The Mirror of mind: Visualizing mental representations of self through reverse correlation

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Abstract

Reverse correlation (RC) method has been widely used, because it allows visualization of mental representations without a priori assumptions about relevant dimensions. We employed RC method to visualize mental representations of self and examined their relationships with traits related to self-image. For this purpose, 110 participants (70 women) performed a two-image forced choice RC task to generate a classification image of self (self-CI). Participants perceived their self-CIs as bearing a stronger resemblance to themselves than did CIs of others (filler-CIs). Valence ratings of participants who performed the RC task (RC sample) and of 30 independent raters both showed positive correlations with self-esteem, explicit self-evaluation, and extraversion. Moreover, valence ratings of independent raters were negatively correlated with social anxiety symptoms. On the other hand, valence ratings of the RC sample and independent raters were not correlated with depression symptoms, trait anxiety, or social desirability. The results imply that mental representations of self can be properly visualized by using RC method.

1 Introduction

Self-image is defined as a subjective perception of oneself, affecting one's thoughts, feelings, and behavior to a great extent (Coon, 1997). Self-image is commonly known to be in a verbal form. For example, a person with a positive self-image associates words like 'Nice', 'Competent', or 'Attractive' with oneself (Amos, Gray, Currie, & Elton, 1997). It can also be in a visual form, when people conceive images of themselves. Among those images, a facial self-image is claimed to be a fundamental factor of self-identity, self-recognition, and self-awareness, by which one distinguishes oneself from others (Keenan, Wheeler, Gallup, & Pascual-Leone, 2000; Lou et al., 2004). However, very little is known about the visual aspect of facial self-image. To understand self-image more thoroughly, we aimed to visualize mental representations of self by using a technique called *reverse correlation* (RC) and examine its relationships with traits relevant to self-image.

RC method is a data-driven approach to creating visual proxies of mental representations (Brinkman, Todorov, & Dotsch, 2017; Dotsch & Todorov, 2012; Mangini & Biederman, 2004). In a typical RC image classification task, a large set of facial stimuli are presented to participants in pairs. These facial stimuli are produced by superimposing random noise patterns on a single base facial image. In each trial, participants select one from a pair of faces that better resembles the target category. By averaging the selected stimuli across many trials, one classification image (CI) is generated. (For technical details, see Brinkman, Todorov, and Dotsch (2017), who suggested interpreting a CI as a visual form of the internal representations of interest.)

In the field of psychology, RC method has been widely used to visually identify diagnostic features that are involved in social judgments (Brinkman et al., 2017). For example, it has been used to classify features diagnostic for race: Chinese faces (Dotsch, Wigboldus, Langner, & van Knippenberg, 2008), Moroccan faces(Dotsch et al., 2008; Dotsch, Wigboldus, & van Knippenberg, 2011), and Black and White faces (Krosch & Amodio, 2014). It has also been employed to classify features diagnostic for personality traits. Dotsch and Todorov (2012) found that diagnostic facial features that are key to the judgment of trustworthiness were a subtle smile and femininity, and dominance was also related to facial masculinity. In another line of research, RC method has been employed to examine the associations between the distortion in mental representation and pre-existing knowledge or prejudice. For instance, Dotsch et al. (2008) found that higher the Dutch participants' level of implicit prejudice toward Moroccans, independent raters rated the CIs of typical Moroccan faces as more criminal and less trustworthy. Imhoff, Woelki, Hanke, and Dotsch (2013) also assessed participant's mental representation of two occupation groups: male nursery teachers and managers. The CIs of nursery teachers were evaluated as warmer but less competent than those of managers.

An RC task has an important strength of incorporating participants' spontaneous use of information, because they can freely adopt criteria that are important for their judgments about the stimuli (Brinkman et al., 2017). For example, when asked to select faces that bore a stronger resemblance to themselves, some may place greater weight on the eyes or noses of the presented face, but others may focus on somewhat ambiguous factors, such as facial outlines. Some participants may not even be aware of the features they adopt to make such judgments. Because RC method allows participants to make spontaneous and instinctive decisions, *a priori* assumptions about related dimensions are not needed to visualize a participant's self-image.

Although RC method has yielded notable findings in the area of social perception, an RC task has not yet been actively used to visualize mental representation of self. In a pioneering study, Imhoff

and Dotsch (2013) generated CIs of self, a national in-group (German), and superordinate group (European). They found that self-image and images of their in-group were independently projected into the visual representation of the superordinate group. However, they examined neither the individual differences in the CIs of self nor its associations with traits relevant to self-image. In fact, to our knowledge, RC method has not yet been used to examine self-image.

Because CIs can be interpreted as internal representations of, for example, personality traits and stereotypes toward a group, CIs applied to self would reflect how individuals perceive themselves. Application of RC method in the dimension of self can provide additional knowledge for the following reasons. First, reverse correlation task can generate a visual proxy for self-image, whereas traditional assessments of self-image have been focused on verbalized evaluation, such as self-report measures. For example, Amos et al. (1997) measured self-image by directly asking participants to rate themselves on 19 traits using a Likert scale. Though verbal assessments can reveal important aspects of self-image, they would miss out on a visual aspect. This can also be true for indirect measures. Implicit measures can, for example, assess semantic categories and certain target are associated (e.g., the Implicit Association Test; Greenwald & Farnham, 2000; Greenwald, McGhee, & Schwartz, 1998), spontaneous affective reaction primed by target (e.g., the Affect Misattribution Procedure; Falk, Heine, Takemura, Zhang, & Hsu, 2015; Payne, Cheng, Govorun, & Stewart, 2005), and whether one prefers to choose letters that are in one's own name (e.g., the Name-Letter Effect; Koole, Dijksterhuis, & van Knippenberg, 2001). Although these measures can

In this study, we aim to visualize mental representations of self by using a reverse-correlation task and examining their relationships with traits related to self-image. Our hypotheses are as follows. First, people would perceive their CIs as bearing a stronger resemblance to themselves than would CIs of others. Second, CI valence rated by self and independent raters would be positively correlated with self-esteem, explicit self-evaluation, and extraversion, but negatively with social anxiety symptoms. Self-esteem is a long-established variable associated with positive self-image (Rosenberg, 1965). According to Oikawa et al. (2012), evaluation of one's own face and self-esteem are linked at the neural level. Also, previous findings support that socially anxious individuals tend to have negative self-images, as is known to be a maintaining factor of social anxiety disorder (see for review Ng, Abbott, & Hunt, 2014). We postulated that extraversion (X) of the HEXACO model would be positively correlated with CI valence ratings, because multiple studies have shown stable associations between extraversion, self-esteem, and the quality of interpersonal relationships (Aghababaei et al., 2016; Visser & Pozzebon, 2013). In addition to the main hypotheses, we explored the relationships between self-CI and psychological indices, including depression symptoms, trait anxiety, and social desirability.

2 Method

2.1 Participants and design

We recruited two separate samples: one that performed the RC task (RC sample) and a sample of independent raters. The RC sample included 110 students (70 women). Each participant in the RC sample produced one CI. The mean age of this sample was 22.90 (SD_{age} = 3.09; age range, 18-34). The RC sample received a gift card equivalent to $13 for their participation. Additionally, 60 participants were recruited as independent raters (30 men; M_{age} = 25.17, SD_{age} = 3.75; age-range: 19-35) to acquire objective evaluations of the valence of the CIs created by the RC sample. They received $10 for their participation.

We used deception in introducing the aim of the study to blind the participants to the hypotheses and then debriefed them after the experiment. This study was approved by the Institutional Review Board (IRB).

2.2 Materials and procedures

2.2.1 Image creation

To generate a classification image of the self, the RC sample performed a two-image forced choice RC task (Dotsch & Todorov, 2012). In 300 trials, participants selected one from two facial stimuli that looked more like themselves. Female participants only viewed female faces; males only male faces. Presented images were a one-base facial image (a morphed composite of one hundred faces) with superimposed random visual noises (see Figure 1 and Brinkman et al., 2017 for details). Stimuli were presented in random order to the participants, who were forced to make a choice within 3 s (Peirce et al., 2019). The self-CI of a participant was seamlessly generated by the rcicr package (Dotsch, 2016) in R (R Core Team, 2019) upon the completion of the RC task. The entire procedure of participation was computerized using psychoPy (Peirce et al., 2019).

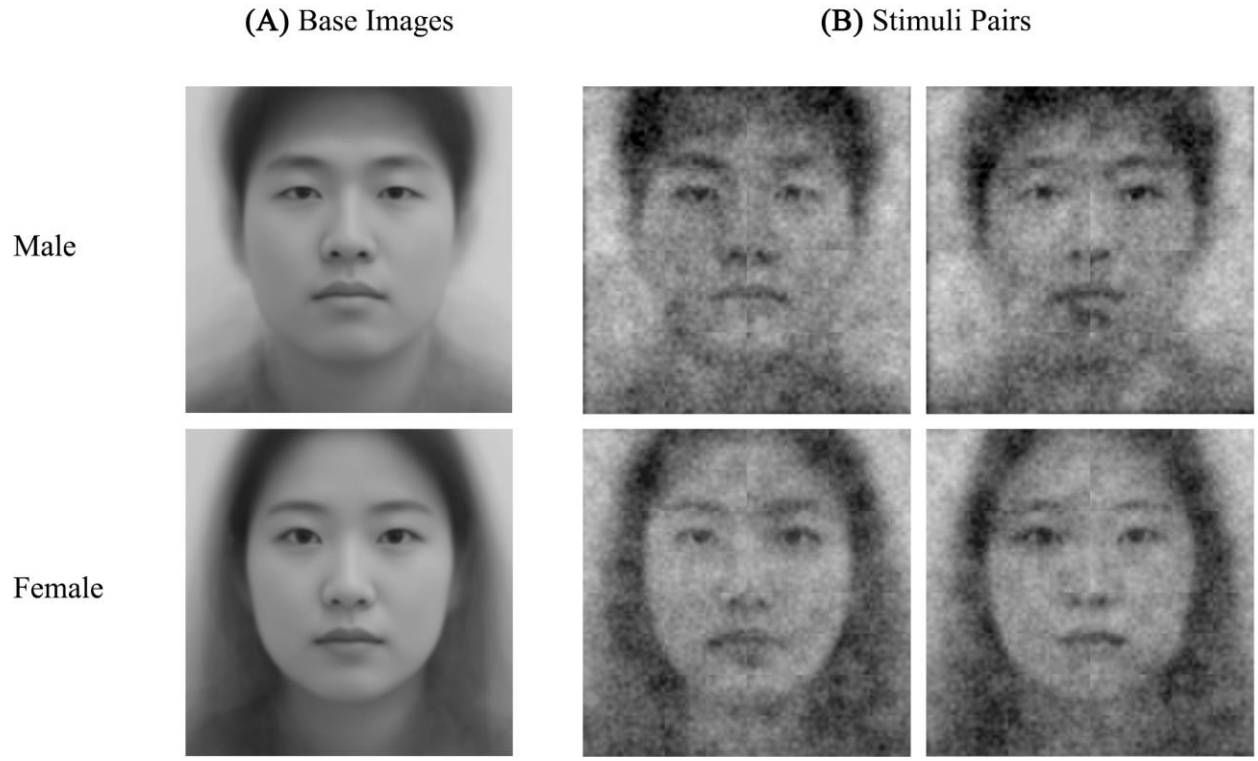

Figure 1. (A) Base Images and **(B)** Exmaples of Stimuli Pairs Used in the Reverse Correlation Task.

2.2.2 Image rating

Two separate samples rated the CIs generated: the RC sample and the independent rater sample. The RC sample rated the CIs that they generated on the valence and on how much it resembled oneself. Participants were blinded from how the CI was generated. Also, we presented five filler-CIs with the CI that the participant generated; these filler-CIs for each sex were selected from a pilot study.[1] The

presentation order of six CIs (five filler-CIs and one self-CI) was randomized to reduce experimental biases. We did not inform participants that they were viewing the CI that they had generated.

Resemblance was rated on 9 Likert points ranging from 1 = *weaker resemblance to myself* to 9 = *stronger resemblance to myself*. Valence was measured with seven items adopted from 14 self-presentational domains (Leary & Allen, 2011).[2] They were presented on 9–point bipolar scales. Seven items were (a) unfriendly, unlikeable vs. friendly, likeable; (b) incompetent, unintelligent vs. competent, intelligent; (c) irresponsible, undependable vs. responsible, dependable; (d) immoral, unethical vs. moral, ethical; (e) serious, not playful vs. humorous, playful; (f) unattractive, ugly vs. attractive, good-looking; (g) illogical, irrational vs. logical, reasonable. All items were presented in random order.

The independent raters who were blinded to the study hypotheses also rated the valence of the CIs generated by the RC sample with the seven items listed above. We randomly assigned the independent raters into two groups taking sex ratio into account. Each group evaluated 55 images out of 110 self-CIs.

2.2.3 Self-image relevant variables

2.2.3.1 Rosenberg Self-Esteem Scale (RSE)

We used the RSE (Rosenberg, 1965) to measure self-reported global self-esteem. The RSE consists of ten 5-point Likert-scale items (1 = *not very true of me* to 5 = *very true of me*). We used the Korean version of RSE (Lee & Won, 1995).

2.2.3.2 Social Interaction Phobia Scale (SIPS)

The SIPS was employed to assess social anxiety symptoms (Carleton et al., 2009). The scale consists of fourteen 5-point Likert-scale items (0 = *Not at all characteristic of me* to 4 = *Extremely characteristic of me*). Higher scores indicate a higher degree of social anxiety symptoms. We used the Korean version of the SIPS (Kim, Yoon, & Kwon, 2013).

2.2.3.3 Explicit self-evaluation

To assess explicit self-evaluation, we asked the RC sample to rate how they evaluate themselves using seven items from 14 self-presentational domains (Leary & Allen, 2011). These seven items were also used for the valence ratings of CIs.

2.2.3.4 Extraversion

To assess extraversion, we used 10 items from the HEXACO-60 (Ashton & Lee, 2009). [3] The HEXACO-60 is scored on a 5-point Likert scale (*1 = strongly disagree* to *5 = strongly agree*). The extraversion dimension of the HEXACO-60 consists of four subscales: social self-esteem, social boldness, sociability, and liveliness. We used the Korean version of the HEXACO-60 (Lee & Ashton, 2013).

2.2.4 Control variables

2.2.4.1 Center for Epidemiological Studies Depression Scale (CES-D)

The CES-D is a 20-item measure to assess depressive symptomatology (Randloff, 1977). The inventory is scored on a 4-point Likert-scale ranging from 0 = rarely or none of the time (less than 1 day) to 3 = most or all of the time (5-7 days) to assess how often participants felt depressed during

the past week. Higher scores indicate more depressive symptoms. We used the Korean version of CES-D (Chon, Choi, & Yang, 2001).

2.2.4.2 Taylor Manifest Anxiety Scale (TMAS)

Taylor (1593) developed the Manifest Anxiety Scale (MAS) to measure chronic anxiety symptoms, and Bendig (1956) developed the shortened version of the original scale. The TMAS consists 20 binary items. We used the Korean version of the TMAS (Lee, 2000).

2.2.4.3 Marlowe-Crowne Social Desirability Scale (MCSDS)

The MCSDS is a self-report scale developed by Crowne and Marlowe (1960) to measure the tendency to appear socially desirable. The MCSDS consists of 33 binary items. We used the Korean version of MCSDS (Lee, 2000).

3 Results

3.1 Resemblance rating

To test whether participants perceived their own CI as bearing a stronger resemblance to themselves than did filler CIs, we performed a one-way (target: self-CI vs. filler-CIs) repeated measure analysis of variance (ANOVA) with resemblance rating as a dependent variable. There was a significant main effect of target, $F(1, 109) = 124.38$, $p < .001$, $\eta_p^2 = .53$, with a stronger resemblance rating for self-CI ($M = 5.89$, $SD = 1.93$, 95% CI = 5.61, 6.17) than for filler-CIs ($M = 3.76$, $SD = 2.00$, 95% CI = 3.48, 4.04). The resemblance rating was significantly correlated only with valence ratings of participants' self-CI, $r = .33$, $p < .001$.

3.2 Valence rating

The basic statistics and correlations are shown in Table 1. Reliabilities were acceptable for all measures, with the lowest being .72 for MCSDS (Marlowe-Crowne Social Desirability Scale). The valence ratings of the RC sample and independent raters were positively correlated. For descriptive purpose, we averaged the resulting self-CIs by high and low groups of self-esteem, social anxiety symptoms, and explicit self-evaluation (see Figure 2). To test the main hypothesis, we investigated the association between the valence ratings of CIs and variables related to self-image. As expected, the valence ratings of the RC sample and independent raters were positively associated with self-esteem, explicit self-evaluation and extraversion. In addition, the valence rating of the independent raters was negatively correlated with social anxiety symptoms. Meanwhile, the valence ratings of neither the RC sample nor the independent raters were correlated with depression symptoms, trait anxiety, and social desirability. On the other hand, all of the self-reported measures included in the analysis were significantly correlated to each other, $|r|s = .28 \sim .76$, $p < .01$.

Table 1
Means, Standard Deviations, Cronbach's αs, and Correlations among Study Variables

	1	2	3	4	5	6	7	8	9
1. VR_{RC}	-								
2. VR_{IR}	0.59***	-							
3. RSE	0.23*	0.24*	-						
4. SIPS	-0.14	-0.27**	-0.44***	-					
5. ES	0.28**	0.44***	0.58***	-0.51***	-				
6. X	0.25**	0.37***	0.71***	-0.61***	0.61***	-			
7. CESD	-0.11	-0.03	-0.73***	0.43***	-0.41***	-0.51***	-		
8. TMAS	-0.14	-0.18	-0.76***	0.59***	-0.52***	-0.72***	0.71***	-	
9. MCSDS	0.04	0.11	0.38***	-0.25**	0.36***	0.28**	-0.29**	-0.41***	-
M	5.58	4.88	29.47	12.54	6.36	30.76	16.98	8.18	15.82
SD	1.09	0.73	5.88	7.46	0.89	6.89	9.77	5.37	4.8
Cronbach's α	0.78	0.92	0.89	0.84	0.73	0.85	0.91	0.89	0.72

Note. $N = 110$. VR_{RC} = Valence Ratings of the Reverse Correlation sample; VR_{IR} = Valence ratings of the Independent Raters; RSE = Rosenberg Self-Esteem Scale; SIPS = Social Interaction Phobia Scale; ES = Explicit Self-evaluation; X = the Extraversion dimension of the HEXACO; CES-D = Center for Epidemiological Studies Depression Scale; TMAS = Taylor Manifest Anxiety Scale; Marlowe-Crowne Social Desirability Scale.
* $p < .05$. ** $p < .01$. *** $p < .001$.

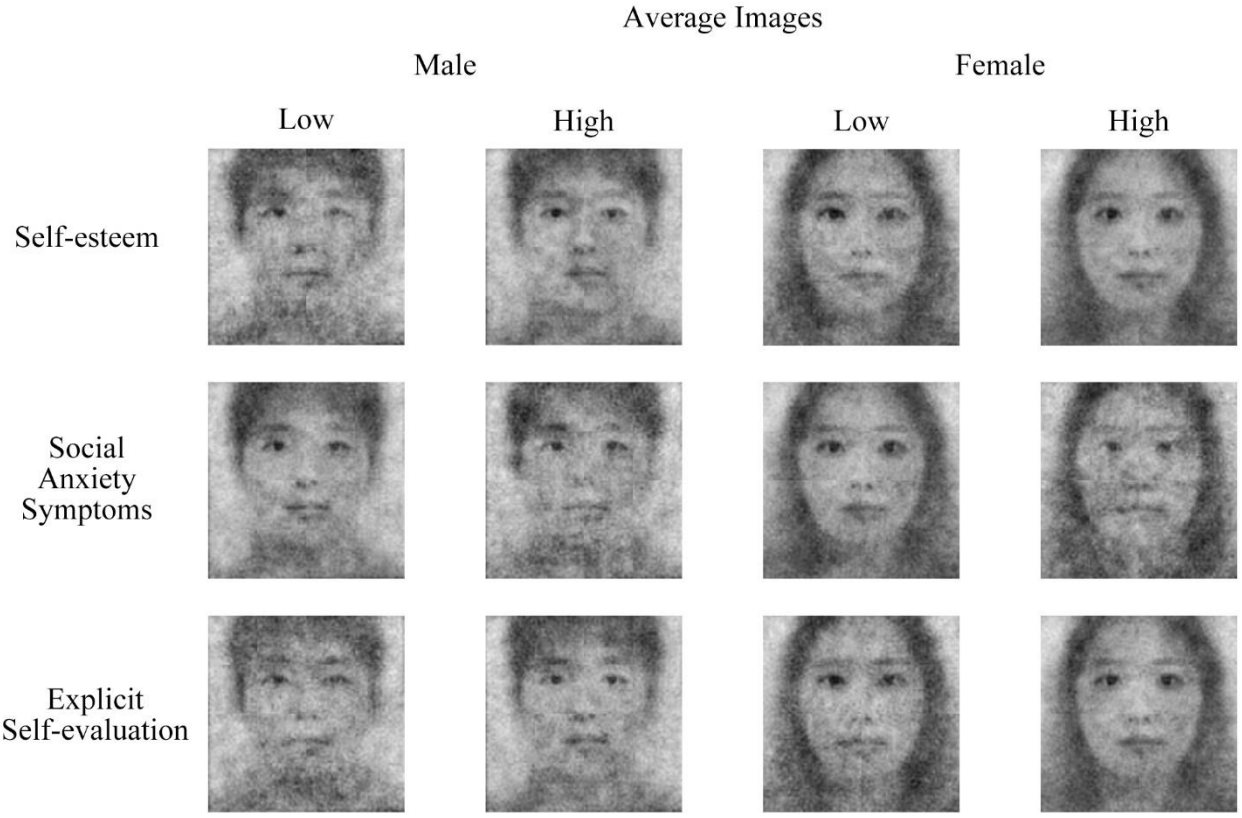

Figure 2. The average self-CIs by low (-1 SD) and high (+1 SD) groups of self-esteem, social anxiety symptoms, and explicit self-evaluation.

4 Discussion

Using the RC image classification task (Dotsch & Todorov, 2012), we visualized the mental representation of self. Our data provide evidence that CIs can be regarded as valid proxies of facial self-images. Participants perceived their self-CIs as bearing a stronger resemblance to themselves than did filler CIs, without knowing that the self-CI was an image that they had created via the RC task. Also, in line with our hypothesis, the valence ratings of self-CIs were significantly associated with variables relevant to self-image, including self-esteem, social anxiety symptoms, explicit self-evaluation, and extraversion.

Consistent with the existing literature, our findings suggest that self-image is associated with self-esteem (Oikawa et al., 2012; Rosenberg, 1965) and social anxiety symptoms (Hirsch, Clark, Mathews, & Williams, 2003; Hirsch, Meynen, & Clark, 2004). Our findings extend previous research by illustrating that mental representation of self can be visualized through the RC method. It is shown that individuals' self-images may differ in terms of valence, and this difference can be reliably evaluated across independent raters. Moreover, the data imply that the valence of a mental representation of self pertains to the attitude toward self and the social interaction patterns that one shows.

We also found that the valence ratings of self-CIs were not associated with self-reported depressive symptoms, trait anxiety, or social desirability. On the other hand, all the self-reported variables in this study were correlated with each other. Given the close correlations between self-reported measures, it is interesting that the valence ratings of self-CIs did not show significant

correlations with depressive symptoms, trait anxiety, or social desirability. This may imply an advantage of examining self-CIs over self-reported measures, because they allow the researchers to assess participants' perception of self with less chances of being biased by certain response patterns or social desirability.

It has been reported that distortion in self-perception is a key factor of psychiatric symptoms such as social anxiety disorder (Clark & Wells, 1995; Hirsch et al., 2003, 2004) or body dysmorphic disorder (Buhlmann, Etcoff, & Wilhelm, 2008). Thus, clinicians assess how patients perceive themselves to evaluate the severity of the symptoms and to examine the effectiveness of the therapeutic interventions. Our research suggests clinical usefulness of using RC method as a tool to assess how patients see themselves, which may be hard to depict in words.

4.1 Limitations

The limitations of this study are as follows. First, because we employed only self-reported measures to measure the validity of self-CIs, variables that were significantly associated with valence ratings of self-CIs were also closely related to self-reported measures. Thus, the incremental validity of self-CI ratings is rather debatable. However, the result of Epley and Whitchurch (2008) suggests that visual representations of self may be more closely related to implicit measures than to explicit measures. Therefore, future research should include both implicit and self-reported measures to examine the incremental validity of CI ratings. Also, since we did not incorporate the physical appearance of participants into our analyses, our data cannot explicitly demonstrate an advantage of evaluating self-CI over physical appearance. It remains for future studies to examine the additional information that visualized representation of self provides apart from physical appearance. Finally, the sample in this study was limited to young adults; therefore, the results may not be applicable to other ages. Future research with a broader age range is needed to generalize the current findings.

4.2 Conclusion

Overall, our results support that mental representation of self can be visualized via the RC method. Participants perceived their self-CIs as bearing a stronger resemblance to themselves than did CIs of others (filler-CIs). The valence ratings of participants (RC sample) and independent raters were associated with variables related to self-image. A remaining issue for future research is about the intrinsic and additional information about self-image that RC method can provide but that traditional measures cannot.

5 Notes

[1]In the pilot study, ten men and ten women (M_{age} = 25.05, SD_{age} = 3.14) evaluated trustworthiness and dominance with a 9-point likert scale from ninety CI stimuli. We selected a set of five CI stimuli per sex considering the average of trustworthiness and dominance of each stimulus set to be similar to the total average.

[2]We conducted an exploratory factor analysis to reduce the dimensions of the 14 self-presentational domains based on the ratings of independent raters. Seven items with high factor loadings on the valence (trustworthiness) factor were selected to calculate valence ratings (factor loadings = .94 ~ .88).

[3]Participants also answered the other 50 items of the HEXACO-60. However, the other five personality dimensions were not significantly correlated with the valence ratings of self-CIs, $|r|$s < .17.

6 Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

7 Author Contributions

Conceived and designed experiment: KM and YK. Performed the experiment: KM and JK. Analyzed the data: KM, YK, and HK. Wrote the paper: KM, SK, and JK.

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