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**The ‘not-so-strange’ body in the mirror: A Principal Components
Analysis of direct and mirror self-observation**

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Abstract

In this study we adopted a psychometric approach to examine how the body is subjectively experienced in a mirror. One hundred and twenty-four healthy participants viewed their body for five minutes directly or via a mirror, and then completed a 20-item questionnaire designed to capture subjective experiences of the body. PCA revealed a two-component structure for both direct and mirror conditions, comprising *body evaluations (and alienation)* and *unusual feelings and perceptions*. The relationship between these components and pre-existing tendencies for appearance anxiety, body dysmorphic-type beliefs, dissociative symptomatology, self-objectification and delusion ideation further supported the similarity between direct and mirror conditions; however, the occurrence of strange experiences like those reported to occur during prolonged face viewing was not confirmed. These results suggest that, despite obvious differences in visual feedback, observing the body via a mirror (as an outside observer) is subjectively equivalent to observing the body directly (from our own viewpoint).

Keywords: mirror; body experience; principal components analysis; self-observation

1. Introduction

Mirrors allow us to view the physical appearance of our own face and body from an observer (third person) perspective. Moreover, self-recognition in a mirror is considered a measure of self-awareness (but see Rochat & Zahavi, 2011, for a critical discussion), with only humans and a few other animals possessing this capacity (Amsterdam, 1972; Gordon, 1970; Plotnik, de Waal, & Reiss, 2006; Reiss & Marino, 2001)(Amsterdam, 1972; Gordon, 1970; Plotnik et al., 2006; Reiss & Marino, 2001). However, a human's relationship with mirrors and reflections goes beyond simple self-recognition, as we frequently use mirrors to perform complex actions (e.g. driving), as well as for self-grooming and checking our physical appearance.

Interestingly, mirrors have such a strong association with viewing the self that we naturally assume individuals are using mirrors for self-observation even when the laws of physics make this impossible, known as the Venus effect (Bertamini, Latto, & Spooner, 2003; Bertamini, Lawson, Jones, & Winters, 2010).

What is more, deficits in self or body perception often involve a preoccupation with viewing the body that can be seen in their atypical interactions with mirrors; for example, individuals suffering from eating disorders, who are thought to have an abnormal experience of their body, often exhibit frequent body checking that involves mirrors, or conversely mirror avoidance (Shafran, Fairburn, Robinson, & Lask, 2004). Sufferers of body dysmorphic disorder can spend hours in front of a mirror or other reflective surface (Veale & Riley, 2001), and deficits in self processing following neurological damage can result in a failure to recognise one's own reflection (Phillips, 1996). Mirrors can also alleviate pathological symptoms involving the self/body experience; for example, patients with somatoparaphrenia who deny ownership of their limbs following brain injury have been found to have ownership temporarily

reinstated when viewing their disowned limb via a mirror (Fotopoulou et al., 2011; Jenkinson, Haggard, Ferreira, & Fotopoulou, 2013). Moreover, certain types of “mirror therapy” can reduce negative feelings towards the body in eating disorder patients (Jansen et al., 2015), and can change the body experience and alleviate pain in amputee and neurological patients (Rosén & Lundborg, 2005).

Outside the clinic, recent experimental studies have **suggested** that even healthy individuals can encounter strange experiences when looking in a mirror. During the “strange face illusion” **it has been reported that** participants who view their face in a mirror at low illumination for several minutes **describe** experiences that their reflection changes and distorts; for example, appearing deformed, like another person, or like another being/animal (Caputo, 2010, 2013a; Caputo et al., 2012; see also Schwarz & Fjeld, 1968 for an earlier investigation of the phenomenon). **It is surprising that healthy participants can experience strong visual illusions after only a few minutes of normal mirror viewing, given that this is an everyday activity. Thus, it is possible that demand characteristics play a role in these reported strange face illusions, particularly as the illusion is yet to stand up to full scientific rigor, with the few experiments so far reporting the phenomenon having a small sample size and not being fully controlled (Caputo, 2010, 2013a). Less surprising, however, is the finding that these strange illusory experiences are found to be stronger in individuals suffering from schizophrenia (Caputo et al., 2012) and it is thought that they are related to experiences of body dysmorphia and difficulty with self/other distinctions. Indeed, schizophrenia as well as schizotypal traits are thought to be related to deficits in self-face recognition (Irani et al., 2006; Platek & Gallup, 2002) and body/action perception (Louzolo, Kalckert, & Petrovic, 2015; Thakkar, Nichols, McIntosh, & Park, 2011), which seems compatible with the experiences of strange face illusions.**

For many conditions in which self and body perception is impaired these experiences focus predominantly on the body rather than the face, yet, to date, whether perceptual illusions can occur when viewing our body rather than our face in the mirror has not been investigated. Moreover, investigating the body also allows for more rigorous experimental control; you can view your own body both directly and via a mirror, whereas viewing your own face is only possible via a mirror, or other reflective surface. Therefore, with face illusions it is difficult to determine whether any reported illusory experiences reveal something special about seeing ourselves in a mirror, or are simply due to viewing our own face.

It is widely thought that faces are special and not just another part of the body, both in terms of behavioural and neural processing (Kanwisher, McDermott, & Chun, 1997; McKone, Kanwisher, & Duchaine, 2007; Schwarzlose, 2005). However, some suggest that our specialism for processing faces is purely due to familiarity and expertise (Diamond & Carey, 1986; Gauthier, Skudlarski, Gore, & Anderson, 2000; Gauthier, Tarr, Anderson, Skudlarski, & Gore, 1999). In addition, mirror self-recognition studies in infants find no difference in accuracy of self-recognition for the face and other body parts (Nielsen et al., 2016). Furthermore, multisensory perceptual illusions originally applied to body parts (Botvinick & Cohen, 1998) or whole bodies (Maselli & Slater, 2013; Petkova & Ehrsson, 2008; Preston & Ehrsson, 2014), have now also be adapted, at least to some degree, to the face (Tajadura-Jiménez, Longo, Coleman, & Tsakiris, 2012; Tajadura-Jiménez, Lorusso, & Tsakiris, 2013; Tsakiris, 2008). These illusions use principles of multisensory integration to create an illusory experience of embodiment/ownership over a different body/body part or someone else's face.

A notable difference between these multisensory face and body illusions is that the subjective illusion strength appears to be greatly reduced for the face compared to the body or body parts (e.g. compare Botvinick & Cohen, 1998; Tajadura-Jiménez et al., 2012). For illusions involving the body, participants tend to explicitly agree that they feel like the new body/limb belongs to them, whereas they deny ownership in control conditions. This effect occurs even with a body/body part that is noticeably different from their own in terms of, for example, size, race and even gender (Farmer, Tajadura-Jiménez, & Tsakiris, 2012; Kilteni, Normand, Sanchez-Vives, & Slater, 2012; Normand, Giannopoulos, Spanlang, & Slater, 2011; Preston & Ehrsson, 2014; Preston & Newport, 2012; van der Hoort, Guterstam, & Ehrsson, 2011). For the face illusions, however, although they result in an increase in judgements of ownership compared to control conditions, participants' responses generally reflect uncertainty or a neutral response, rather than strong affirmation of the illusion (Ma, Sellaro, Lippelt, & Hommel, 2016; Tajadura-Jiménez et al., 2012). Synchronous touch of the own and someone else's face seems to blur distinctions between self and other representations. Thus, this "enfacement effect" appears to shift the boundaries of self-recognition as opposed to replacing the actual representation with that of another, as may happen in the rubber hand and other multisensory body (non-face) illusions. This may suggest that our subjective perceptual representation of our own face is relatively rigid, whereas our perceptual experience of the body is more flexible, and as such, may be more prone to perceptual distortions during mirror gazing.

However, studies investigating the effect of mirror viewing on these multisensory body illusions find equivalent results in the mirror compared with direct view (Bertamini, Berselli, Bode, Lawson, & Wong, 2011; Jenkinson & Preston, 2015; Preston, Kuper-Smith, & Ehrsson, 2015) and as such, have suggested that mirror view

is no different from a direct ‘first person’ perspective (Preston et al., 2015). This line of argument may therefore suggest that viewing the body in a mirror is essentially the same as viewing the body directly (at least in an explicit or subjective sense), and so be less prone to visual illusions arising simply from prolonged self-observation in a mirror. Viewing our face, on the other hand, cannot be done directly and as such is a relatively more unusual (albeit still frequent) behaviour, in which case we might expect that illusions experienced whilst viewing our face in the mirror may not be present to the same extent for the body.

The aim of this study was to explore the structure of experience during self-observation of the body in a mirror, using a psychometric approach. We were particularly interested in exploring whether seeing the body in a mirror would result in a subjective experience that was equivalent to seeing the body directly (see Bertamini et al., 2011; Jenkinson & Preston, 2015; Preston et al., 2015), or if mirror observation would produce strange perceptual experiences, like those reported during prolonged self-viewing of the face (Caputo, 2010, 2013a; Caputo et al., 2012; Schwarz & Fjeld, 1968). Additionally, we explored whether these experiences related to pre-existing tendencies to: (i) have anxiety about one's appearance (appearance anxiety), (ii) possess body dysmorphic-type motivations for using mirrors, (iii) have unusual dissociative experiences (e.g. dissociative symptomatology), (iv) objectify the body, and (v) generally hold unusual (delusional) beliefs (i.e. delusion ideation). In our study participants looked at their body continuously, either directly or in a mirror, for a period of five minutes, and then rated 20 statements describing their subjective experiences. We subsequently used Principal Components Analysis (PCA) to explore the structure underlying the experience, and examined the relationship between the extracted components and the aforementioned individual characteristics.

2. Method

2.1. Participants

One hundred and twenty four naïve healthy volunteers participated in the research (21 men; 103 women; mean age = 20.52¹, SD = 3.70). All participants self-reported not having a history of neurological or psychiatric illness, had normal or corrected-to-normal vision, and gave fully-informed, written consent. The study was approved by an institutional research ethics committee.

2.2. Design and Materials

A repeated measures design was used to compare subjective experiences of (1) direct and (2) mirror views of the body, using a Body Experience Questionnaire (BEQ; see 2.2.1). We also measured: (i) appearance anxiety (see 2.2.2), (ii) motivations for mirror gazing (2.2.3) (iii) dissociative symptomatology (2.2.4), (iv) self objectification (2.2.5), and (v) delusion ideation (see 2.2.6) in order to examine how these variables might relate to experiences of the body.

2.2.1. Body Experience Questionnaire (BEQ). We designed a 20-item questionnaire based on previous research into embodiment (Longo, Schüür, Kammers, Tsakiris, & Haggard, 2008) and experiences elicited from self-observation during the Strange-Face-Illusion (Caputo, 2010, 2013a; Caputo et al., 2012; Schwarz & Fjeld, 1968). The items were designed to quantify a wide range of both normal and unusual subjective experiences during self-observation of the body. The items covered a wide range of themes that participants might experience, including (four from each of the following categories): loss of self, change and deformation, affect, embodiment and awareness, and general suggestibility to strange or unusual experiences (see Table S1 in Supplementary Materials). Participants indicated their level of agreement with each statement using a 7-point Likert scale ranging from -3 (strongly disagree) to +3 (strongly agree).

2.2.2. Appearance Anxiety Inventory (AAI; Veale et al., 2014). The AAI is a self-report measure of appearance anxiety, focusing on the cognitive processes and

¹ Age data for two participants were missing for calculation of mean & SD.

behaviours that are characteristic of a distorted body image (typically found in body dysmorphic disorder). The scale comprises 10 items scored on a 5-point Likert scale (0 = not at all; 4 = all the time; range = 0 to 40). A total score is obtained by summing all items, with higher scores therefore reflect greater frequency of appearance anxiety processes. Psychometric properties of the AAI are reported in (Veale et al., 2014).

2.2.3. *Mirror Gazing Questionnaire (MGQ; Veale & Riley, 2001)*. The MGQ was developed to measure motivations that people with body dysmorphic disorder have for looking in a mirror. Participants rate the strength of agreement (1 = strongly disagree; 5 = strongly agree) with 12 statements that refer to beliefs individuals might hold before looking in a mirror (e.g. “I have to know for certain how I appear in public”; “I look in the mirror to see how I feel”; and “If I resist looking in the mirror then I will feel worse”). None of the items are reversed. We therefore calculated a total score by summing the score of each item (min = 12, max = 60), with higher scores indicating greater body-dysmorphic-type motivations for mirror gazing.

2.2.4. *Clinician Administered Dissociative State Scale (CADSS; Bremner et al., 1998)*. The CADSS provides a standardised measure of present-state dissociative symptomatology. The CADSS comprises 27 items, with 19 subject-rated items and 8 scored by an observer. Only the 19 subject-rated items were used in this study to measure dissociative states. Each item is rated on a 5-point scale (0 = not at all, 1 = slightly, 2 = moderately, 3 = considerably, 4 = extremely). A total CADSS score is calculated by summing the individual items (range = 0 to 76). Reliability and validity of the CADSS have been examined and reported in Bremner et al. (1998).

2.2.5. *Self Objectification Questionnaire (SOQ; Noll & Fredrickson, 1998)*. The SOQ measures trait self-objectification (i.e. the extent to which people self-objectify or appreciate their bodies more from a third-person perspective than from a first-person perspective; (Noll & Fredrickson, 1998). The questionnaire comprises 10 statements that relate to appearance-based and competence based attributes of the body, which participants rank in terms of the impact each has on their physical self-concept (0 = least impact, 9 = greatest impact; score range = -25 to 25). Higher scores indicate a greater emphasis on appearance and higher trait self-objectification. Importantly, the questionnaire does not examine body satisfaction; but only concern with appearance without a judgmental or evaluative component.

2.2.6. *Peters Delusion Inventory-21 (PDI-21; Peters, Joseph, Day, & Garety, 2004)*. The PDI-21 measures delusion ideation in the general population. It comprises

21 items, to which participants first provide a yes/no response to indicate the presence (scored 1) or absence (scored 0) of a given delusional belief, and subsequently (for endorsed items only) ratings are provided for: (i) distress (1 = not at all distressing, 5 = very distressing), (ii) preoccupation (1 = hardly ever think about it, 5 = think about it all the time), and (iii) conviction (1 = Don't believe it's true, 5 = Believe it is absolutely true). Four separate scores can thus be obtained: a PDI yes/no score (range 0-21), and scores for distress, preoccupation and conviction (each ranging from 0-105). A grand total PDI score can be obtained by summing all four components (range 0-336) to provide a global measure of delusion ideation. Psychometric properties of the PDI-21 have been examined and reported in Peters et al., (2004).

2.3. Apparatus and Procedure

Participants completed all questionnaires via an online survey prior to attending a face-to-face experimental testing session (minimum 24 hours later). The experimental testing session took place in a large (~3m x 5m) testing room (psychology laboratory) illuminated by only a 40w frosted halogen lamp (no lamp shade), which was positioned on a small (~0.5m high) table located 1m behind and to the right of the participant, where it could not be seen directly (see Figure 1). This set-up created a dim, diffused illumination in the room.

Participants wore their own clothes during the procedure and were not forewarned about the prolonged mirror observation or given any clothing requirements beforehand so that a more naturalistic experience of body self-observation could be obtained. However, upon arrival at the lab participants removed any outdoor or bulky items of clothing that covered their body (overcoats, jackets, hoodies, hats, gloves, scarves, etc.). The experiment involved two conditions, the order of which was counterbalanced across participants. During the mirror self-observation condition participants stood at a distance of 1m in front of a full-length (1.6m x 0.4m) mirror, and were instructed to observe their body continuously for a 5-minute period via the mirror. Participants were instructed to look at their body only via the mirror and to not look directly (down) at their body. Participants were free to look at any part of their body for as long as they wished, but were told to continue looking at their body for the full 5-minute duration and avoid distraction (i.e. turn off their phone and not look around the room or close their eyes). The top of the mirror

was covered with a black cloth to prevent vision of the face, whilst allowing a full and unobstructed view of the body (checked prior to commencing the condition).

The direct self-observation condition followed the same general instructions, but with participants instructed to look down and observe their body directly and continuously for a 5-minute period. During this condition the mirror was covered completely with the black cloth. The experimenter timed each 5-minute period and remained in the room throughout (sitting out of sight of the participant) to ensure compliance with instructions (and giving reminders if necessary).

2.4. Statistical Analyses

Descriptive statistics were calculated for each item on the BEQ following direct and mirror feedback separately (see Figure 2). Likewise, scores for the AAI, MGQ, CADSS, SOQ, and PDI-21 were calculated as specified above. Principal Components Analyses (PCA) with varimax rotation was then used to investigate the structure underlying direct and mirror self-observation of the body, using scores from the BEQ. Separate PCAs were conducted for the direct and mirror conditions. To compare the similarity of the resulting components during direct and mirror conditions we then carried out a Procrustes rotation on the mirror component loading matrix to fit the direct component matrix, followed by calculation of Tucker's congruence coefficient (see Burt, 1948; Lorenzo-Seva & ten Berge, 2006; Tucker, 1951). To examine the relationship between experiences of the body and other psychological traits, scores from the AAI, MGQ, CADSS, SOQ and PDI-21 were subsequently correlated with component scores obtained from the BEQ PCA.

In addition to the above main analyses, we also used Multivariate Analysis of Variance (MANOVA) to explore differences in responses to each of the 20 BEQ items during direct and mirror views. This analysis identified significant differences between direct and mirror view for only two items (Q4 & 12), both of which were not generally agreed with by participants (see Figure 2, below). For brevity, full details of this analysis are reported in the Supplementary Materials.

3. Results

Figure 2 summarises the descriptive statistics for the BEQ items. Summary statistics for the AAI, MGQ, CADSS, SOQ and PDI-21 are shown in Table 1.

Table 1. Mean and standard deviation of AAI, MGQ, CADSS, SOQ and PDI-21

	Mean	SD
AAI (min = 0, max = 40)	13.00	7.45
MGQ (min = 12, max = 60)	36.72	8.26
CADSS (min = 0, max = 76)	9.85	10.72
SOQ (min = -25, max = 25)	1.61	13.78
PDI-21		
Yes/No (min = 0, max = 21)	5.22	3.41
Distress (min = 0, max = 105)	14.71	11.09
Preoccupation (min = 0, max = 105)	15.90	11.62
Conviction (min = 0, max = 105)	17.36	12.27
Total (min = 0, max = 336)	53.83	37.36

Note: online data could not be matched to the experimental session data in 12 cases; therefore N = 112 for all statistics reported in this table. AAI = Appearance Anxiety Inventory; MGQ = Mirror Gazing Questionnaire; CADSS = Clinician Administered Dissociative State Scale; SOQ = Self Objectification Questionnaire; PDI-21 = Peters Delusion Inventory-21.

3.1. Direct Body Self-Observation PCA

The Kayser-Meyer-Olkin measure (Kaiser, 1974; KMO = .86), Bartlett's test of sphericity (Bartlett, 1954; $p < .001$), and presence of many coefficients above .3 in the correlation matrix, indicated the adequacy of performing a PCA with the BEQ data. For direct view of the body, examination of the scree plot, eigenvalues, and Horn's Parallel Factor Analysis (Horn, 1965; based on corresponding criterion values for a randomly generated data matrix of the same size: 20 variables x 124 respondents with 100 replications; implemented using Monte Carlo PCA for Parallel Analysis; Watkins, 2005) were used to determine the number of components extracted. This led to the extraction of a two-component structure, which together accounted for 50.22% of the

overall variance in the data (see Table 2). To aid interpretation and ensure a solid structure, only those items that loaded strongly (i.e. .50 or better; see Costello & Osborne, 2005) onto a given component were used for interpretation. Component one accounted for 37.99 % of the variance, with several items loading substantially (.80 or higher) on only this component, including items 3 (I was disgusted with my body) and 16 (I was uncomfortable with my body), and negative loadings (-.80 or higher) for items 11 (I was satisfied with my body) and 20 (I was happy with my body). Other items loading only on this component related to the body being different (item 14), uncomfortable (item 16) and fatter than usual (item 13). We therefore termed this component *body evaluations*. The second component accounted for 12.23% of the variance, with strong items loading only on this component describing changes to physical characteristics of the body (item 8: my clothes changed; item 5: my body changed shape), and strange or unusual experiences (item 7: I felt two dimensional; item 15: my body seemed like a stranger; item 17: it seemed like I had an extra limb; item 4: my body seemed to disappear). We termed this component *unusual feelings and perceptions*.

Table 2. Component loadings from PCA with varimax rotation of direct (dark grey columns) and mirror view (light grey columns) BEQ item responses.

Item	“During the procedure there were times when...”	Direct condition			Mirror condition		
		<i>Component 1</i>	<i>Component 2</i>	<i>Communalities</i>	<i>Component 1</i>	<i>Component 2</i>	<i>Communalities</i>
1.	...my body seemed strange	.571	.515	.592	.650		.505
2.	...it seemed like the body I saw belonged to me			.383		-.502	.468
3.	...I was disgusted with my body	.879		.811	.876		.782
4.	...my body seemed to disappear		.604	.373		.674	.512
5.	...my body changed shape		.632	.548			.454
6.	...my body seemed deformed	.542	.549	.595	.711		.596
7.	...I felt two dimensional		.688	.511		.608	.385
8.	...my clothes changed		.725	.525		.747	.566
9.	...my body seemed vivid			.101			.134
10.	...it seemed like I was looking at myself			.312	-.651		.608
11.	...I was satisfied with my body	-.854		.754	-.879		.777
12.	...the body I saw looked upside down			.212		.533	.293

13.	...my body seemed fatter than usual	.702		.521		.725		.533
14.	...my body was different than expected	.606		.565		.628		.567
15.	...my body seemed like a stranger		.686	.679		.543	.572	.622
16.	...I was uncomfortable with my body	.859		.766		.864		.753
17.	...it seemed like I had an extra limb		.682	.491			.625	.471
18.	...my body seemed thinner than usual			.368				.272
19.	...I was very aware of my bodily sensations			.117				.004
20.	...I was happy with my body	-.893		.819		-.862		.754
Eigenvalues		7.597	2.446			7.793	2.239	
Random Eigenvalue (from Parallel Analysis)		1.800	1.634			1.806	1.654	
Percentage variance explained		37.986	12.229			38.966	11.194	

Note: Component loadings less than 0.5 are not displayed.

3.2. Mirror Body Self-Observation PCA

The adequacy of the mirror BEQ data was again established (KMO = .87; Bartlett's test of sphericity, $p < .001$) and, applying the same criteria as for the direct view PCA, a similar two-component structure was extracted, explaining 50.16% of the total variance (see Table 2). Component one explained 38.97% of the total variance, and component two 11.19%. The main differences between the direct and mirror view PCA were the addition of items 1 (my body seemed strange) and 6 (my body seemed deformed), both of which previously loaded onto both components one and two, but now strongly loaded only onto component one. In addition, item 10 (it seemed like I was looking at myself), which did not previously load onto either component, now had a strong negative loading onto component one, while item 15 (my body seemed like a stranger) now loaded onto component one and two, despite having previously loaded only onto component two. The theme of these additional items appeared to reflect a dissociation or alienation from the observed body, we therefore termed component one of the mirror view PCA *body evaluations and alienation*. Component two maintained most of the same items as for the direct PCA, but (in addition to the changes in shared items described above) there was the addition of item 12 (the body I saw looked upside down), which previously did not load onto either component, and item 2 (it seemed like the body I saw belonged to me) now had a strong negative loading onto this component. In addition, items 5 (my body changed shape) and 6 (my body seemed deformed), no longer loaded onto component two. Taking into account these changes, the overall theme of this component continued to reflect unusual feelings or perceptual experiences; therefore, we maintained this component as before (i.e. terming it *unusual feelings and perceptions*).

3.3. *Secondary PCAs on Body Evaluations (and Alienation)*. Because the body evaluations (and alienation) component of the above PCAs accounted for a large proportion of variance in each condition, we performed a follow-up analysis to explore whether a further structure that had been masked in our top-level PCA might exist within this component (see Longo et al., 2004; Hair, Black, Babin, Anderson & Tatham, 2006; Nunnally & Bernstein, 1994). Following the method of Longo et al., (2004), we performed this PCA for direct and mirror view separately using only items that loaded strongly ($>.50$) onto component one in both of the previous analyses (i.e. items 1, 3, 6, 11, 13, 14, 16 & 20). The outcome of this analysis confirmed each of the original, single components, but did not identify any further sub-components (i.e. both direct and mirror PCA extracted only one component).

3.4. *Statistical comparison of direct and mirror components*. To compare the similarity between direct and mirror component interpretations we carried out a Procrustes rotation to transform the mirror component matrix loadings to fit the direct component matrix (Burt, 1948), and then calculated the congruency coefficient (Tucker's Phi; Tucker, 1951) between direct and mirror conditions for each component (see Wuensch, 2016 for the SPSS syntax used to conduct this procedure). The results showed a $\phi = .99$ between direct and mirror conditions for component one, and $\phi = .97$ for component two, indicating that the two components have good similarity such that direct and mirror conditions can be considered equal (Lorenzo-Seva & ten Berge, 2006).

3.5. *Relationship between experiences of the observed body and other measures*.

Finally, we investigated whether the above components related to measures of appearance anxiety (AAI), body dysmorphic-type mirror gazing beliefs (MGQ), dissociative symptomatology (CADSS), self-objectification (SOQ), and delusion ideation (PDI-21). Preliminary checks indicated that the data were non-normally distributed (Shapiro-Wilk tests, $p < .001$) for all measures except the MEQ ($p = .312$); therefore, we used Spearman's correlations and applied a False Discovery Rate (Benjamini & Hochberg, 1995) corrected significance level (q^*) of 0.031 to control for multiple testing. and the component scores obtained from each of the top-level PCAs (see Table 3 for summary results; scatter plots of these correlations can be found in Supplementary Materials).

Table 3. Correlations between BEQ component scores and AAI, MGQ, CADSS, and PDI-21.

	BEQ ¹			
	Direct		Mirror	
	<i>Component One</i>	<i>Component Two</i>	<i>Component One</i>	<i>Component Two</i>
AAI	$r_s = .423, p < .001^*$	$r_s = .119, p = .219$	$r_s = .510, p < .001^*$	$r_s = .153, p = .113$
MGQ	$r_s = .408, p < .001^*$	$r_s = .231, p = .016^*$	$r_s = .466, p < .001^*$	$r_s = .293, p = .002^*$
CADSS	$r_s = .132, p = .174$	$r_s = .428, p < .001^*$	$r_s = .154, p = .110$	$r_s = .470, p < .001^*$
SOQ	$r_s = -.111, p = .253$	$r_s = -.015, p = .874$	$r_s = -.017, p = .863$	$r_s = .046, p = .635$
PDI-21				
Yes/No	$r_s = .065, p = .507$	$r_s = .440, p < .001^*$	$r_s = .190, p = .048$	$r_s = .388, p < .001^*$
Distress	$r_s = .169, p = .08$	$r_s = .387, p < .001^*$	$r_s = .289, p = .002^*$	$r_s = .299, p = .002^*$
Preoccupation	$r_s = .115, p = .234$	$r_s = .405, p < .001^*$	$r_s = .225, p = .018^*$	$r_s = .378, p < .001^*$
Conviction	$r_s = .106, p = .276$	$r_s = .372, p < .001^*$	$r_s = .229, p = .016^*$	$r_s = .326, p = .001^*$
Total	$r_s = .121, p = .213$	$r_s = .400, p < .001^*$	$r_s = .242, p = .011^*$	$r_s = .348, p < .001^*$

Notes: ¹component scores cannot be calculated when data are missing; therefore N = 108 for all direct PCA results and 109 for all mirror PCA results. AAI = Appearance Anxiety Inventory; MGQ = Mirror Gazing Questionnaire; CADSS = Clinician Administered Dissociative State Scale; SOQ = Self Objectification Questionnaire; PDI-21 = Peters Delusion Inventory-21. Component 1 = Body Evaluations; Component 2 = Unusual feelings and Perceptions. *significant correlation applying FDR corrected significance level of $q^* < .031$

3.5.1. *Direct self-observation of the body.* We found that *body evaluations* (i.e. component one) following direct observation of the body correlated significantly with appearance anxiety and body dysmorphic-type mirror gazing beliefs. The size of both effects was moderate to strong (Cohen, 1988, 1992), with higher appearance anxiety and body dysmorphic-type beliefs being related to increased body evaluations. No other correlations with component one were significant. By contrast, *unusual feelings and perceptions* (i.e. component two) did not correlate with appearance anxiety or self-objectification, but showed significant medium correlations with body dysmorphic-type mirror gazing beliefs, dissociative symptomatology, and all measures of delusion ideation (i.e. all PDI-21 scores; see Table 3). Hence, greater unusual feelings and perceptions of the directly-observed body were experienced in those with greater body dysmorphic-type beliefs, dissociative symptomatology and delusional ideation.

3.5.2. *Mirror self-observation of the body.* Following self-observation of the body in a mirror, *body evaluations and alienation* (i.e. component one) again correlated strongly with appearance anxiety and body dysmorphic-type beliefs, and also (moderately) with delusion ideation (all PDI-21 scores except Yes/No scores), but not dissociative symptomatology or self-objectification. Finally, *unusual feelings and perceptions* (i.e. component two) correlated moderately with all measures (body dysmorphic-type beliefs, dissociative symptomatology, and delusion ideation), except appearance anxiety and self-objectification.

4. Discussion

Our study used a psychometric approach to explore the subjective experience of the body observed directly and in a mirror. In so doing we examined whether illusory

experiences **reported** during prolonged observation of the face (i.e. the strange face illusion) also occur for the body. In addition, we examined how several pre-existing tendencies (i.e. appearance anxiety, body dysmorphic-type mirror gazing beliefs, dissociative symptomatology, self-objectification, and delusion ideation) might influence experiences of the body. Our results indicate a two-component structure to experiencing the body, which is consistent across conditions of direct and mirror self-observation. The first and largest component of self-observation relates to an affective evaluation of the body, while a smaller, second component involves unusual experiences arising during self-observation. Overall the results highlight an overarching similarity between experiencing the body directly and in a mirror.

Our findings suggest that under normal circumstances viewing our own body in a mirror may be functionally equivalent to seeing a direct, ‘first person’ view of our body, despite the obvious physical differences in visual feedback. **That is, when we look in a mirror and view our specular body as an object seen “from the outside”, this image is deemed a part of the self, and analogous to the body we habitually see from a first-person perspective.** Humans seem to possess an implicit knowledge about the reflective properties of mirrors, such that what we see in a mirror is automatically transformed and translated back to the space in front of the mirror (Preston et al., 2015). **This process develops in early infancy allowing for self-recognition in a mirror, as demonstrated when an infant can use a mirror reflection to notice a mark on the face or body – seeing the mark on the body in the mirror is interpreted as the mark being located on the actual body (Anderson, 1984).** Thus, we receive and synthesise information about the body from different sources and perspectives, and integrate these to construct a stable sense of embodied self (Jenkinson et al., 2013). The current findings are largely in line with this view, as the same two components were found in

the PCA for both direct and mirror conditions, suggesting that there is little difference in terms of subjective experience when viewing the body in the mirror and when viewing the body directly. This conclusion is supported by the high Tucker's congruence coefficient, and the additional MANOVA reported in supplementary materials, which found significant differences between direct and mirror view for only 2 of the 20 items.

We did, however, find that for the mirror condition, the component involving negative feelings towards the body also incorporated questionnaire items relating to alienation that were not present for the direct view. The highest loading factors for this component remained consistent between the two conditions, and even alienation items that did load following mirror viewing were generally not agreed with in the questionnaire. Therefore, although these alienation items contributed to this component for the mirror and not direct view condition, on average participants did not report explicitly experiencing alienation in either instance. More generally, although ratings to several of the BEQ items were negative, this does not indicate an absence of experience, but rather a disagreement with positively worded items. Overall, the pattern of responses indicate that looking at the body, in a mirror or directly, is a highly evaluative and not perceptually neutral experience.

Interestingly, both direct and mirror views of the body involved a component relating to unusual feelings and perceptual experiences; however, this component accounted for only a minority of the explained variance in both direct and mirror conditions. On average participants denied experiencing any type of unusual perceptual experience in either condition, although as one might expect, such experiences were positively correlated with greater body dysmorphic-type motivations for mirror gazing, dissociative symptomatology, and delusion ideation.

This general lack of agreement with the BEQ questionnaire items suggests that, despite being a component of experience during self-observation, perceptual illusions reported whilst viewing the face in the mirror are not present when viewing the rest of the body.

The absence of a “strange body illusion” when viewing the body in a mirror is compatible with a dissociation between face and body processing. Interestingly, whereas other multisensory perceptual body illusions seem to elicit, on average, higher subjective ratings of ownership for the body (Botvinick & Cohen, 1998; Petkova & Ehrsson, 2008) compared to the face (Ainley, Tajadura-Jiménez, Fotopoulou, & Tsakiris, 2012; Ma et al., 2016; Tajadura-Jiménez et al., 2012), illusory mirror-based perceptual experiences, based purely on prolonged visual feedback, seem to occur only when viewing the face (Caputo, 2010, 2013a; Caputo et al., 2012; Schwarz & Fjeld, 1968) and not the body. However, neither such illusory experiences have yet been examined within the same participants for the face and body, so direct comparisons cannot be made. Additionally, because it is not possible to view one’s own face directly (i.e. from a first-person perspective), it is unclear whether it is the third-person view of the face (provided by a mirror or video) that creates the unusual perceptual experiences in the strange face illusion, or simply viewing one’s own face. Indeed strange-face-illusion-type experiences have been reported when participants are staring at the face of another person (Caputo, 2013b, 2015), which may indicate that it is not the mirror, but the face that is important for these face-based illusions. However, with a lack of an adequate control condition, and generally low sample sizes, it is difficult to interpret these reports of mirror and interpersonal strange-face illusions. Future studies should try to verify the strange face illusion in larger samples, compare face and body viewing in the same participants,

and investigate how mirror view of the self differs from viewing the self in a photograph or video for the face as well as the body.

As mentioned above, body dysmorphic-type mirror-gazing beliefs, dissociative traits, and delusion ideation were all found to correlate with unusual feelings and perceptions, both when viewing the body directly and viewing the body in the mirror. This does suggest that unusual perceptual experiences relate to these traits, but not specifically from looking in a mirror. Those suffering from body dysmorphic disorder are found to engage in frequent mirror gazing (Veale & Riley, 2001), and treatment with Cognitive Behavioural Therapy reduces mirror checking behaviours (Neziroglu, McKay, Todaro & Yaryura-Tobias, 1996), but this does not necessarily mean that mirror viewing contributes to the pathology. Our results imply that body dysmorphic beliefs relate to greater unusual perceptions *per se*, and not just when looking in a mirror. In support of this view, previous studies have also found body dysmorphic beliefs to relate to unusual perceptions when viewing the face of another person (Caputo, 2013b, 2015). Individual differences in delusion ideation were also found to relate to reported unusual perceptual experiences in both conditions. Schizophrenic patients are found to have stronger experiences of the strange face illusion compared to healthy controls (Caputo et al., 2012). Individuals suffering from schizophrenia are also found to have deficits in self recognition (Irani et al., 2006; Platek & Gallup, 2002) and body/action awareness (Louzolo et al., 2015; Thakkar et al., 2011), but these unusual experiences are also not confined to mirror viewing, such that, similar to dysmorphic traits, delusions and schizophrenic/delusion symptoms may be related to usual experiences, but not specifically when looking in a mirror.

The other, major component identified by the PCA related to negative evaluations of the body. Again, this component was not specific to mirror viewing,

but was present for both direct and mirror conditions. Unsurprisingly, greater negative experiences were related to greater appearance anxiety and body dysmorphic-type motivations for mirror gazing, but this was found for both mirror and non-mirror conditions. Indeed, mirrors can actually help treat body image disturbances and associated mirror avoidance behaviours. Therapies involving mirror viewing can improve body satisfaction in people with body image disturbances that may lead to eating disorders (Delinsky & Wilson, 2006), and can also reduce anxiety and increase body satisfaction in obese adolescents (Jansen et al., 2008). Moreover, although improvements have typically been reported following guided mirror exposure, during which a therapist encourages non-evaluative, neutral descriptions of the body, even ‘pure’ mirror exposure without any guidance has been found to improve body satisfaction in a non-clinical, female sample (Moreno-Domínguez, Rodríguez-Ruiz, Fernández-Santaella, Jansen, & Tuschen-Caffier, 2012). However, this later study did not examine the effect of such ‘pure’ exposure in individuals with eating disorders or body image disturbance, and further research is needed to establish more clearly the effect of pure mirror exposure on body satisfaction in individuals with different body image disturbances or eating disorders.

One notable difference between the mirror and direct views can be seen in the relationship between delusion ideation (PDI-21) and body evaluations (component 1), which are present after mirror, but not direct observation of the body. These correlations suggest that people with greater delusion ideation are prone to evaluate their body more when it is seen in a mirror. We also found a correlation between dissociative symptomology and unusual feelings and perceptions about the body (component 2), although this was during both direct and mirror view, which may indicate that dissociative states are linked to a more labile, or unstable bodily self.

Indeed, recent research indicates that the rubber hand illusion is enhanced in patients with delusions and dissociation-associated changes in body-perception such as schizophrenia (Peled, Ritsner, Hirschmann, Gena & Modai, 2000) and borderline personality disorder (Bekrater-Bodmann, Chung, Foell, Gescher, Bohus, & Flor, 2016), and healthy individuals given ketamine (Morgan et al., 2011), which is known to reproduce the symptoms of schizophrenia. Our ideas are speculative and based only on correlations in healthy individuals; however, they open up the opportunity for future research to confirm and explore these ideas further.

In sum, using a psychometric approach we found that the body observed in a mirror is treated as equivalent to the body observed directly. Contrary to similar investigations involving prolonged observation of the face, simply viewing the body in a mirror does not lead to unusual, illusory experiences. Further research is needed to directly compare the occurrence of face and body illusions in the same participants, and examine the effect of pure mirror feedback on negative body-related feelings in people with body image disturbances and/or eating disorders.

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Figure Captions

Figure 1. The experimental setup (a) with example of direct (b) and mirror (c) views of the body.

Figure 2. Mean (SE) responses to BEQ items. Adjacent bars of the same colour represent responses for the direct (left/stippled colour) and mirror (right/solid colour) views. See Table 2 for item labels (Q1-20)

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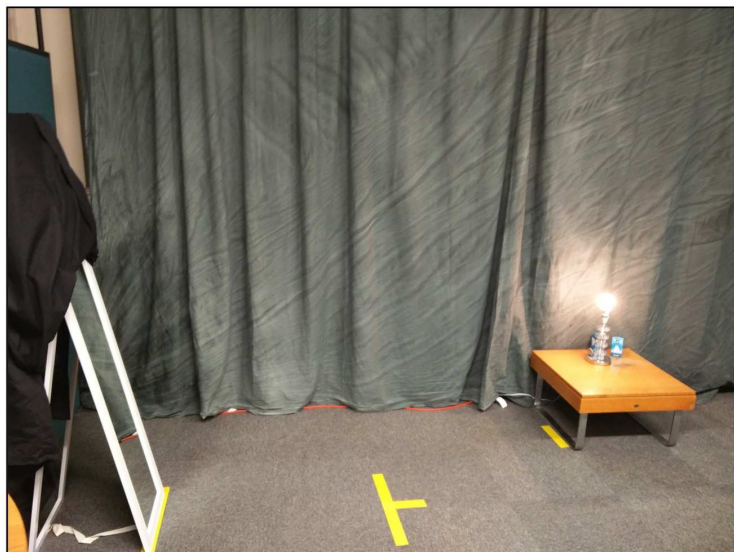
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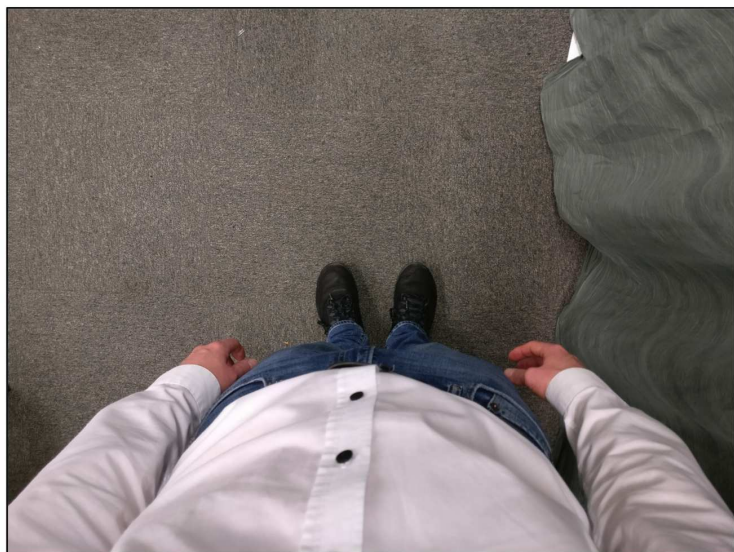
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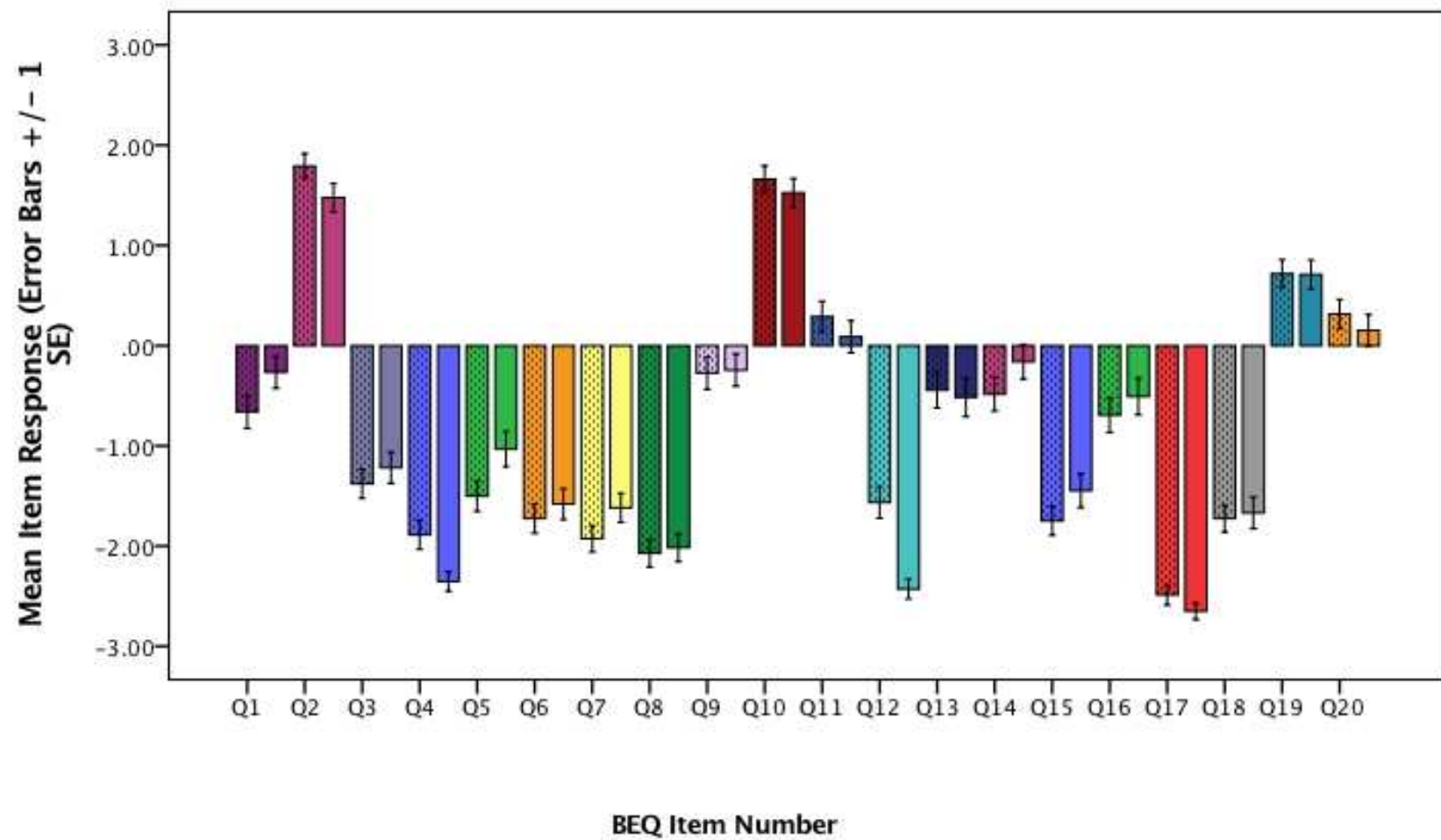


(C)



(B)





Supplementary Materials

S1. Comparison of responses to BEQ items during direct and mirror view.

We conducted an additional, exploratory analysis to determine whether direct and mirror view of the body resulted in differences in response to the questionnaire items. A 2 (View: Direct vs. Mirror) x 20 (Item: 1-20) repeated-measures MANOVA revealed a significant main effect of Item, $F(19, 99) = 64.68, p < .001$, and Visual Feedback x Item interaction, $F(19, 99) = 3.76, p < .001$, but no main effect of View, $F(1, 117) = .004, p = .947$. Follow-up paired-samples *t*-tests comparing the direct and mirror view for each item (applying a Bonferroni correction for 20 comparisons; $\alpha = .0025$) revealed that the interaction was driven by significant differences between direct and mirror view only for items 4 (my body seemed to disappear) and 12 (the body I saw looked upside down' see Table S1). Moreover, despite the significant difference between direct and mirror views for these two items, neither statement had a mean score above zero, indicating that participants generally did not agree with these statements (see Figure 1 of main manuscript).

Table S1. Post-hoc comparisons of direct and mirror view for each item on the BEQ.

Item	<i>t</i>	df	<i>P</i>
1. ...my body seemed strange	-2.35	123	.020
2. ...it seemed like the body I saw belonged to me	2.64	123	.009
3. ...I was disgusted with my body	-1.47	123	.145
4. ...my body seemed to disappear	3.35	123	.001*
5. ...my body changed shape	-2.34	123	.012
6. ...my body seemed deformed	-1.05	123	.294
7. ...I felt two dimensional	-2.20	122	.030
8. ...my clothes changed	-.39	122	.700
9. ...my body seemed vivid	-0.65	122	.949
10. ...it seemed like I was looking at myself	.94	123	.349
11. ...I was satisfied with my body	1.52	123	.131
12. ...the body I saw looked upside down	5.15	123	<.001*
13. ...my body seemed fatter than usual	.40	123	.687
14. ...my body was different than expected	-2.28	121	.024

15. ...my body seemed like a stranger	-2.02	121	.046
16. ...I was uncomfortable with my body	-1.28	123	.202
17. ...it seemed like I had an extra limb	2.48	121	.015
18. ...my body seemed thinner than usual	-.40	123	.692
19. ...I was very aware of my bodily sensations	.06	123	.954
20. ...I was happy with my body	1.39	123	.168

* = significant difference between direct and mirror view. Note: Bonferroni corrected alpha = .0025

S2. Scatterplots of correlations

S2.1. Correlations with Direct View BEQ Component 1 (*negative body evaluations*)

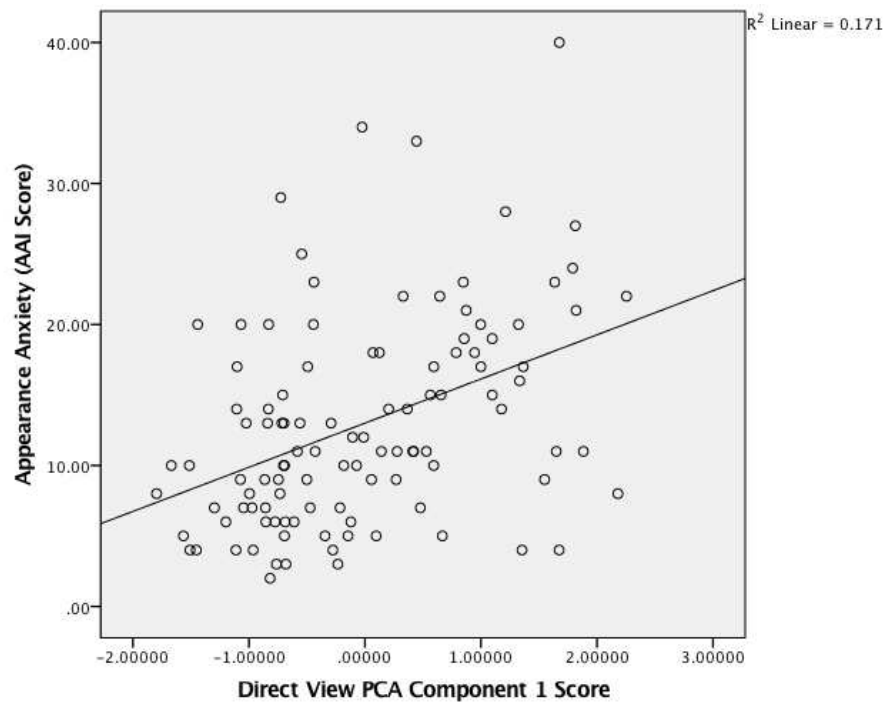


Figure S1. Scatterplot of the relationship between degree of appearance anxiety (AAI score) and Component 1 (negative body evaluations) scores from the direct view PCA.

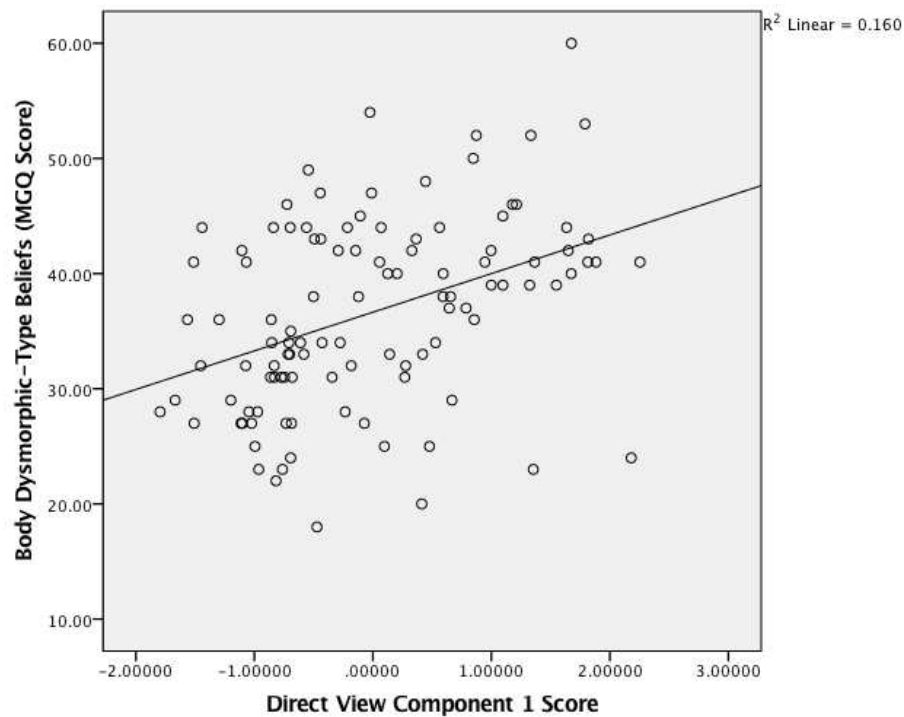


Figure S2. Scatterplot of the relationship between degree of body dysmorphic-type beliefs (MGQ score) and Component 1 (negative body evaluations) scores from the direct view PCA.

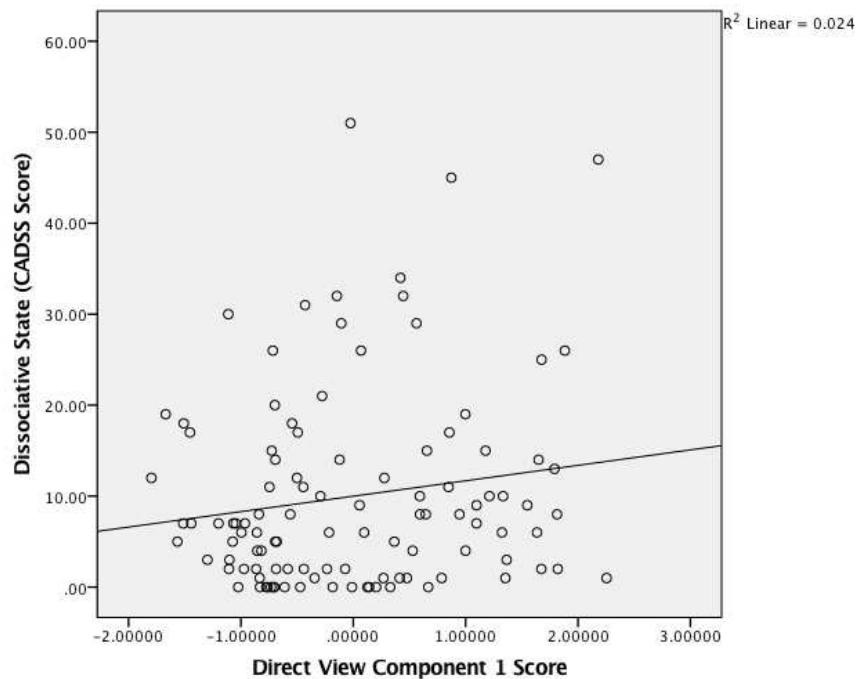


Figure S3. Scatterplot of the relationship between degree of dissociative experiences (CADSS score) and Component 1 (negative body evaluations) scores from the direct view PCA.

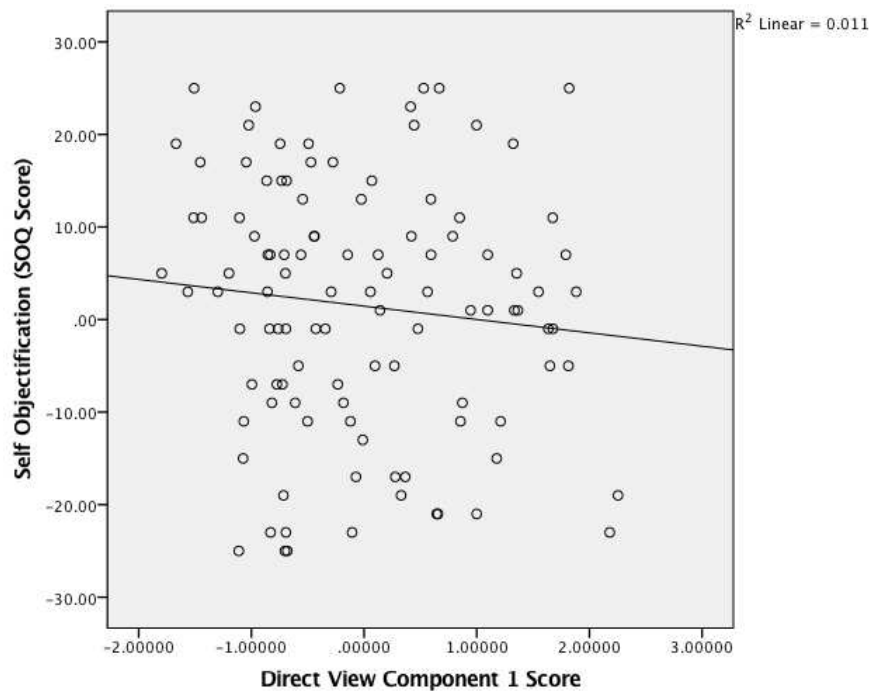
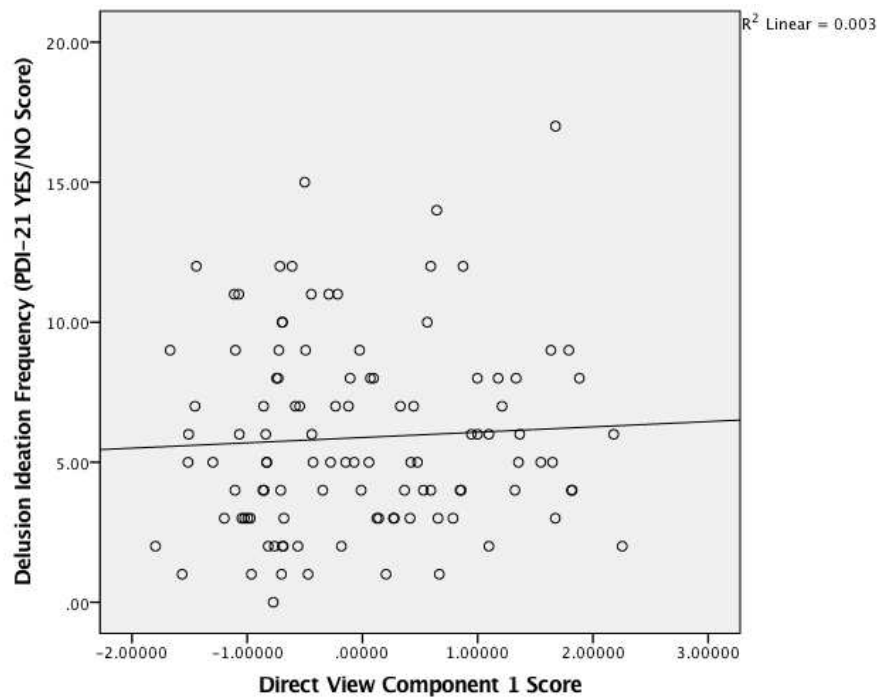
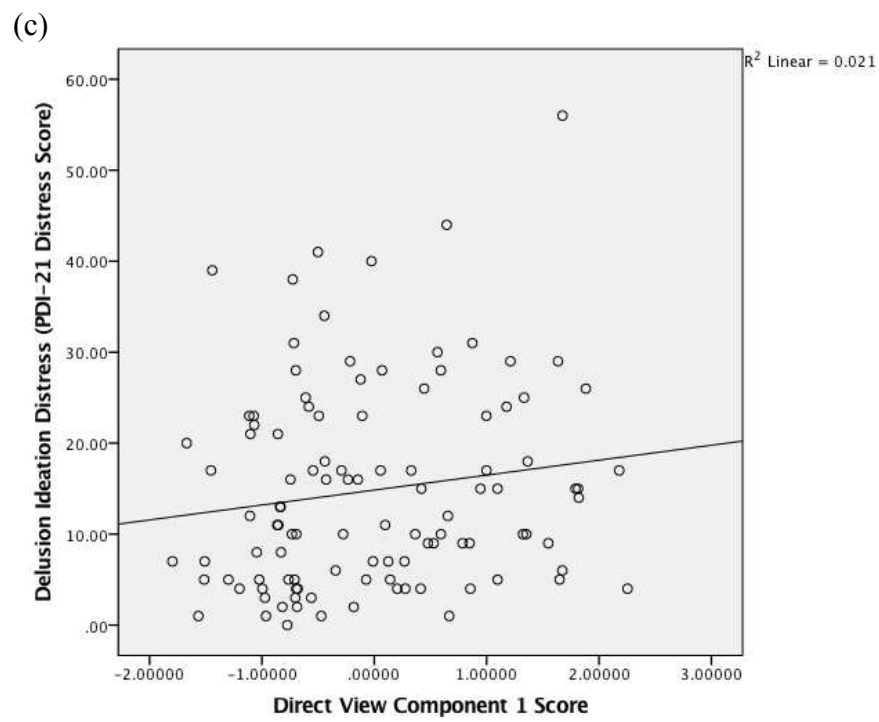
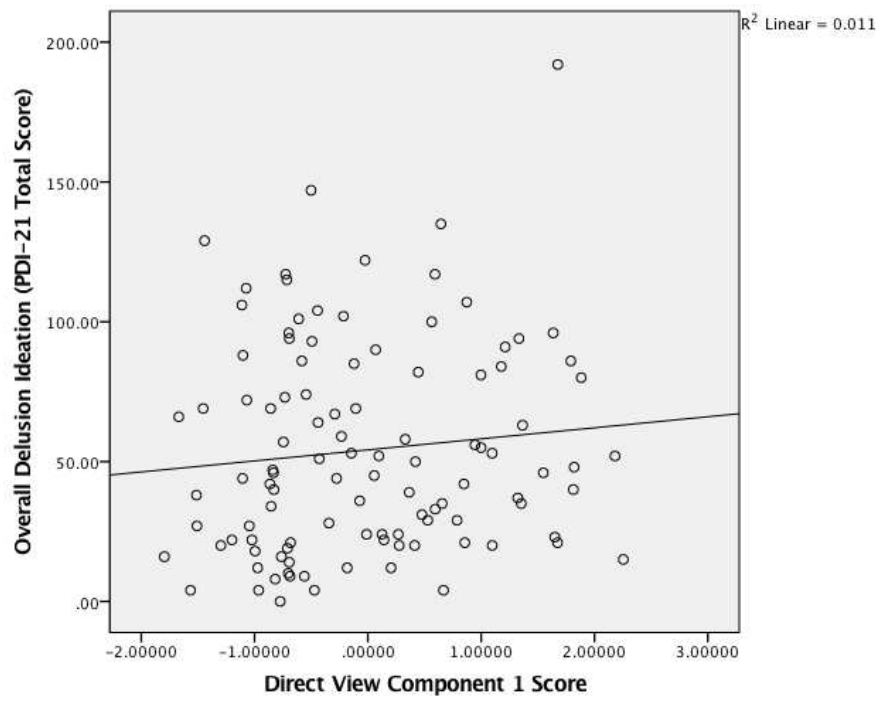


Figure S4. Scatterplot of the relationship between degree of self objectification (SOQ score) and Component 1 (negative body evaluations) scores from the direct view PCA.

(a)



(b)



(d)

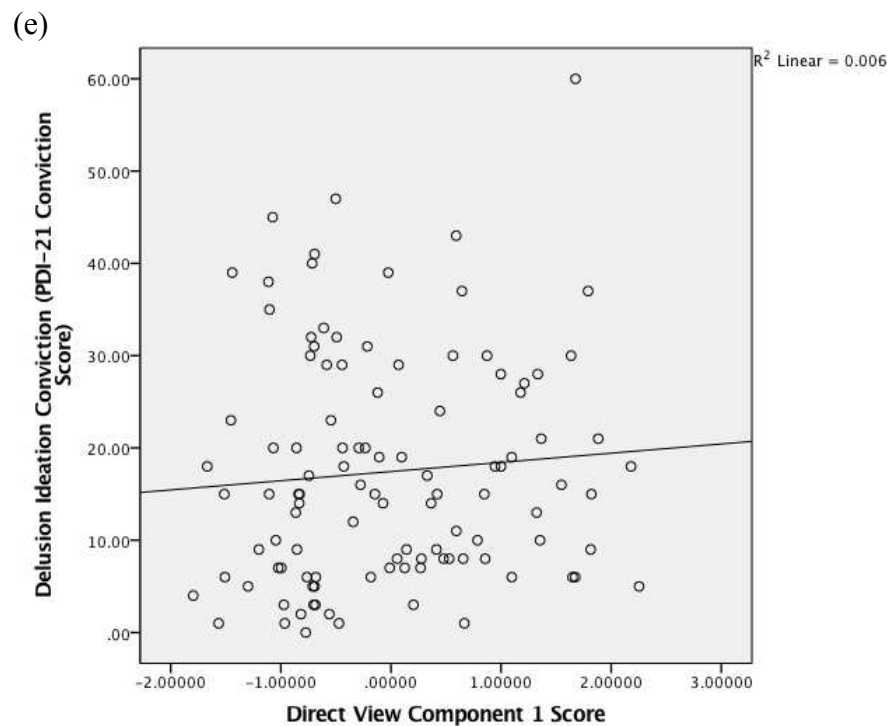
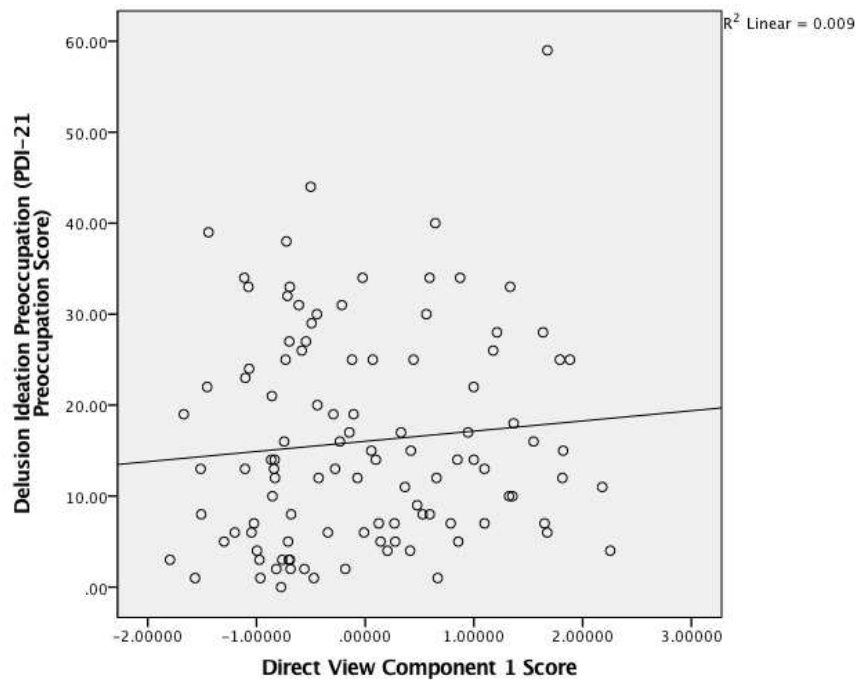


Figure S5. Scatterplot of the relationship between degree of (a) delusion ideation frequency, (b) overall delusion ideation, (c) delusion ideation distress, (d) preoccupation, and (e) conviction and Component 1 (negative body evaluations) scores from the direct view PCA.

S2.2. Correlations with Direct View BEQ Component 2 (*unusual feelings and perceptions*)

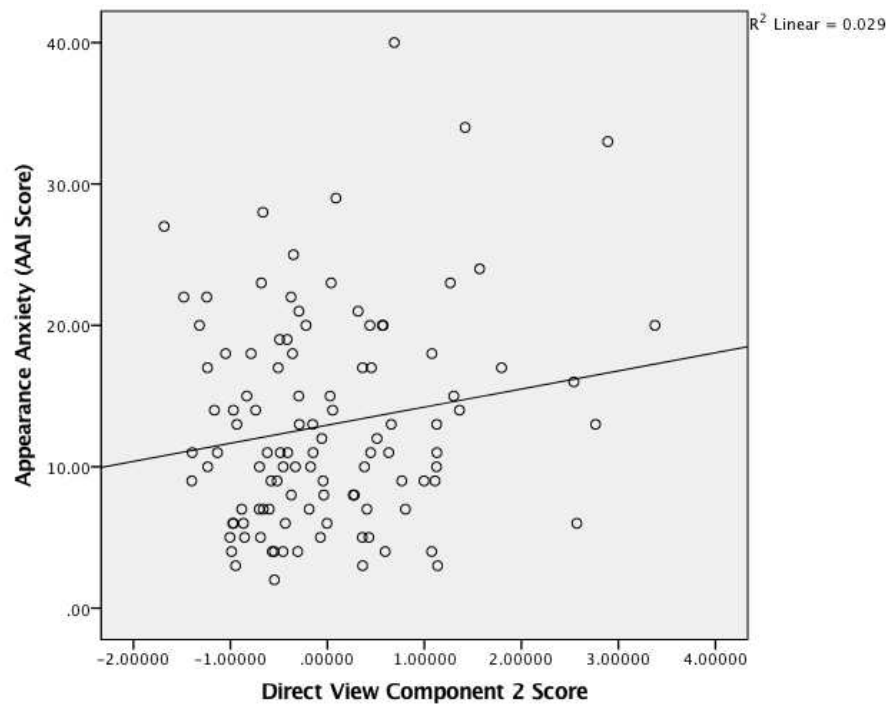


Figure S6. Scatterplot of the relationship between degree of appearance anxiety (AAI score) and Component 2 (unusual feelings and perceptions) scores from the direct view PCA.

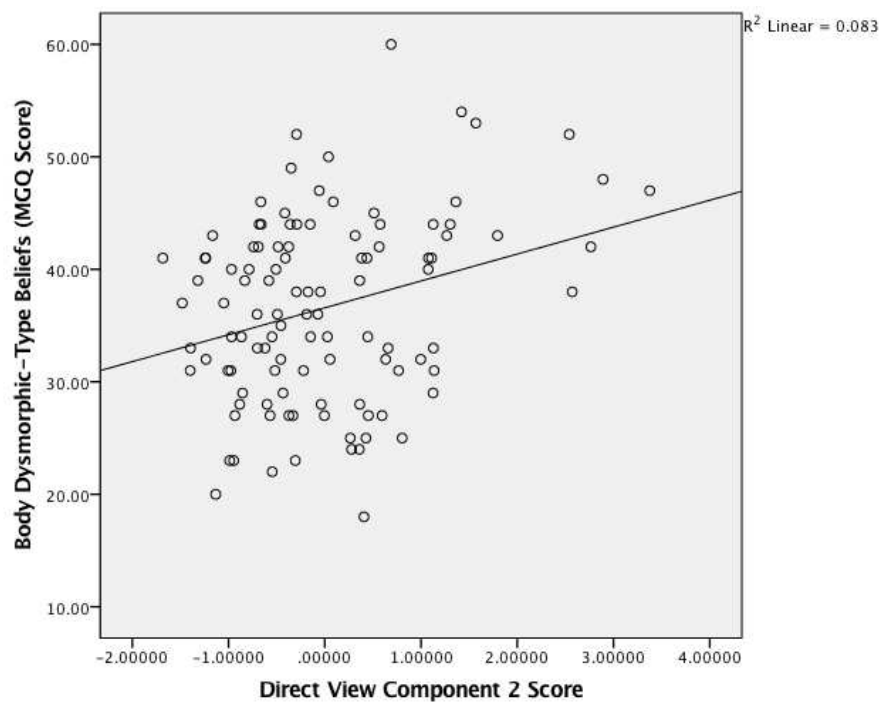


Figure S7. Scatterplot of the relationship between degree of body dysmorphic-type beliefs (MGQ score) and Component 2 (unusual feelings and perceptions) scores from the direct view PCA.

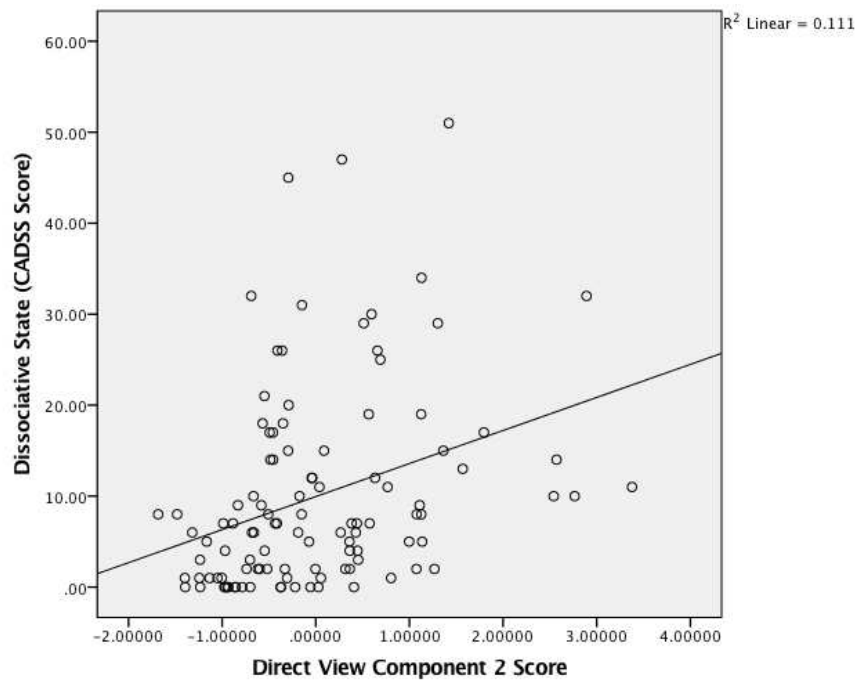


Figure S8. Scatterplot of the relationship between degree of dissociative experiences (CADSS score) and Component 2 (unusual feelings and perceptions) scores from the direct view PCA.

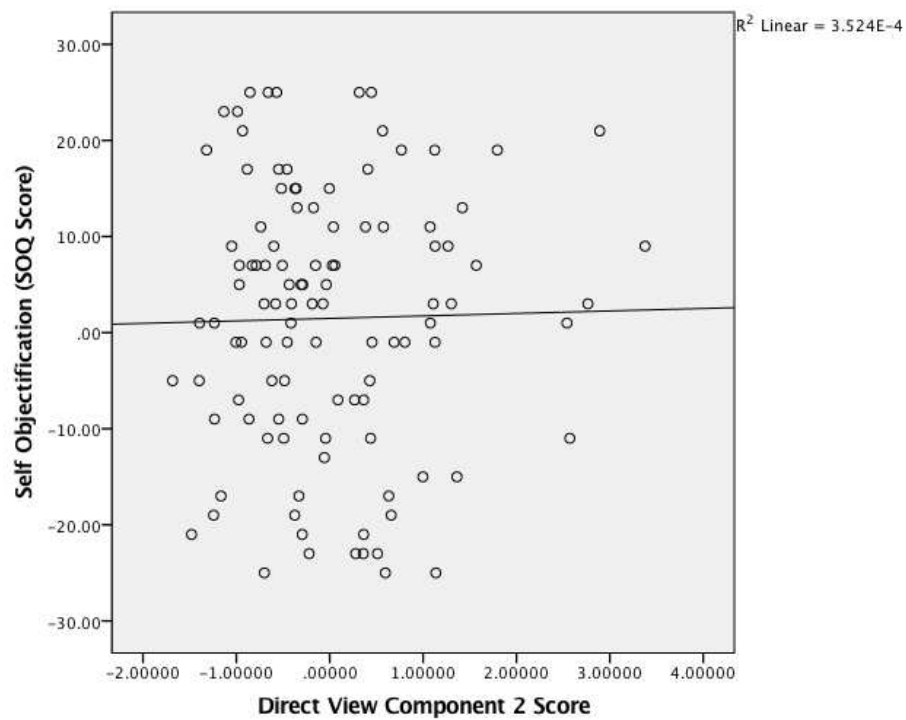
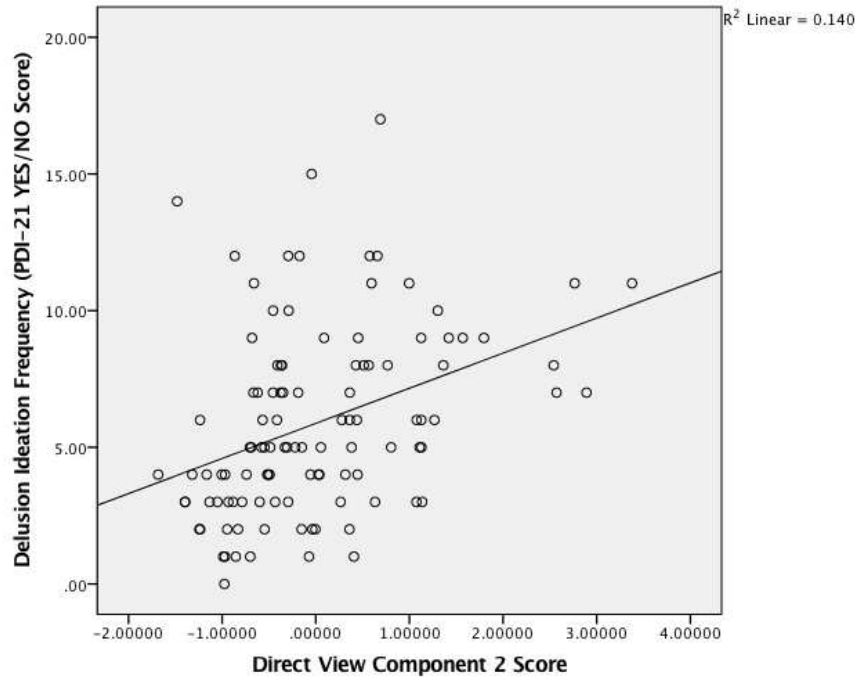
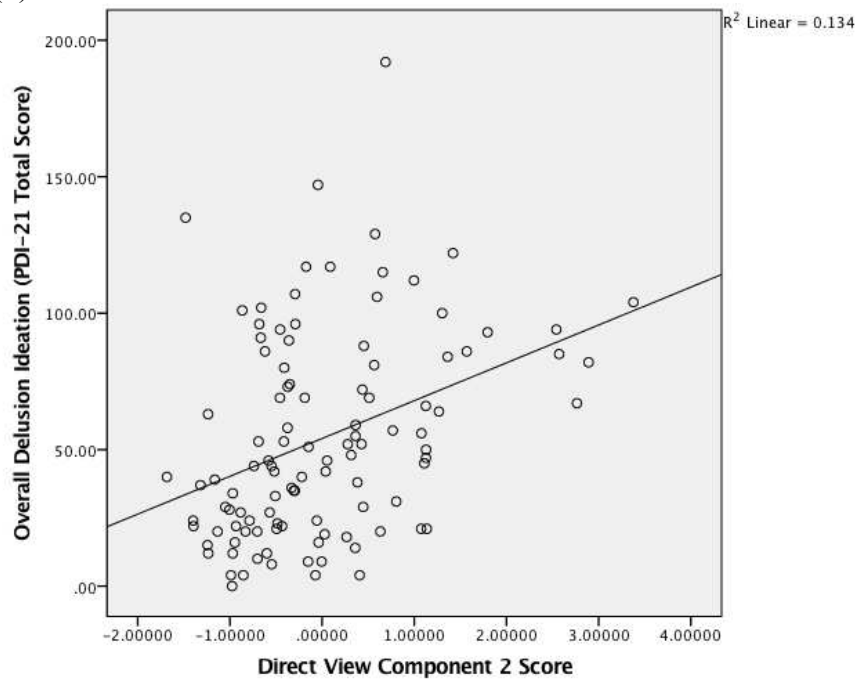


Figure S9. Scatterplot of the relationship between degree of self objectification (SOQ score) and Component 2 (unusual feelings and perceptions) scores from the direct view PCA.

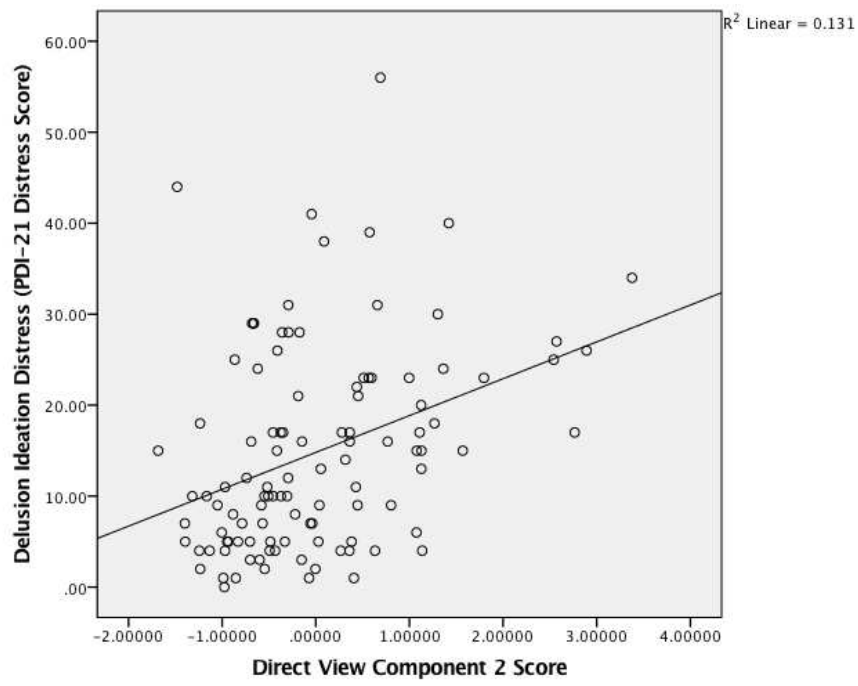
(a)



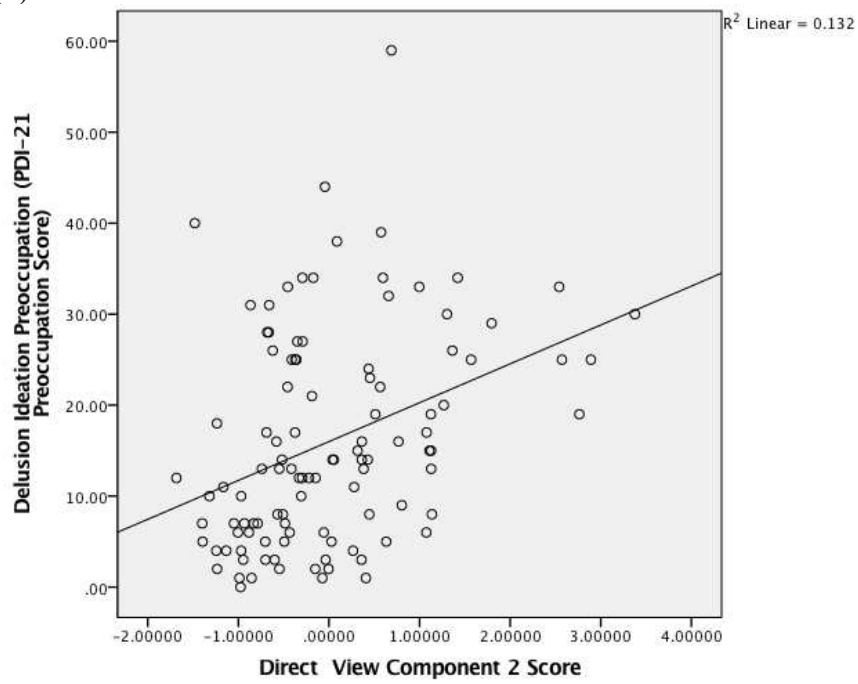
(b)



(c)



(d)



(e)

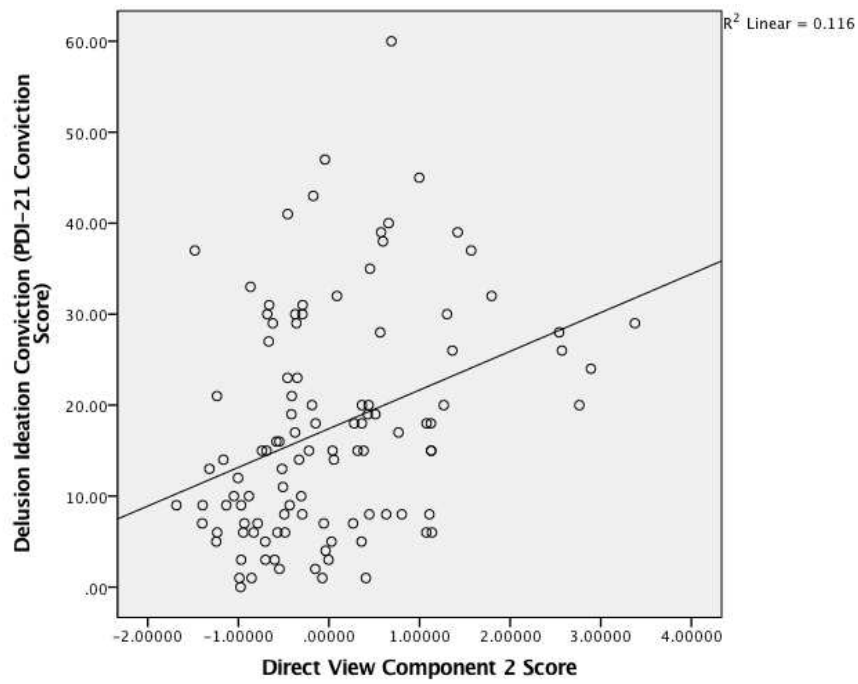


Figure S10. Scatterplot of the relationship between degree of (a) delusion ideation frequency, (b) overall delusion ideation, (c) delusion ideation distress, (d) preoccupation, and (e) conviction and Component 2 (unusual feelings and perceptions) scores from the direct view PCA.

S2.3. Correlations with Mirror view BEQ Component 1 (*negative body evaluations and alienation*)

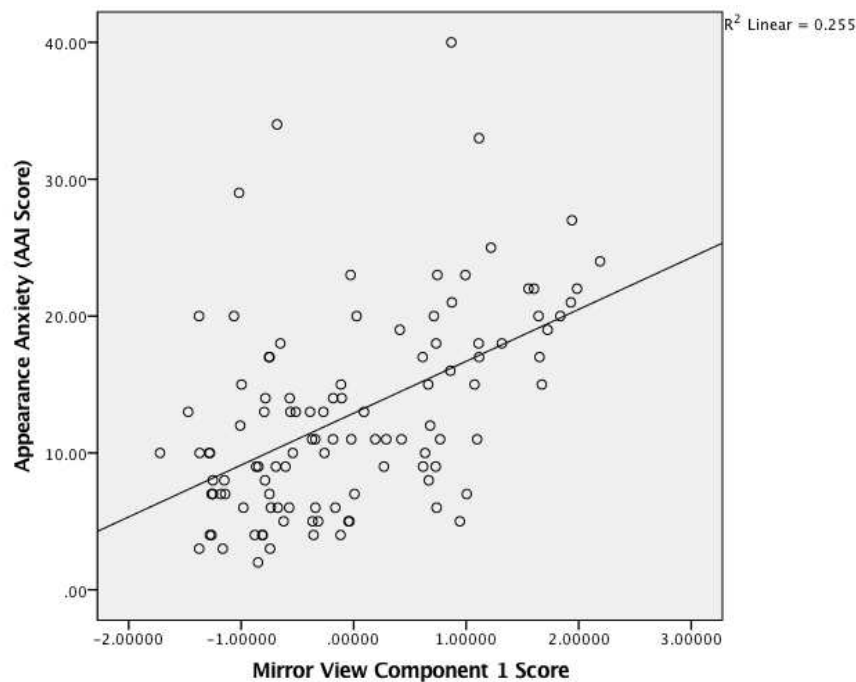


Figure S11. Scatterplot of the relationship between degree of appearance anxiety (AAI score) and Component 1 (negative body evaluations and alienation) scores from the mirror view PCA.

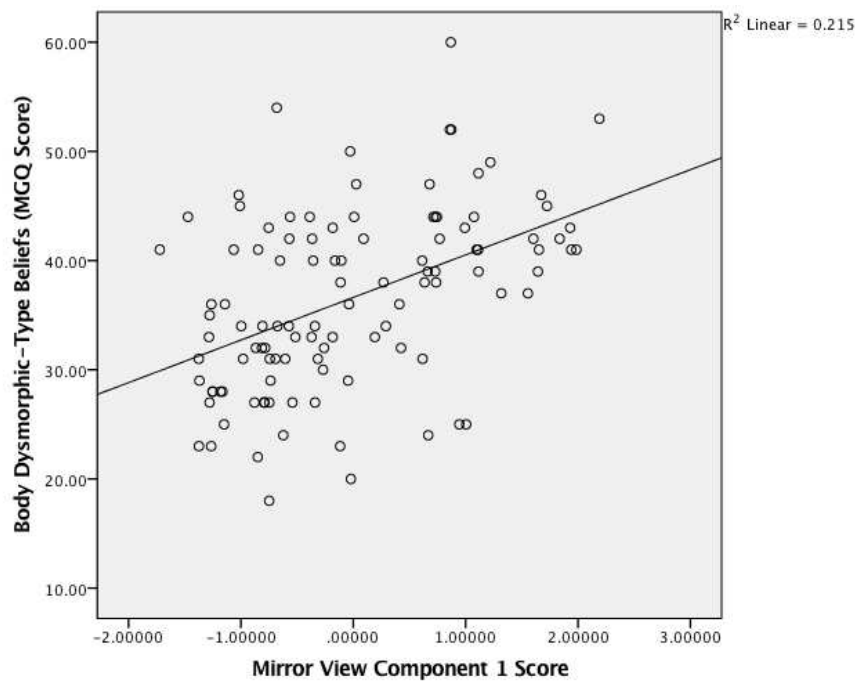


Figure S12. Scatterplot of the relationship between degree of body dysmorphic-type beliefs (MGQ score) and Component 1 (negative body evaluations and alienation) scores from the mirror view PCA.

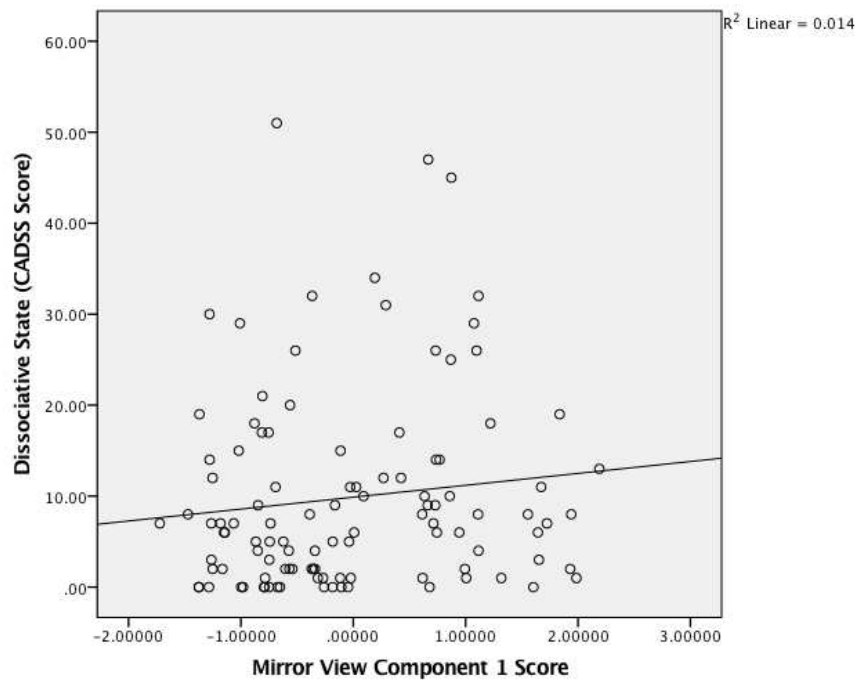


Figure S13. Scatterplot of the relationship between degree of dissociative experiences (CADSS score) and Component 1 (negative body evaluations and alienation) scores from the mirror view PCA.

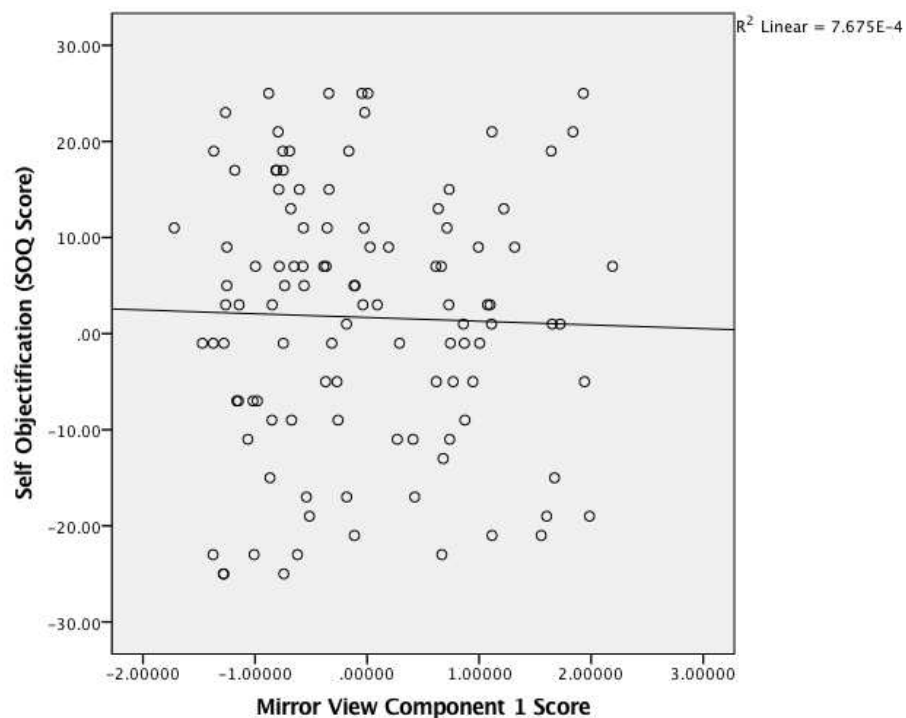
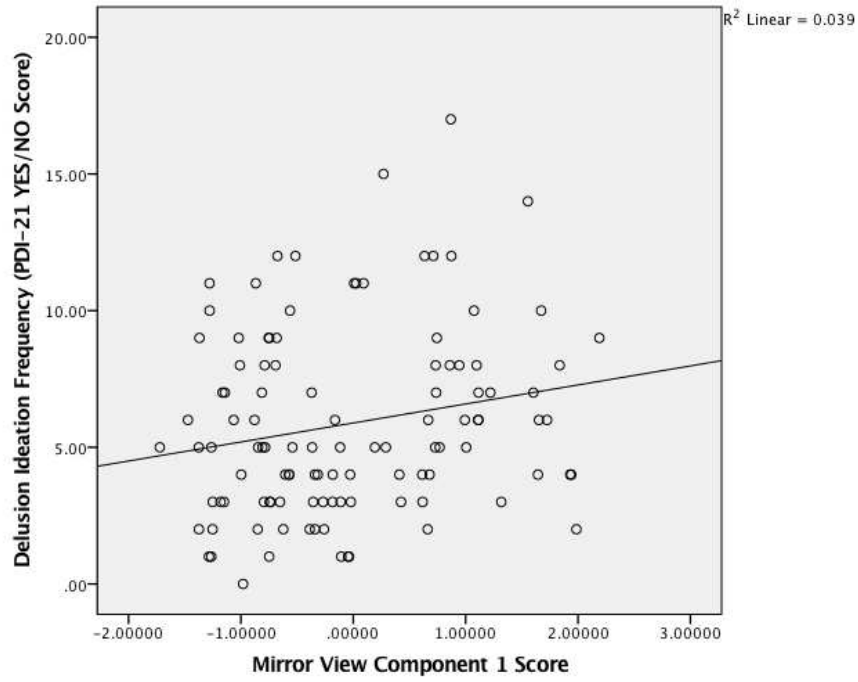
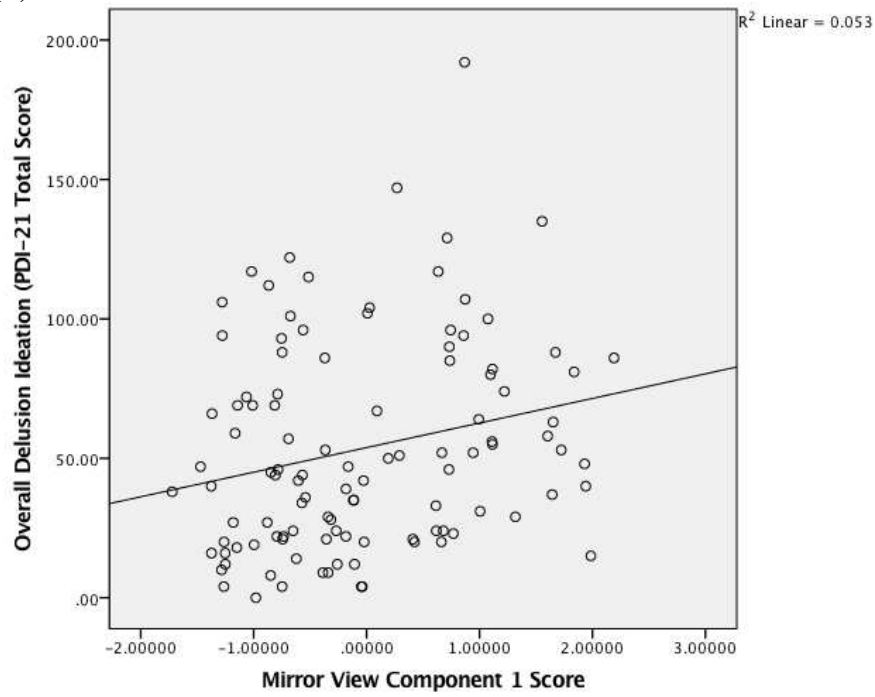


Figure S14. Scatterplot of the relationship between degree of self objectification (SOQ score) and Component 1 (negative body evaluations and alienation) scores from the mirror view PCA.

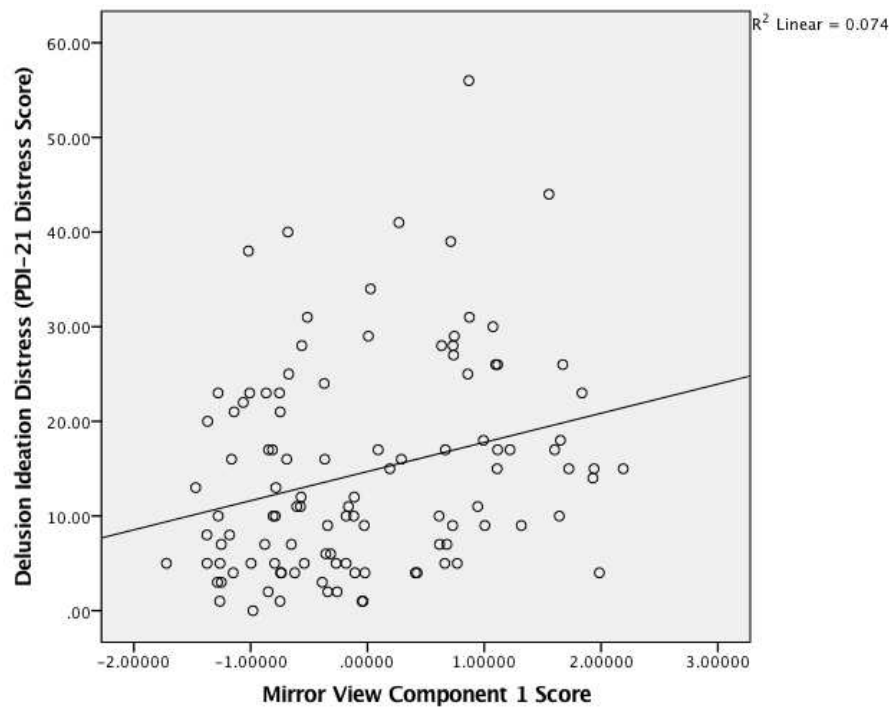
(a)



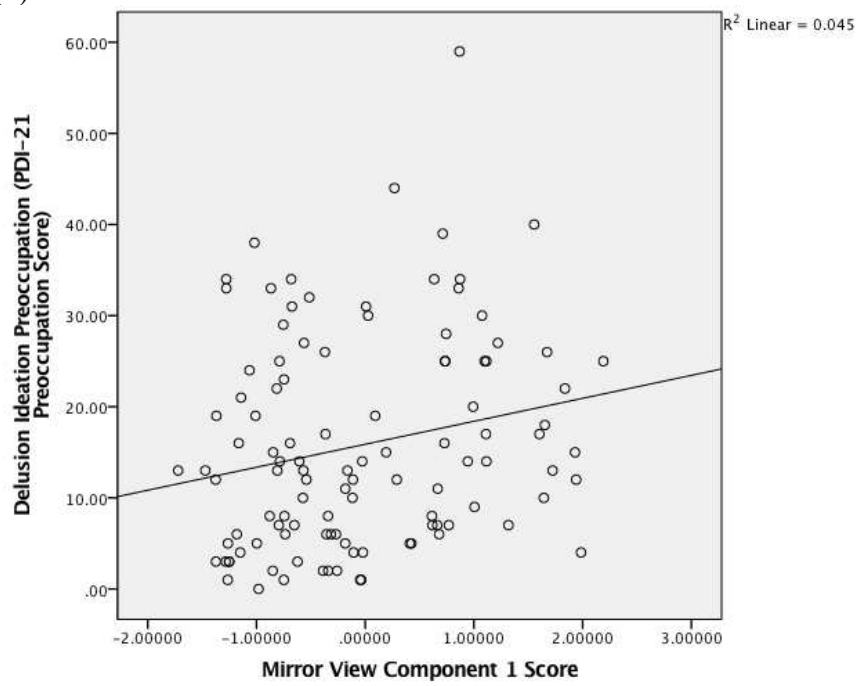
(b)



(c)



(d)



(e)

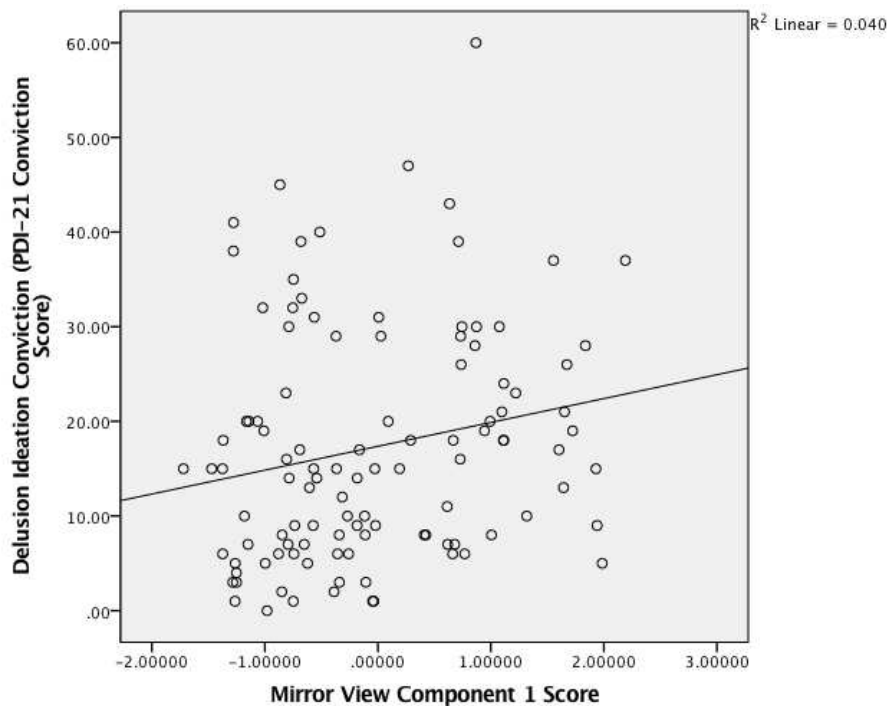


Figure S15. Scatterplot of the relationship between degree of (a) delusion ideation frequency, (b) overall delusion ideation, (c) delusion ideation distress, (d) preoccupation, and (e) conviction and Component 1 (negative body evaluations and alienation) scores from the mirror view PCA.

S2.4. Correlations with Mirror View BEQ Component 2 (*unusual feelings and perceptions*)

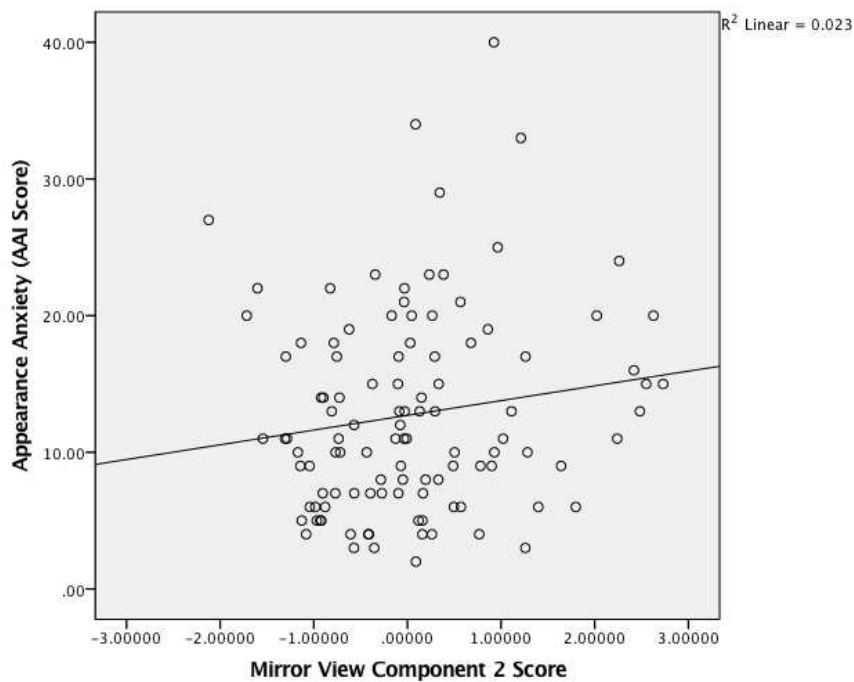


Figure S16. Scatterplot of the relationship between degree of appearance anxiety (AAI score) and Component 2 (unusual feelings and perceptions) scores from the mirror view PCA.

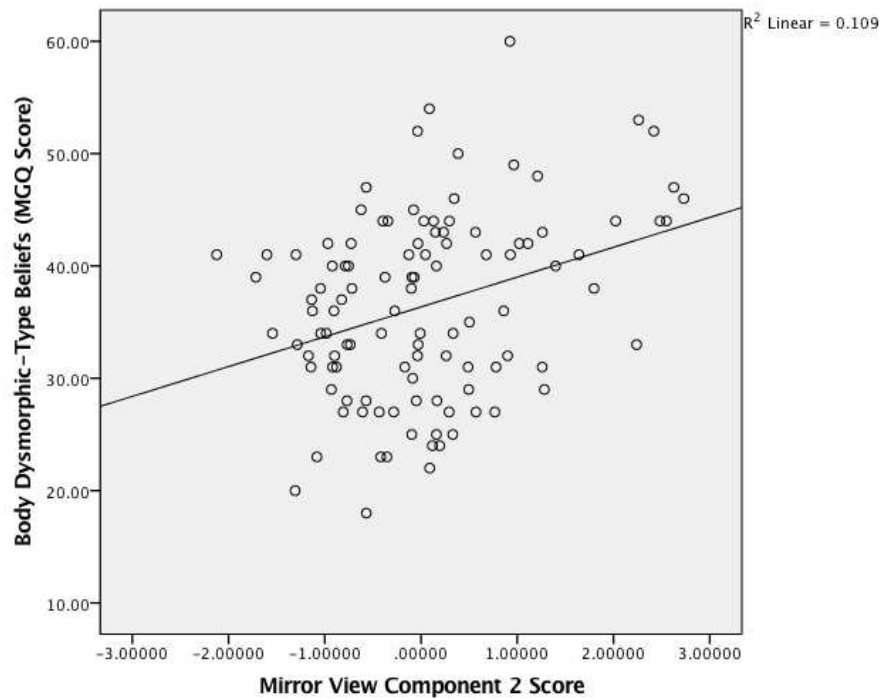


Figure S17. Scatterplot of the relationship between degree of body dysmorphic-type beliefs (MGQ score) and Component 2 (unusual feelings and perceptions) scores from the mirror view PCA.

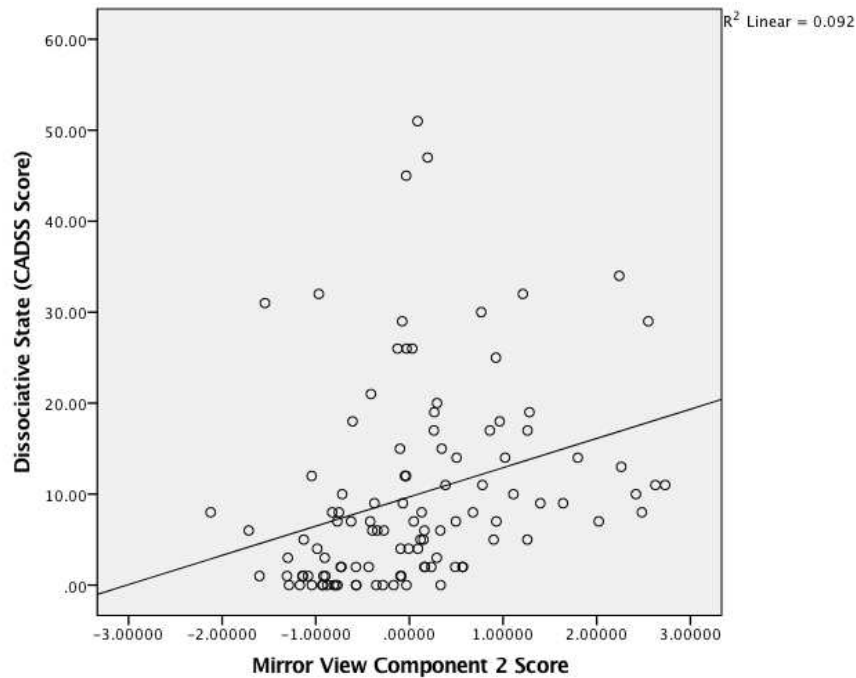


Figure S18. Scatterplot of the relationship between degree of dissociative experiences (CADSS score) and Component 2 (unusual feelings and perceptions) scores from the mirror view PCA.

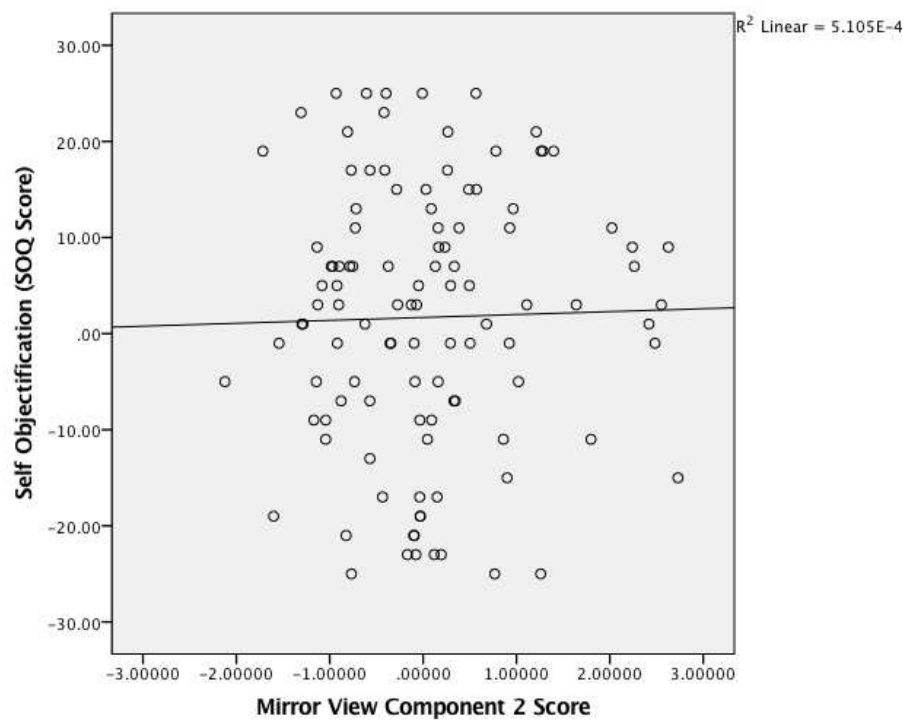
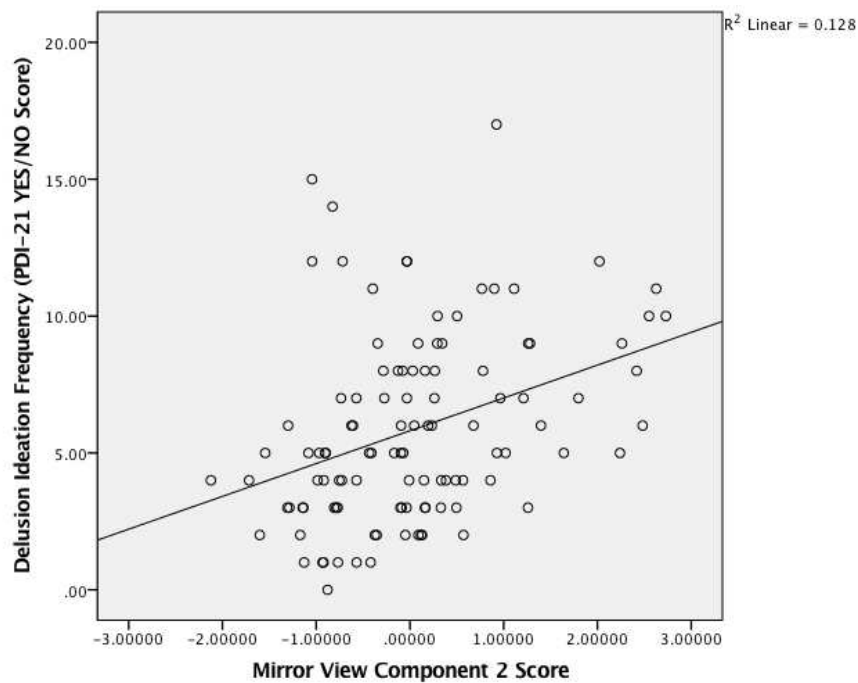
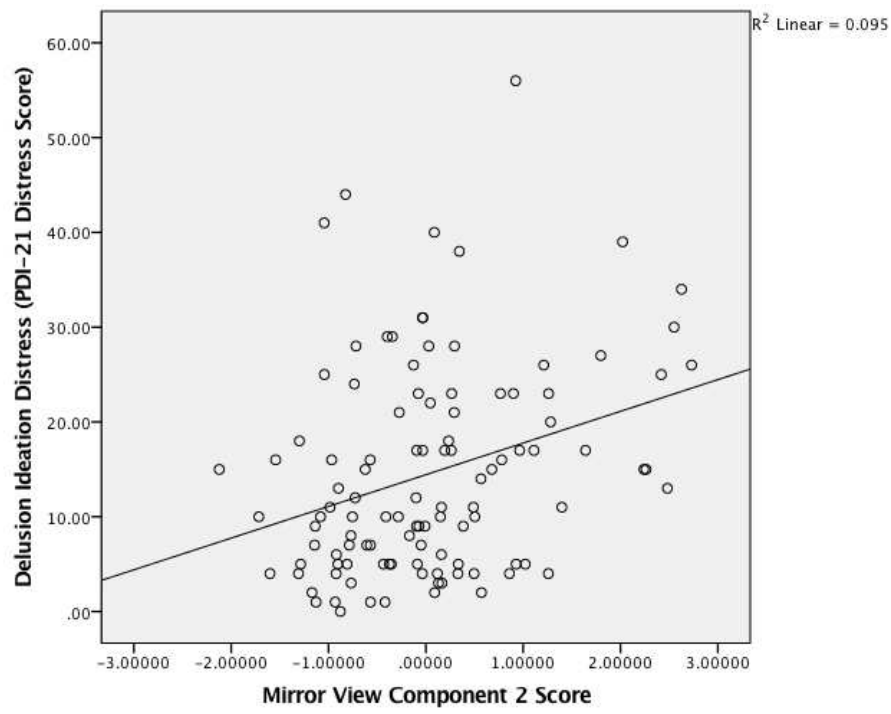
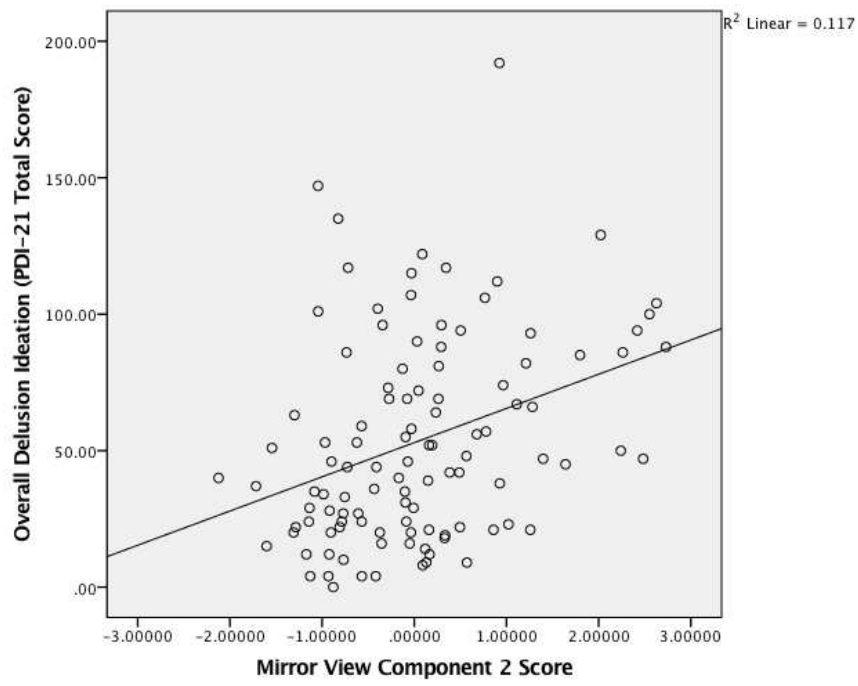


Figure S19. Scatterplot of the relationship between degree of self objectification (SOQ score) and Component 2 (unusual feelings and perceptions) scores from the mirror view PCA.





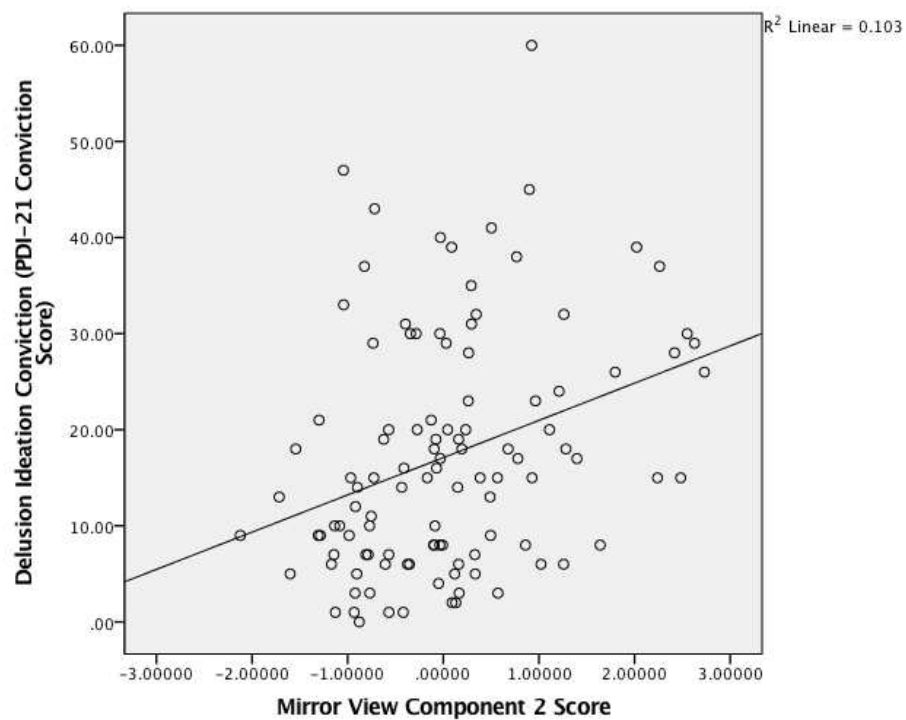
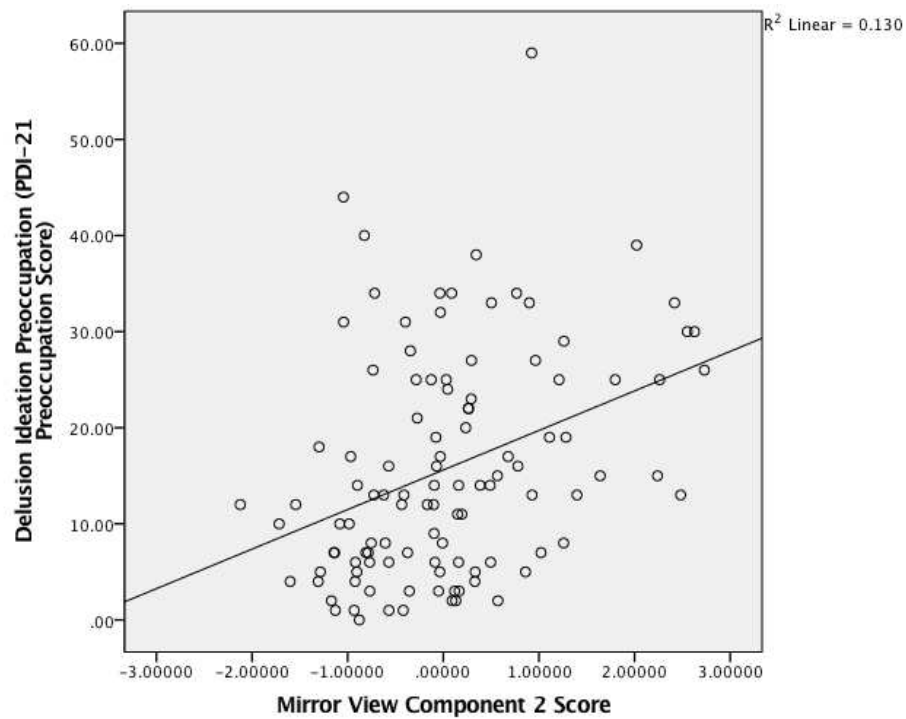


Figure S20. Scatterplot of the relationship between degree of (a) delusion ideation frequency, (b) overall delusion ideation, (c) delusion ideation distress, (d) preoccupation, and (e) conviction and Component 2 (unusual feelings and perceptions) scores from the mirror view PCA.

Highlights

- Healthy participants viewed their body for 5 minutes directly and in a mirror
- PCA was used to explore the subjective experience of the body
- The same two PCA components were found for direct and mirror view
- Seeing the body directly and in a mirror is experienced as subjectively equivalent