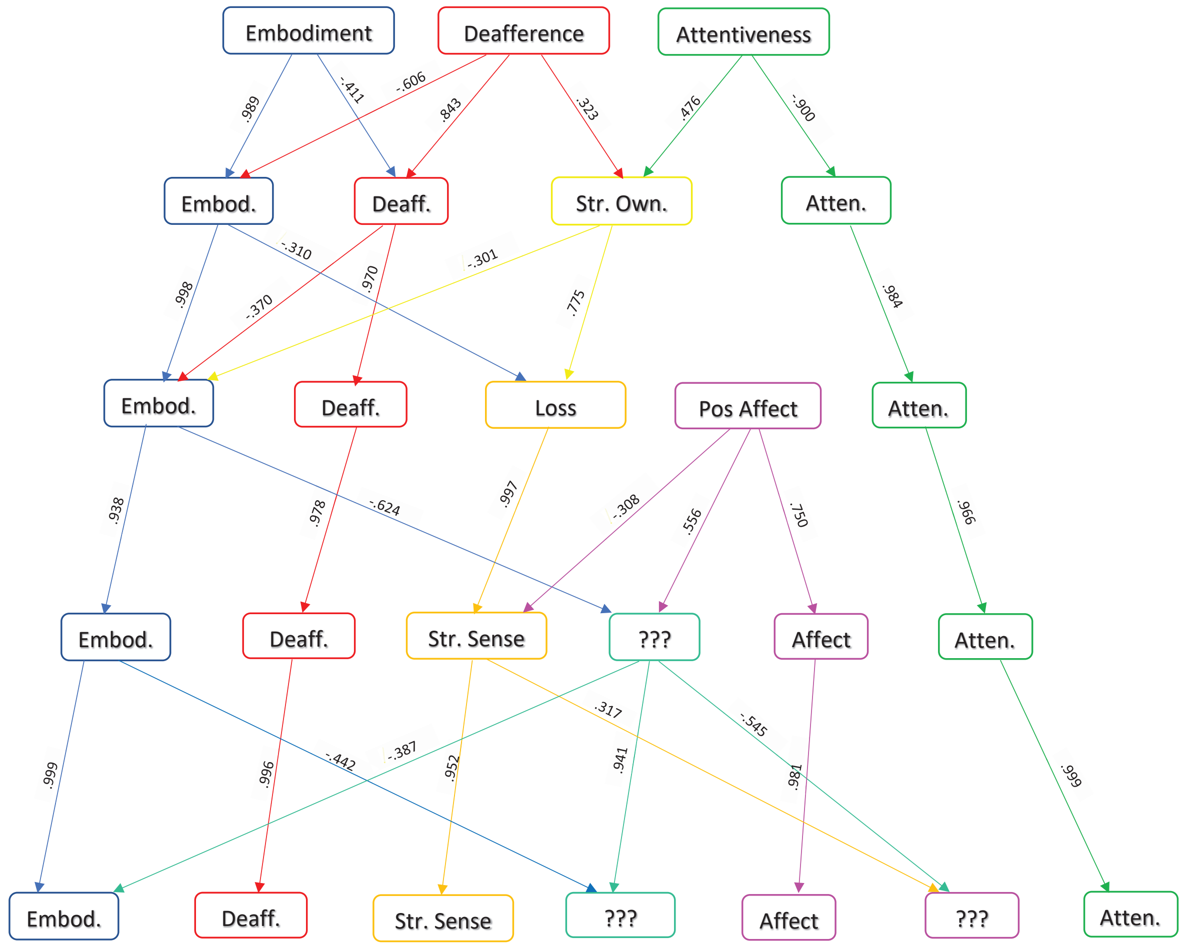
Supplemental Figure 1B – Asynchronous tapping Bass-Ackward plot



Synchronous sliding

Using the Bass-Ackward procedure, component correlations between the factors in the three-component and four-component solutions were relatively high (rs > .84), with the addition of a fourth factor related to the strength of ownership. Correlations between the four-component and five-component solutions were high (rs > .97, with the exception of strength of ownership, r = .775), with the addition of a fifth factor related to positive affect (finding the task enjoyable or surprising). Moving to a six-factor solution, the factors in the five-component solution had relatively high correlations (rs > .9, with the exception of positive affect with r = .75). A new factor emerged that was difficult to characterize, but moderately related to control of the hand. Finally, the seven-component solution consisted of all the factors in the six-component solution (rs > .94), with the addition of an unclear factor related to the hand feeling normal and controlling the mirror hand.

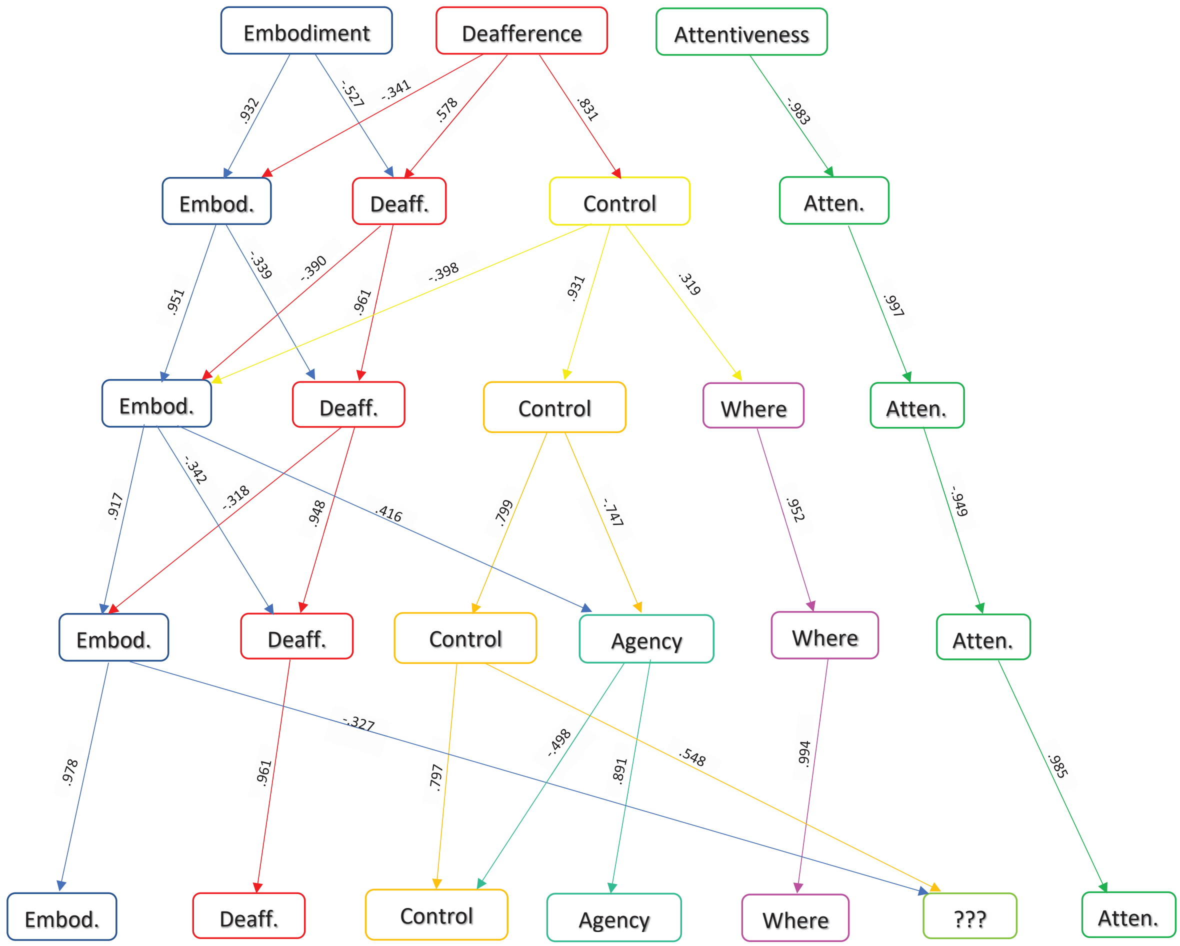
Supplemental Figure 1C – Synchronous sliding Bass-Ackward plot



Asynchronous sliding

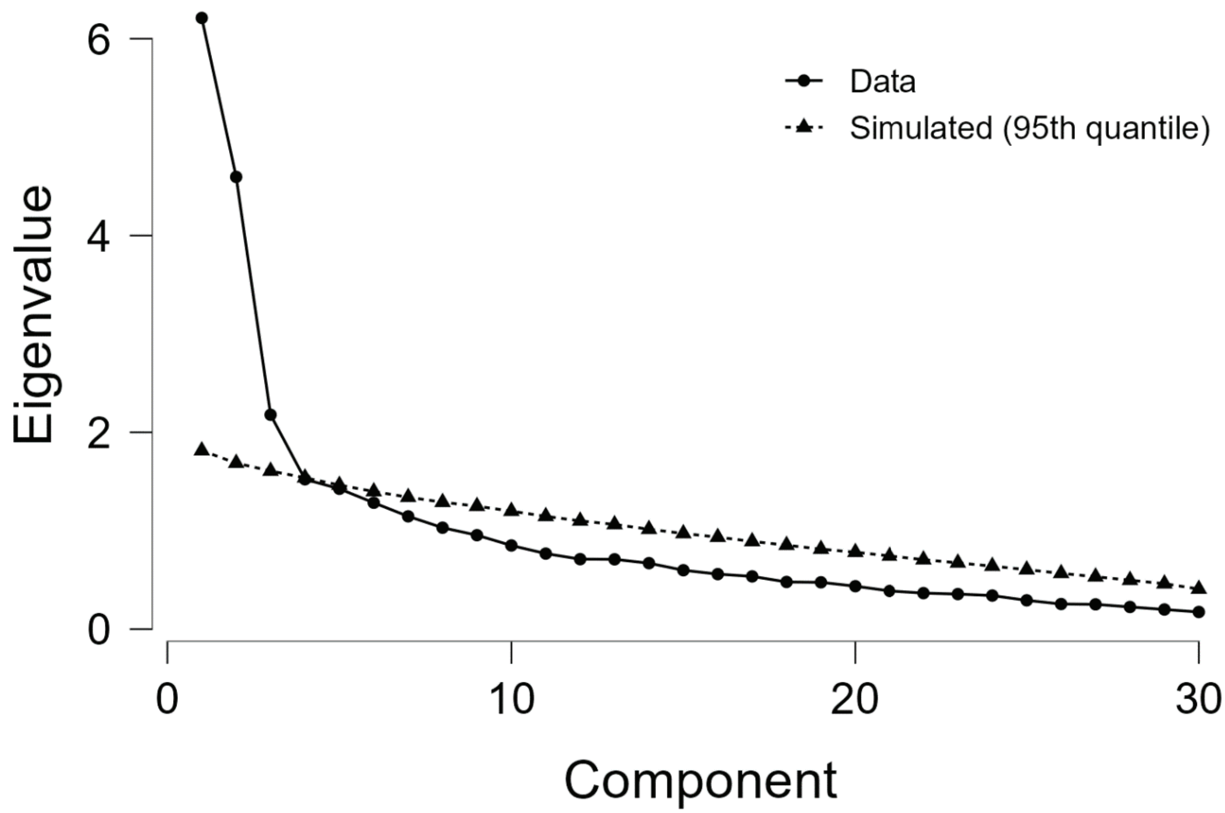
In the Bass-Ackward analysis, the four-component solution shared all components with the three-component solution (rs > .83), though the deafference component from the three-component solution split into two separate components. The first related to feelings of control and normalcy regarding the mirror hand (e.g., “I felt as if I was causing the movement I saw”, “the Hand in the Mirror felt outside of my control”), with the second related more towards the sensory aspect of deafference (e.g., “strange sensations in either hand”, “pins and needles sensations”, feeling the mirror hand as cold and numb). The five-component factor shared all components from the 4-component solution (rs > .93), with the addition of a new factor related to the existence of the hand behind the mirror. Examining a six-component solution, all from the five-component solution continued with high component score correlations (rs > .79), along with the addition of a factor related to agency (with responses related to the mirror hand moving “just like I wanted it to”, feeling “outside of my control”, and feeling as if they caused the movement in the mirror). The 7-component solution shared all of the components from the 6-component solution (rs > .79), with the addition of a component related to positive affect.

Supplemental Figure 1D – Asynchronous sliding Bass-Ackward plot



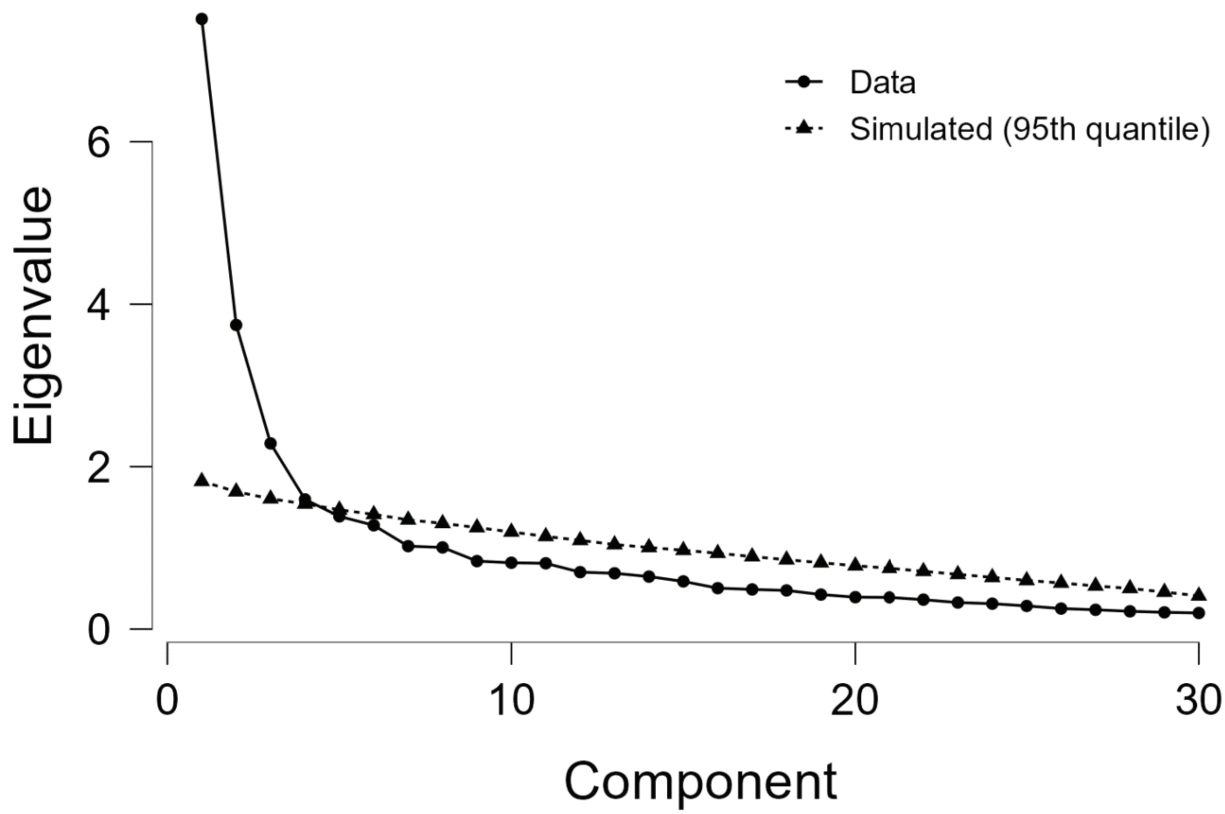
Supplemental Section B – Scree plots

Supplemental Figure B1 – Synchronous Tapping Scree plot



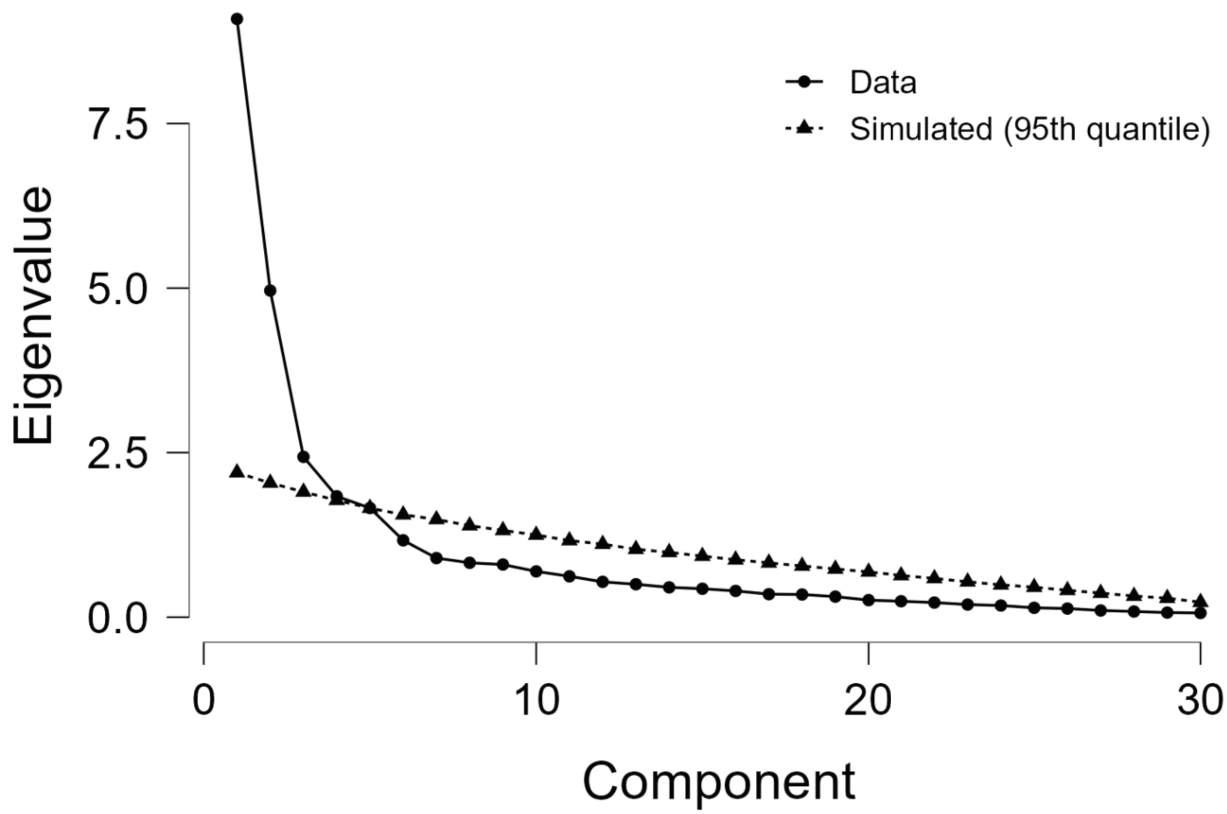
Scree plot for the synchronous tapping condition, with the dashed line showing the simulated data of the parallel analysis.

Supplemental Figure B2 – Asynchronous Tapping Scree plot



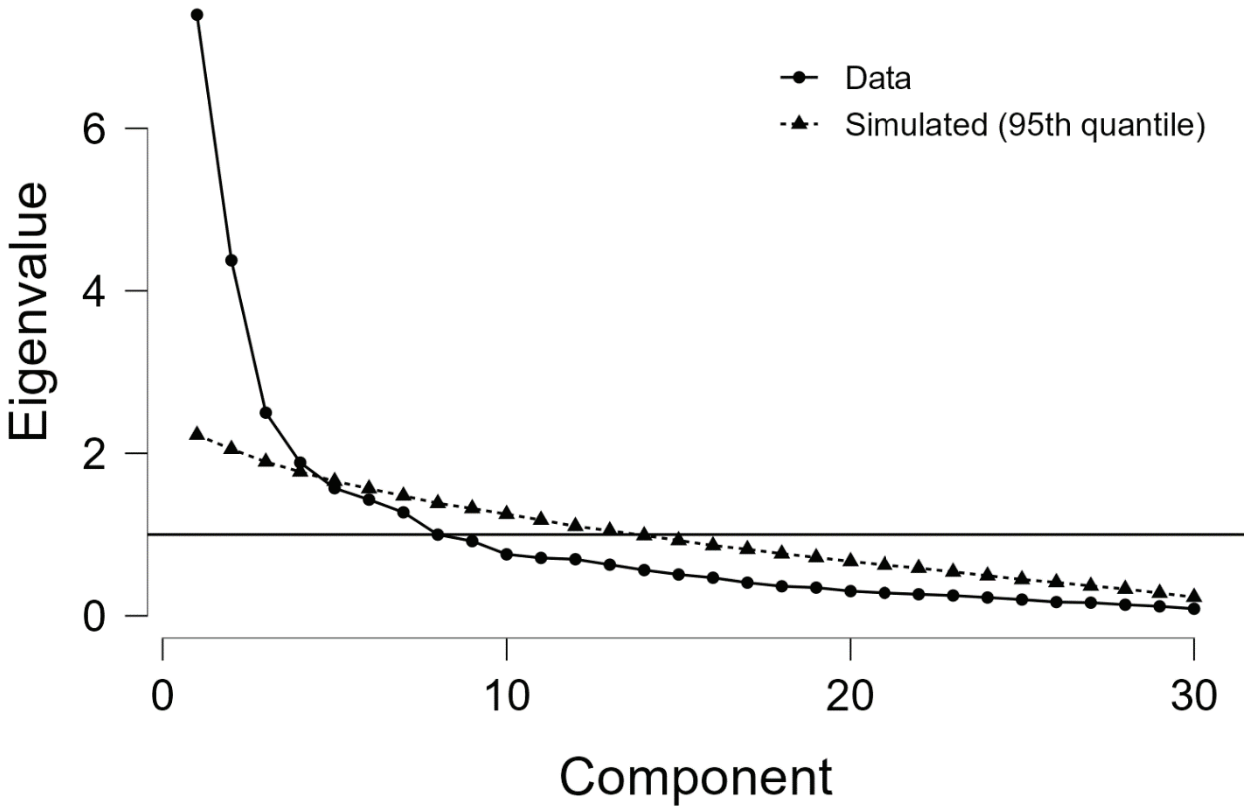
Scree plot for the asynchronous tapping condition, with the dashed line showing the simulated data of the parallel analysis.

Supplemental Figure B3 – Synchronous Sliding Scree plot



Scree plot for the synchronous sliding condition, with the dashed line showing the simulated data of the parallel analysis.

Supplemental Figure B4 – Asynchronous Sliding Scree plot



Scree plot for the asynchronous sliding condition, with the dashed line showing the simulated data of the parallel analysis.