# Continuous Inclusion of Other in the Self

Benjamin Beranek, Geoffrey Castillo

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Benjamin Beranek[*] Geoffrey Castillo[†‡]

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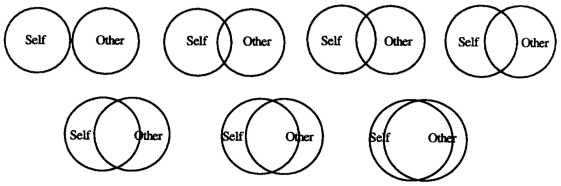
The Inclusion of Other in the Self (IOS) scale is a popular tool to measure interpersonal closeness that is increasingly being used in economics. We develop and validate a continuous version of the IOS scale. This Continuous IOS scale gives a more precise measure and solves a no-overlap avoidance bias present in the standard IOS scale. We also propose a version of the standard IOS scale that, contrary to existing implementations, meets its theoretical requirements. Our IOS scales are easy-to-use, well-documented, and available at `https://github.com/geoffreycastillo/ios-js`.

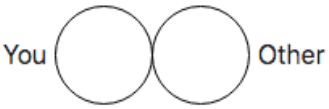
## 1 Introduction

The Inclusion of Other in the Self (IOS) scale is one of the most popular measures of interpersonal closeness. It asks respondents to pick one of seven pairs of increasingly

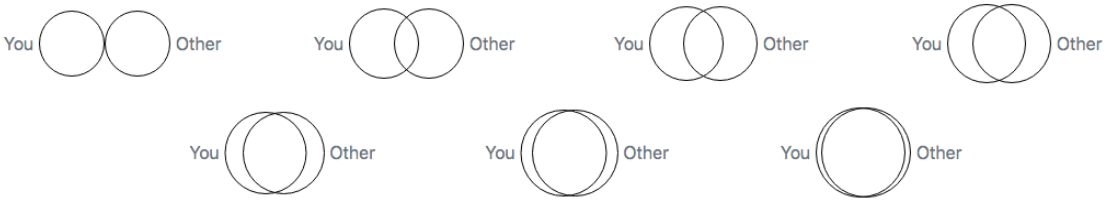
[*]Department of Economics, Missouri State University. `benjaminberanek@missouristate.edu`
[†]Vienna Centre for Experimental Economics, University of Vienna. `geoffrey.castillo@univie.ac.at`
[‡]The Connecticut College Institutional Review Board has approved the experiment reported in this paper. Our pre-registration is available at `https://osf.io/z6y7d`. Data and code to reproduce our results are available at `https://github.com/geoffreycastillo/continuous-ios-data-code`. We thank the AWS Cloud Credit for Research program, the RF Johnson Faculty Development Fund of Connecticut College, and the Heinrich Graf Hardegg´sche Stiftung, for financial support.



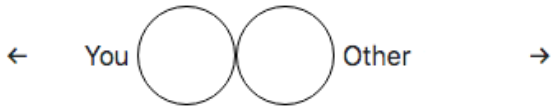

**(a)** Original IOS scale from Aron et al. (1992)




**(b)** Continuous IOS scale: click on the left circle and drag-and-drop it on the right




**(c)** Our implementation of the standard IOS scale




**(d)** Step-Choice IOS scale: click on the arrows to choose a pair of circles

**Figure 1:** Four different IOS scales.

overlapping circles to indicate how close they feel toward another (Figure 1a). Since its creation by Aron et al. (1992), the IOS scale has been repeatedly validated (Gächter et al., 2015) and widely adopted, with over 5,000 citations on Google Scholar (see Aron et al., 2013; Branand et al., 2019, for reviews). In recent years it has spread to economics, for example to explain charitable donations (Goette and Tripodi, 2021), dictator game allocations (Robson, 2021), or team production (Gächter et al., forthcoming).

These papers and our own experience with the IOS scale reveal that the IOS scale might be too coarse to be able to discriminate between different others. For

example, about half of respondents report the same IOS scores for the two recipients they face in both Robson (2021) and Castillo (2021).

To solve this issue, our first contribution is to offer a continuous version of the IOS scale (Figure 1b), which offers a more granular measurement of interpersonal closeness. In the Continuous IOS scale, respondents click the left circle (representing self) and drag-and-drop it on the right circle (representing the other) at the point of overlap that best represents their relationship with the other. It also allows full overlap, and would thus capture better the closest relationships.

The Continuous IOS scale satisfies the requirements set out by Aron et al. (1992) in their seminal paper. In particular, circle diameters increase as the distance between the circles decreases. We find, however, that most existing implementations of the IOS scale do not satisfy these requirements. Our second contribution is thus to offer, alongside the Continuous IOS scale, a re-implementation of the standard IOS scale that meets them (Figure 1c). As a middle-ground, we also propose the Step-Choice IOS scale (Figure 1d), in which only one pair of circles is displayed at a time and respondents click on the left and right arrows to move back and forth between the different pairs. The Step-Choice IOS scale thus retains the discreteness of the standard IOS scale but allows the use of more pairs of circles.

In an online experiment, we validate the Continuous IOS scale and the Step-Choice IOS scale against our implementation of the standard IOS scale. We find that the standard IOS scale elicits higher IOS scores than the Continuous IOS scale. This comes from subjects who select a minimal overlap on both scales. However, both scales do not allow one to report minimal overlap in the same way. Subjects must select the second pair of circles in the standard IOS scale to report minimal overlap, while they can choose an overlap very close to zero in the Continuous IOS scale. Thus, our third contribution is to show that the standard IOS scale might suffer from a no-overlap avoidance bias that our Continuous IOS scale corrects.

As we hinted at above, the IOS scale is becoming a popular tool in economics and has been used to show how social closeness impacts economic outcomes. For example, Goette and Tripodi (2021) find that social proximity as measured by the IOS scale drives social conformity which influences how much money people give to an NGO. Hofmann et al. (2021) show that the presence of close others, as measured by the IOS scale, increases voluntary payments in a Pay-What-You-Want context. In a lab-in-the-field experiment in Uganda, Robson (2021) uses

the IOS scale to show that social connectedness enters the utility function and affects decisions in a modified dictator game. Castillo (2021) uses the IOS scale to show how preferences defined over social distance depend on the task used to elicit them—a translation of the classical preference reversal phenomenon to the social domain. Dimant (forthcoming) studies political polarisation and distinguishes between ingroup love and outgroup hate thanks in part to the IOS scale. Finally, Gächter et al. (forthcoming) show that group cohesion, measured with a oneness scale that includes the IOS scale, increases team production as captured by a weak-link coordination game.

While most of these papers have used the IOS scale to measure the distance between two individuals, the Inclusion of Ingroup in the Self (IIS) scale (Tropp and Wright, 2001) allows one to measure the distance between an individual and a group or even between two groups. The IIS scale is an extension of the IOS scale to groups, obtained by replacing the 'Other' label attached to the right circle by some ingroup. Our IOS scales can thus be directly translated into the IIS scale by modifying the labels attached to the circles.

We offer a standardized implementation of the IOS scale in three versions (original, Step-Choice, and Continuous) that meets the Aron et al. (1992) requirements. Others have previously offered only continuous versions of the IOS scale. For example, Le et al. (2007) offered a version that no longer works on modern browsers because the technology they relied on—Java applets—is deprecated. Kamphorst et al. (2017) ported this version to JavaScript, the technology we also rely on. Since both use circles with a fixed diameter, these versions do not satisfy the requirements of the IOS scale. Further, we are the first to validate a continuous version of the IOS scale in an experiment unlike either Le et al. (2007) or Kamphorst et al. (2017).

Our IOS scales are easy-to-use and can be implemented in any web-based experimental software, such as Qualtrics, oTree (Chen et al., 2016), or LIONESS (Giamattei et al., 2020). They are available at `https://github.com/geoffreycastillo/ios-js` with full documentation. We also offer detailed instructions for Qualtrics and an example app for oTree.

In the next section, we describe how we construct our IOS scales to meet the Aron et al. (1992) requirements. In Section 3 we present the experiment we designed to validate our Continuous and Step-Choice IOS scales. Section 4 presents the results and Section 5 concludes.

**Table 1:** Total area and change in overlap of IOS scales.

| Pair | Aron et al. (1992) | | Ours | |
|---|---|---|---|---|
| | Total area | Change % overlap | Total area | Change % overlap |
| 1 | 157.08 | | 157.08 | |
| 2 | 152.75 | 7.32 | 157.03 | 14.32 |
| 3 | 151.65 | 3.53 | 157.12 | 14.24 |
| 4 | 153.31 | 11.00 | 157.02 | 14.30 |
| 5 | 150.00 | 13.75 | 157.22 | 14.25 |
| 6 | 148.76 | 9.55 | 157.03 | 14.30 |
| 7 | 149.93 | 19.69 | 157.08 | 14.37 |

*Notes.* Starting diameter normalised to 10.
'Change % overlap' does not sum to 100% because the last pair of circles does not represent full overlap (see Appendix A).

# 2 Constructing the IOS Scale

When creating the figures for the IOS scale Aron et al. (1992) required that "(a) the total area of each figure is constant (thus as the overlap of the circles increases, so does the diameter), and (b) the degree of overlap progresses linearly, creating a seven-step, interval-level scale". Requirement (a) ensures that no pair of circles takes more space. If the circles in every pair had the same diameter, the total area of more separated circles would be greater and, therefore, more focal than the area of more overlapping circles. In contrast, increasing the diameters of the circles as the overlap increases ensures all aspects of self and other are preserved, aligning with Aron and Aron's (1986) conception of relationships. Requirement (b) ensures there are no jumps between any two pairs of circles, a necessary condition to generate a valid, linear, one-to-seven measure. Otherwise, some increases in overlap would be larger than others which might give rise to threshold effects.

We show on Table 1, however, that the original figures in Aron et al. (1992) do not satisfy these requirements. That is the case for most, if not all, of the literature that has followed which used either directly the Aron et al. (1992) figures or worse a series of overlapping circles with non-increasing diameters. Finding a series of overlapping circles that satisfies both requirements is a problem without a closed-form solution.

To solve it, we rely on simulations (see Appendix A for details) that allow us

to find, for every proportion of overlap, a corresponding circle diameter. These calculations allow us to create an IOS scale which meets the Aron et al. (1992) requirements. To our knowledge this is the first time these requirements have been met in any IOS scale. We use these calculations to construct our refinement of the standard IOS scale as well as our new Step-Choice and Continuous IOS scales, which we test in the following experiment.

# 3 Experimental Design

In our experiment, we test whether respondents choose the same overlap regardless of the version of our IOS scales they use. More specifically, within-subjects respondents indicate how close they feel toward another using our standard IOS scale and either our Continuous or our Step-Choice IOS scales. The order of the IOS scales is randomised between-subjects. We add a filler task between the IOS scales: we ask subjects to solve 10 mathematics problems involving the addition and subtraction of three-digit numbers under time pressure.

In contrast to most of the literature, we use real people as the target of the IOS scales as opposed to hypothetical 'others'. To do so, we first surveyed members of the US general public on MTurk forming a diverse pool of potential targets. We asked them a number of questions, mostly standard demographic questions as well as some questions about their opinions on various social issues (see Appendix B for a list of questions used). Thereafter, we invited the subjects for the experiment reported here and asked them the same questions. We paired them with a target drawn at random from the pool of the originally surveyed participants.

We present the target—the 'other' participant in the IOS scale—using the card display shown in Figure 2. The card suit (♣♦♠♥) is assigned randomly to the target and used to refer to them throughout the experiment. To make sure subjects engage with their assigned target, we ask them to write the first things that come to their mind when they read the card in at least 25 characters.

The advantage of this procedure is that we can assess whether the IOS score decreases with the demographic dissimilarity between subjects and their target. We can also assess how subjects' characteristics influence the IOS scores they report.

The experiment took place in November 2020. A session lasted about 13 minutes

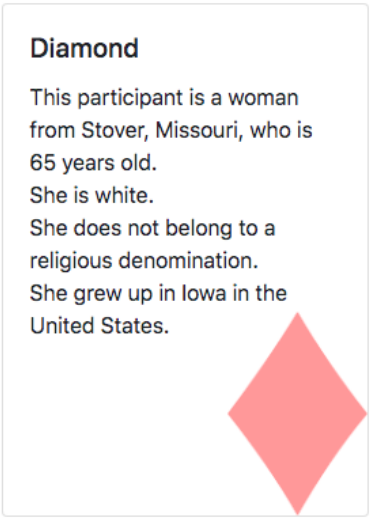



**Figure 2:** Card display used in the experiment.

and the average payment was $1.43. The payment was composed of a fixed $0.50 participation fee and $0.10 for each mathematics problem correctly solved. We analyse below the choices of 644 participants: 328 who evaluate their target using the standard and the Continuous IOS scales and 316 who use the standard and the Step-Choice IOS scales.[1] Instructions for the tasks used in the experiment can be found in Appendix C.

# 4 Results

We consider our new IOS scales—Step-Choice IOS scale, Continuous IOS scale—to be validated against our implementation of the standard IOS scale if there is no difference between the scores reported by subjects when they use the new IOS scale or the standard IOS scale. The scores generated by the standard IOS scale and the Step-Choice IOS scale are discrete variables ranging from one (representing no

[1] In total 998 people participated in our experiment. We removed 96 obvious bots who for example copied-and-pasted the instruction text or random text found online. We also removed 257 participants who gave at least two suspicious answers; for example, stating a ZIP code too far from the location inferred from the IP address or reporting being less than 12 years old or greater than 75 years old when they had their first child. All of these exclusion criteria were pre-registered. We also exclude a subject who managed to report a proportion of overlap greater than 1 in the Continuous IOS scale. Our results are similar when we include all 998 participants regardless of whether they satisfy our exclusion criteria.

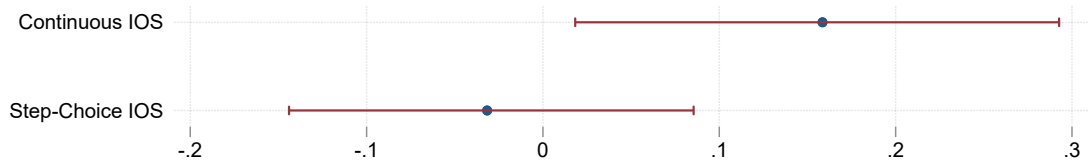



**Figure 3:** Average difference between the IOS scores reported with the Continuous or the Step-Choice IOS scale and the standard IOS scale (with bootstrapped 95% confidence intervals).

overlap) to seven (representing maximal overlap). In contrast, the score generated by the Continuous IOS scale is a continuous variable ranging between zero and one. To compare the Continuous to the standard IOS scale, we first convert the overlap given by the former into a one-to-seven measure.[2] We then subtract the score obtained with the new IOS scale from the score obtained with the standard IOS scale. A positive difference means that subjects reported a higher IOS score when using the standard IOS scale.

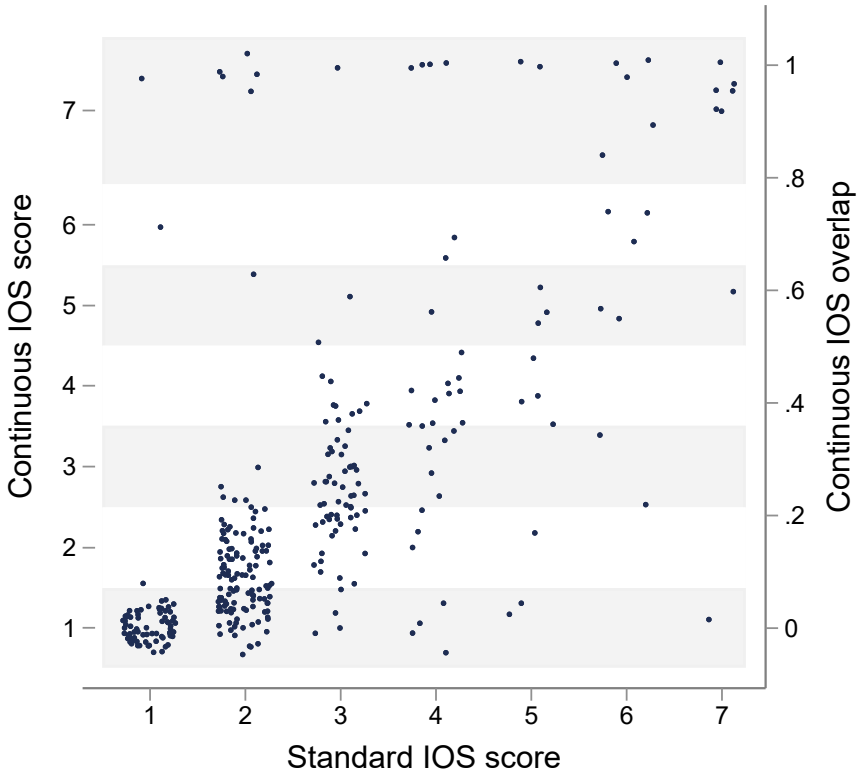
In Figure 3, we plot the average of this difference. We start by comparing the Continuous IOS scale to the standard IOS scale in the top part of the Figure. We see that the standard IOS scale leads to higher IOS scores than the Continuous IOS scale: the difference is small but positive and significant (Wilcoxon matched-pairs signed-ranks test, $z = 4.943$ and $p < 0.001$).[3] Therefore, we reject the null hypothesis that subjects report the same IOS score on both scales. Hence our first result:

**Result 1.** The standard IOS scale elicits higher scores than the Continuous IOS scale.

The bottom part of Figure 3 compares the standard IOS scale to the Step-Choice IOS scale. As can be seen, there is no difference between these two scales: the difference is not statistically different from 0 (Wilcoxon matched-pairs signed-ranks

[2]We convert the proportion of overlap $x$ as follows: 1: $0 \leq x < 0.0711687543$; 2: $0.0711687543 \leq x < 0.2144646286$; 3: $0.2144646286 \leq x < 0.3594493146$; 4: $0.3594493146 \leq x < 0.5017821132$; 5: $0.5017821132 \leq x < 0.6441712323$; 6: $0.6441712323 \leq x < 0.7889021411$; 7: $0.7889021411 \leq x \leq 1$. To generate these thresholds, we took the proportions of overlaps that correspond to each pair of circles in the standard IOS scale, then divided equally the space around them. Those thresholds were pre-registered.

[3]We confirm this with Somers' $D = 0.278$, with a 95% confidence interval $[0.089, 0.466]$.




The left *y* axis shows the continuous IOS measure in seven categories while the right *y* axis shows the continuous IOS measure between 0 and 1. Shown with jitter of 6 to differentiate between data points.

**Figure 4:** Relation between the IOS scores reported with the standard IOS scale and those reported with the Continuous IOS scale.

test, $z = -0.810$ and $p = 0.4135$).[4] Therefore, we cannot reject the null hypothesis that subjects report the same IOS score on both scales. Hence our second result:

**Result 2.** We do not detect a difference between the scores elicited from the standard IOS scale and the Step-Choice IOS scale.

To understand why the standard IOS scale results in higher IOS scores than the Continuous IOS scale, Figure 4 displays the IOS score reported with the Continuous IOS scale as a function of the IOS score reported with the standard IOS scale. Each dot represents a subject. We see that most of the difference between standard and Continuous IOS scales occurs because of subjects who reported a standard

[4]We also confirm this with Somers' $D = 0.063$, with a 95% confidence interval $[-0.124, 0.251]$.

IOS score equal to 2, but a Continuous IOS overlap that is converted to an IOS score of 1. When we remove these 54 subjects, the difference between standard and Continuous IOS scale is no longer significant (Wilcoxon matched-pairs signed-ranks test, $z = 1.018$ and $p = 0.3095$).

The difference thus comes mostly from subjects who report some overlap (IOS score of 2) with the standard IOS scale, but a minimal level of overlap (converted to an IOS score of 1) with the Continuous IOS scale. Our interpretation is that these subjects, when facing the standard IOS scale, are reluctant to report no overlap.[5] In the standard IOS scale, subjects who want to report some connection with their match, at least more connection than no overlap would imply, are forced to pick the second pair of circles. On the other hand, the Continuous IOS scale allows them to report at least some overlap; while at the same time, this overlap falls short of an overlap corresponding to an IOS score of 2. As a consequence, we predict that the difference between the standard IOS scale and the Continuous IOS scale would decrease as the number of pairs of circles in the standard IOS scale increases.

To conclude our analysis, Table 2 shows how demographic dissimilarity between a subject and their target and how a subject's own demographic characteristics influence the IOS score they report. For us, demographic dissimilarity measures the proportion of discordant responses given to the questions displayed on the card shown in Figure 2. A dissimilarity of 0 refers to a subject who answers exactly as their target to those questions, and a dissimilarity of 1, to a subject who answers as differently as possible. We focus on the standard IOS scale since we have the most data for this scale. Note that this analysis was not pre-registered and is thus exploratory.

We find that, as the differences increases, interpersonal closeness as indicated by the IOS score decreases. Therefore, the IOS scale captures something tangible and measurable. We also find that those in a precarious position—doing part-time work, having only completed $12^{\text{th}}$ grade without a degree or less, supporting a political party different from the main parties—report lower IOS scores. This finding suggests that one needs a minimal level of stability to start feeling connected to others. As expected, people who think others are trustworthy and people who

[5] This result might explain why we observe fewer subjects picking an IOS score of 1 than an IOS score of 2 when people evaluate more distant targets (see for example Gächter et al., 2015, S2 Figure, and Castillo, 2021, own calculations).

**Table 2:** How dissimilarity and respondents' characteristics explain the reported IOS score, ordered logistic regression.

| *Dependent variable: IOS score* | Coef. | SE |
|---|---|---|
| Dissimilarity | $-2.264^{***}$ | (0.595) |
| Age | 0.000 | (0.008) |
| Gender (ref.: female) | | |
| Male | $0.319^{*}$ | (0.165) |
| Race (ref.: white) | | |
| Asian indian | 0.388 | (0.536) |
| Black | 0.510 | (0.361) |
| Chinese | $-0.981^{**}$ | (0.381) |
| Korean | $-1.466^{*}$ | (0.769) |
| Other | 0.355 | (0.362) |
| Ethnicity (ref.: none) | | |
| Mexican | 0.149 | (0.429) |
| Other | −0.408 | (0.572) |
| Religion (ref.: none) | | |
| Jewish | 0.356 | (0.578) |
| Other | −0.409 | (0.382) |
| Protestant | $-0.487^{*}$ | (0.263) |
| Roman Cahtholic | $0.493^{**}$ | (0.230) |
| Political party (ref.: democrat) | | |
| Independent | 0.025 | (0.194) |
| No preference | −0.356 | (0.448) |
| Other party | $-1.001^{*}$ | (0.522) |
| Republican | 0.367 | (0.252) |
| Marital status (ref.: married) | | |
| Divorced | −0.528 | (0.323) |
| Never | −0.244 | (0.205) |
| Separated or widowed | $0.879^{*}$ | (0.451) |
| Social class (ref.: middle class) | | |
| Lower class | −0.095 | (0.295) |
| Upper class | 0.237 | (0.473) |
| Working class | 0.029 | (0.186) |
| Work last week (ref.: full time work) | | |
| Housework | −0.250 | (0.208) |

| | | |
|---|---|---|
| Part time work | −0.547** | (0.258) |
| School | −0.038 | (0.458) |
| Place growing up (ref.: small town) | | |
| Farm | 0.099 | (0.422) |
| Large city | 0.099 | (0.261) |
| Medium city | 0.096 | (0.215) |
| Open country | −0.313 | (0.349) |
| Suburb | −0.027 | (0.228) |
| Highest degree (ref.: college or some college) | | |
| 12th grade no degree and less | −1.024* | (0.556) |
| Beyond bachelors | 0.183 | (0.212) |
| High school graduate | −0.060 | (0.266) |
| Number of children | 0.066 | (0.046) |
| Household income | −0.610 | (0.449) |
| People are helpful | 0.154 | (0.228) |
| People try to take advantage of you | 0.277 | (0.245) |
| People are trustworthy | 0.716*** | (0.224) |
| Belong to labour union | 0.797** | (0.311) |
| Unemployed in the past 10 years | −0.084 | (0.173) |
| Support affirmative action | 0.465 | (0.296) |
| Approve sex before marriage | −1.000*** | (0.358) |
| Approve same-sex relations | 0.046 | (0.348) |
| Approve death penalty | 0.225 | (0.174) |
| cut1 | −2.384*** | (0.711) |
| cut2 | −0.331 | (0.706) |
| cut3 | 0.705 | (0.708) |
| cut4 | 1.565** | (0.707) |
| cut5 | 2.241*** | (0.712) |
| cut6 | 3.213*** | (0.731) |
| Observations | 644 | |
| Pseudo $R^2$ | 0.088 | |
| Wald $\chi^2$ | 162.343 | |
| Prob $> \chi^2$ | 0.000 | |

*Notes.* Robust standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

belong to a labour union report higher IOS scores.

Some associations are more difficult to interpret: for example, people who approve of sex before marriage report lower IOS scores. Others should be interpreted with care: for example, people who report their race as Chinese or Korean report lower IOS scores. However, there are not many people in our sample who reported their race as Chinese or Korean and, consequently, they are less likely to be matched with someone who reported the same race.

# 5 Conclusion

In summary, we offer a new implementation of the standard IOS scale that satisfies the requirements set out by Aron et al. (1992). We also offer a new version of the IOS scale—the Continuous IOS scale—that allows for the selection of any degree of overlap. As an intermediary, we propose the Step-Choice IOS scale. We validate our new IOS scales in an experiment, where we find that the standard IOS scale results in higher IOS scores than the Continuous IOS scale. We explain this difference as a no-overlap avoidance bias where subjects avoid selecting the IOS score corresponding to no overlap in the standard IOS scale. We also find that IOS scores decrease with demographic dissimilarity between subject and target.

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# Appendices

## Appendix A Formulas to generate the IOS scale

Following Aron et al. (1992), the IOS has two requirements:

1. the total area of each pair of overlapping circles should stay constant; and
2. the degree of overlap should increase linearly between each pair.

Let $r$ be the radius of the circles and $d$ the distance between them measured centre-to-centre. Before any overlap occurs, the total area is the area of the two circles:

$$A_C(r) = 2\pi r^2.$$

As the circles start to overlap, however, using this formula would result in counting the overlap area twice. We thus need to compute the overlapping area[6]

$$A_O(r,d) = 2r^2\cos^{-1}\left(\frac{d}{2r}\right) - \frac{1}{2}d\sqrt{4r^2 - d^2}$$

and remove it once from the total area, giving us the area

$$A_T(r,d) = A_C(r) - A_O(r,d) = 2\pi r^2 - 2r^2\cos^{-1}\left(\frac{d}{2r}\right) + \frac{1}{2}d\sqrt{4r^2 - d^2}.$$

Denote by $r_0$ the starting radius, when there is no overlap. Using these formulas, we can translate the first requirement as: for all $r$ and $d$, it must be that

$$A_T(r,d) = A_C(r_0);$$

and the second requirement as: the ratio

$$\frac{A_O(r,d)}{A_T(r,d)}$$

should increase linearly as the distance $d$ decreases.

To find a solution to the problem, we applied the following algorithm:

- Fix the initial radius $r_0$, $d = 2r_0$, and compute the initial area $A_C(r_0)$
- Generate all $(r,d)$ such that $r_0 < r < 2r_0$ and $0 < d < 2r_0$
- For each $(r,d)$, compute $A_O(r,d)$, $A_T(r,d)$ and $\frac{A_O(r,d)}{A_T(r,d)}$
- Remove any $(r,d)$ such that $A_T(r,d)$ is not within 0.1% of $A_C(r_0)$

[6] `https://mathworld.wolfram.com/Circle-CircleIntersection.html`, accessed 17/02/2022.

**Table A1:** Estimates from the polynomial fitted to the simulated values.

| | |
|---|---|
| $\beta_0$ | $1.41450\times10^{3}$*** |
| | $(1.39585\times10^{-1})$ |
| $\beta_1$ | $-6.42812\times10^{-1}$*** |
| | $(2.14726\times10^{-3})$ |
| $\beta_2$ | $1.78871\times10^{-4}$*** |
| | $(9.48586\times10^{-6})$ |
| $\beta_3$ | $-2.05904\times10^{-8}$ |
| | $(1.52208\times10^{-8})$ |
| $\beta_4$ | $6.93823\times10^{-11}$*** |
| | $(7.96705\times10^{-12})$ |
| $R^2$ | $9.99991\times10^{-1}$ |
| Observations | 101 |

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

- If we want $n$ pairs of overlapping circles, for each target proportion of overlap $\tau \in \{0, \frac{1}{n}, \frac{2}{n}, \ldots, 1\}$, pick the $(r, d)$ that result in the closest $\frac{A_O(r,d)}{A_T(r,d)}$ to $\tau$.

Therefore, we find suitable $(r, d)$ for any number of circles $n$. Note that, in the IOS scale, the last pair of circles does not represent full overlap. Therefore, to find an IOS scale with $n$ pairs of circles, we do it as if we were generating $n + 1$ pairs of circles and then ignore the last one. For this reason, the overlaps we target are $\{0, \frac{1}{n}, \frac{2}{n}, \ldots, 1\}$ and not $\{0, \frac{1}{n-1}, \frac{2}{n-1}, \ldots, 1\}$. Table 1 in the main text compares our values to Aron et al. (1992) for $r_0 = 5$ and $n = 7$.

To create the Continuous IOS, we repeat the above steps with $n = 100$, then fit a polynomial

$$2\hat{r} = \sum_{i=0}^{m} \beta_i d^i + \epsilon$$

on the generated data. We stop at $m = 4$ since greater $m$ do not improve fit. Table A1 shows the estimates. In our JavaScript widget, we use all the decimals we get from the estimation.

The code of the simulation is available at `https://github.com/geoffreycastillo/continuous-ios-r-simulation`.

# Appendix B Survey questions

We ask the following questions in the survey. We include each question as written followed immediately by the answer type in italics and where appropriate the options from which subjects selected.

1. What is your sex? *Multiple choice*
    - Male
    - Female
2. What is your date of birth? *Calendar date entry*
    - Date
3. What is your marital status? *Multiple choice*
    - Now married
    - Widowed
    - Divorced
    - Separated
    - Never married
4. Have you had any children? *Multiple choice*
    - Yes (*Selecting this answer led to parts a and b below*)
    - No

    a) How many children have you had? Please count all that were born alive at any time (including any you had from a previous relationship). *Numerical entry*
        - Number

    b) How old were you when your first child was born? *Numerical entry*
        - Number
5. What language do you normally speak at home? *Multiple choice*
    - English
    - Spanish
    - Chinese (including Mandarin and Cantonese)
    - Tagalog (including Filipino)
    - Vietnamese
    - Arabic
    - French
    - Korean
    - Russian
    - German
    - Other
        - *Please enter the language:*
6. What is the ZIP code in which you reside? Please only enter the first 5 numbers. *Numerical entry restricted to existing zip codes*
    - Number
7. Are you of Hispanic, Latino, or Spanish origin? *Multiple choice*

- Yes (*Selecting this answer led to part a below*)
- No

a) If yes, which one? *Multiple choice*
   - Mexican, Mexican American, Chicano
   - Puerto Rican
   - Cuban
   - Another Hispanic, Latino, or Spanish origin
     - *Please enter your origin (for example, Argentinean, Colombian, Dominican, Nicaraguan, Salvadoran, Spaniard, and so on):*

8. What race do you consider yourself? *Multiple choice*
   - White
   - Black or African American
   - American Indian or Alaska Native
   - Asian Indian
   - Chinese
   - Filipino
   - Other Asian (including Cambodian, Laotian etc.)
     - *Please enter your race (for example, Hmong, Laotian, Thai, Pakistani, Cambodian, and so on):*
   - Japanese
   - Korean
   - Vietnamese
   - Native Hawaiian
   - Guamanian or Chamorro
   - Samoan
   - Other Pacific Islander:
     - *Please enter your race (for example, Fijian, Tongan, and so on):*
   - Other (including Two or more races such as Biracial, Multiracial, etc.)
     - *Please enter your race:*
9. Do you belong to a religious denomination? *Multiple choice*
   - Yes (*Selecting this answer led to part a below*)
   - No

a) Which religious denomination do you belong to? *Multiple choice*
   - Roman Catholic
   - Protestant
   - Mormon
   - Orthodox (Russian/Greek/etc.)
   - Jew
   - Muslim
   - Hindu
   - Buddhist

- Other denomination
  - *Please enter your religious denomination:*

10. Where did you grow up? *Multiple choice*
    - In the the United States (*Selecting this answer led to part a below*)
    - In another country (*Selecting this answer led to part b below*)

    a) Please select the State or Territory in which you grew up: *Dropdown list of states and territories*
       - State or Territory

    b) Please select the country in which you grew up: *Dropdown list of countries*
       - Country

11. Are you a citizen of the United States? *Multiple choice*
    - Yes (*Selecting this answer led to part a below*)
    - No

    a) Were you: *Multiple choice*
       - Born in the United States
       - Born in American Samoa, Guam, the Northern Mariana Islands, Puerto Rico, or the Virgin Islands
       - Born abroad of United States citizen parent or parents
       - United States citizen by naturalization

12. Which best describes the building where you live? *Multiple choice*
    - A mobile home
    - A one-family house detached from any other house
    - A one-family house attached to one or more houses
    - A building with less than 5 apartments
    - A building with 5 or more apartments
    - A dormitory or hall of residence
    - Boat, RV, van etc.
    - Other
      - *Please enter the type of building you live in:*

13. Do you happen to have in your home any guns or revolvers? *Multiple choice*
    - Yes
    - No

14. Which of the categories comes closest to the type of place you were living in when you were 16 years old? *Multiple choice*
    - In open country but not on a farm
    - On a farm
    - In a small city or town (under 50,000)
    - In a medium-size city (50,000–250,000)
    - In a suburb near a large city
    - In a large city (over 250,000)

15. What is the highest degree or level of school you have COMPLETED?

If currently enrolled, mark the previous grade or highest degree received. *Multiple choice*

- No schooling completed
- Nursery or preschool through grade 12
  - Nursery school
  - Kindergarten
  - Grade 1 through 11
    - *Specify the highest grade completed:*
- 12th grade – no diploma
- High school graduate
  - Regular high school diploma
  - GED or alternative credential
- College or some college (*Selecting this answer led to part a below*)
  - Some college credit, but less than 1 year of college credit
  - 1 or more years of college credit, no degree
  - Associate's degree (for example: AA, AS)
  - Bachelor's degree (for example: BA, BS)
- Postgraduate education (*Selecting this answer led to part b below*)
  - Master's degree (for example: MA, MS, MEng,MEd, MSW, MBA)
  - Professional degree beyond a bachelor's degree (for example: MD, DDS, DVM, LLB, JD)
  - Doctorate Degree (for example: PhD, EdD)

a) What has been your main area of study? (For example a major like chemical engineering, elementary education, nursing, or organizational psychology): *Free text response*
   - Main area of study

b) What has been your main area of study? (For example a major like chemical engineering, elementary education, nursing, or organizational psychology): *Free text response*
   - Main area of study

16. What were you doing for the majority of last week? *Multiple choice*
    - Working full time (*Selecting this answer led to parts a, b, and c below*)
    - Working part time (*Selecting this answer led to parts a, b, and c below*)
    - Studying
    - Keeping house

    a) What do you do for work? Please write your profession: *Free text response*
       - Profession

    b) What category best describes your employer? *Multiple choice*
       - Government or public institution
       - Private business or industry
       - Private non-profit organization

- I am self employed

c) Are the tasks you do at work mostly manual or mostly intellectual? Please select the number where 1 means "mostly manual tasks" and 10 means "mostly intellectual tasks": *Multiple choice*
   - Ranging from 1 to 10

17. At any time during the last ten years, have you been unemployed and looking for work for as long as a month? *Multiple choice*
    - Yes
    - No
18. Do you belong to a labor union? *Multiple choice*
    - Yes
    - No
19. To the best of your knowledge, in which of these groups did your total household income from all sources (before taxes) fall last year? (If you are a student who is supported financially by your family, please include their income in your calculation of household income.): *Multiple choice*
    - Under $1,000
    - $1,000 to $2,999
    - $3,000 to $3,999
    - $4,000 to $4,999
    - $5,000 to $5,999
    - $6,000 to $6,999
    - $7,000 to $7,999
    - $8,000 to $9,999
    - $10,000 to $12,499
    - $12,500 to $14,999
    - $15,000 to $17,499
    - $17,500 to $19,999
    - $20,000 to $22,499
    - $22,500 to $24,999
    - $25,000 to $29,999
    - $30,000 to $34,999
    - $35,000 to $39,999
    - $40,000 to $49,999
    - $50,000 to $59,999
    - $60,000 to $74,999
    - $75,000 to $89,999
    - $90,000 to $109,999
    - $110,000 to $129,999
    - $130,000 to $149,999
    - $150,000 or over

20. Imagine an income scale from 1 to 10 where 1 indicates the lowest income group in America and 10 indicates the highest income group. Counting all wages, salaries, pensions and other incomes that come in, please specify what income group your household is in: *Multiple choice*
    - Ranging from 1 to 10
21. Thinking about the time when you were 16 years old, compared with families in general then, where would you say your family income was? *Multiple choice*
    - Far below average
    - Below average
    - Average
    - Above average
    - Far above average
22. Compared to your parents when they were the age you are now, do you think your own standard of living now is: *Multiple choice*
    - Much better
    - Somewhat better
    - About the same
    - Somewhat worse
    - Much worse
23. If you were asked to use one of four names for your social class, which would you say you belong in? *Multiple choice*
    - the Lower Class
    - the Working Class
    - the Middle Class
    - the Upper Class
24. How satisfied are you with the present financial situation of you and your family? *Multiple choice*
    - Pretty well satisfied with my present financial situation
    - More or less satisfied with my present financial situation
    - Not satisfied at all with my present financial situation
25. How important is it for you to live in a country that is governed democratically? Please indicate the importance on a scale where 1 means it is "not at all important" and 10 means "absolutely important". *Multiple choice*
    - Ranging from 1 to 10
26. How proud are you to live in the United States? *Multiple choice*
    - Very proud
    - Quite proud
    - Not very proud
    - Not at all proud
27. Generally speaking, do you usually think of yourself as a Democrat, a Republican, an Independent, or what? *Multiple choice*

- Democrat
- Republican
- Independent
- Other party
  - *What other political party do you identify with:*
- No preference

28. We hear a lot of talk these days about liberals and conservatives. Here is a seven-point scale on which the political views that people might hold are arranged from extremely liberal to extremely conservative. Where would you place YOURSELF on this scale? *Multiple choice*
    - Extremely liberal
    - Liberal
    - Slightly liberal
    - Moderate; middle of the road
    - Slightly conservative
    - Conservative
    - Extremely conservative
29. The table below lists some institutions in this country. As far as the people running these institutions are concerned, would you say you currently have a great deal of confidence, only some confidence, or hardly any confidence at all in them?
    a) Executive Branch of the Federal Government *Multiple choice*
        - Hardly any confidence at all
        - Only some confidence
        - A great deal of confidence

    b) Congress *Multiple choice*
        - Hardly any confidence at all
        - Only some confidence
        - A great deal of confidence

    c) The Supreme Court *Multiple choice*
        - Hardly any confidence at all
        - Only some confidence
        - A great deal of confidence

    d) The Military *Multiple choice*
        - Hardly any confidence at all
        - Only some confidence
        - A great deal of confidence

    e) The Police *Multiple choice*
        - Hardly any confidence at all
        - Only some confidence
        - A great deal of confidence

f) Banks and Financial Institutions *Multiple choice*
   - Hardly any confidence at all
   - Only some confidence
   - A great deal of confidence

g) Organized Labor (or Unions) *Multiple choice*
   - Hardly any confidence at all
   - Only some confidence
   - A great deal of confidence

h) Public Education *Multiple choice*
   - Hardly any confidence at all
   - Only some confidence
   - A great deal of confidence

i) The Press *Multiple choice*
   - Hardly any confidence at all
   - Only some confidence
   - A great deal of confidence

30. We are faced with many problems in this country. For those listed in the table below, do you think that we are spending too much, too little, or about the right amount on them?
    a) Improving the conditions of African Americans *Multiple choice*
       - Spending too much
       - Spending the right amount
       - Spending too little

    b) Improving the conditions of those living in Foreign Countries *Multiple choice*
       - Spending too much
       - Spending the right amount
       - Spending too little

    c) Improving and protecting the Environment *Multiple choice*
       - Spending too much
       - Spending the right amount
       - Spending too little

31. On a seven-point scale, where 1 means very important and 7 means not important at all, how important do you think it is for the government in Washington to reduce the differences in income between the rich and the poor? *Multiple choice*
    - Ranging from 1 to 7

32. Do you consider the amount of federal income tax we pay as too high, about right, or too low? *Multiple choice*
    - The federal income tax I pay is too high
    - The federal income tax I pay is about right

- The federal income tax I pay is too low

33. Do you favor or oppose the death penalty for persons convicted of murder? *Multiple choice*
    - I favor the death penalty for persons convicted of murder
    - I oppose the death penalty for persons convicted of murder
34. Are you for preferential hiring and promotion of African Americans or are you against it? Common considerations when evaluating this policy include the past discrimination of African Americans as well as the discriminatory impact of this policy on others. *Multiple choice*
    - Strongly opposed to giving preference to African Americans in hiring and promotion
    - Somewhat opposed to giving preference to African Americans in hiring and promotion
    - Somewhat in favor of giving preference to African Americans in hiring and promotion
    - Strongly in favor of giving preference to African Americans in hiring and promotion
35. In your opinion, if two consensual adults have sexual relations before marriage, do you think it is: *Multiple choice*
    - Always wrong
    - Almost always wrong
    - Wrong only sometimes
    - Not wrong at all
36. Similarly, if two consensual adults of the same sex have sexual relations, do you think it is: *Multiple choice*
    - Always wrong
    - Almost always wrong
    - Wrong only sometimes
    - Not wrong at all
37. Do you think it should be possible for a pregnant woman to obtain a legal abortion if the woman wants one for any reason? *Multiple choice*
    - Yes, it should be possible
    - No, it should not be possible
38. Would you say that most of the time people try to be helpful, or that they are mostly just looking out for themselves? *Multiple choice*
    - Most of the time people try to be helpful
    - People are mostly just looking out for themselves
39. Do you think most people would try to take advantage of you if they got a chance, or would they try to be fair? *Multiple choice*
    - Most people would try to take advantage of you if they got a chance
    - Most people would try to be fair

40. Generally speaking, would you say that most people can be trusted or that you can not be too careful in dealing with people? *Multiple choice*
    - Most people can be trusted
    - You cannot be too careful in dealing with people

# Appendix C Tasks used in the experiment

First, subjects complete a forty question *survey*. Appendix B contains a full list of the questions from the survey.

Second is the *presentation of the target*. As described in Section 3 of the main text, the survey that subjects in this experiment completed was the same survey that a pool of previously surveyed participants completed. We randomly pair each subject in this experiment with a target from the previous subject pool. We introduce the target to the subject by revealing the target's answers to several of the survey questions. Figure C1 shows how we present the target's answers to the selected survey questions on a card.

Third, subjects complete a *target familiarization task* where they write the first things that come to mind about the target in at least 50 characters. This functions, to some extent, as an attention check for the subjects in order to ensure subjects read closely the information on the card. Our evaluation of their responses is one means by which we identify bots. The instructions for this target familiarisation task are shown in Figure C2.

Fourth, subjects complete our version of the *standard IOS scale task*. The instructions for the standard IOS scale task are shown in Figure C3. The standard IOS scale task itself is shown in Figure C4.

Fifth, subjects complete a *filler task* where they add or subtract two three-digit numbers. This is the only experimental task that is financially incentivised; subjects receive \$0.10 for each correctly solved problem. We implement this filler task so that subjects do not complete the two IOS tasks back to back. The instructions for the filler task are shown in Figure C5. The filler task itself is shown in Figure C6.

Sixth, subjects complete either the *Step-Choice IOS task* or the *Continuous IOS task*. In order to advance from the instruction screen to the task itself, we require subjects to manipulate each scale such that the circles overlap as much as possible. This functions as an attention check for the subjects and forces them to recognise the full extent of possible overlap. The instructions for the Step-Choice IOS scale task are shown in Figure C7. The Step-Choice IOS scale task itself is shown in Figure C8. The instructions for the Continuous IOS scale task are shown in Figure C9. The Continuous IOS scale task itself is shown in Figure C10.

All subjects complete two IOS tasks: the standard IOS scale task and one of either the Continuous IOS scale task or the Step-Choice IOS scale task. The order in which they participate the IOS tasks is randomized between subjects.

Demo versions of our IOS scales can be found at `https://geoffreycastillo.com/ios-js-demo/`.

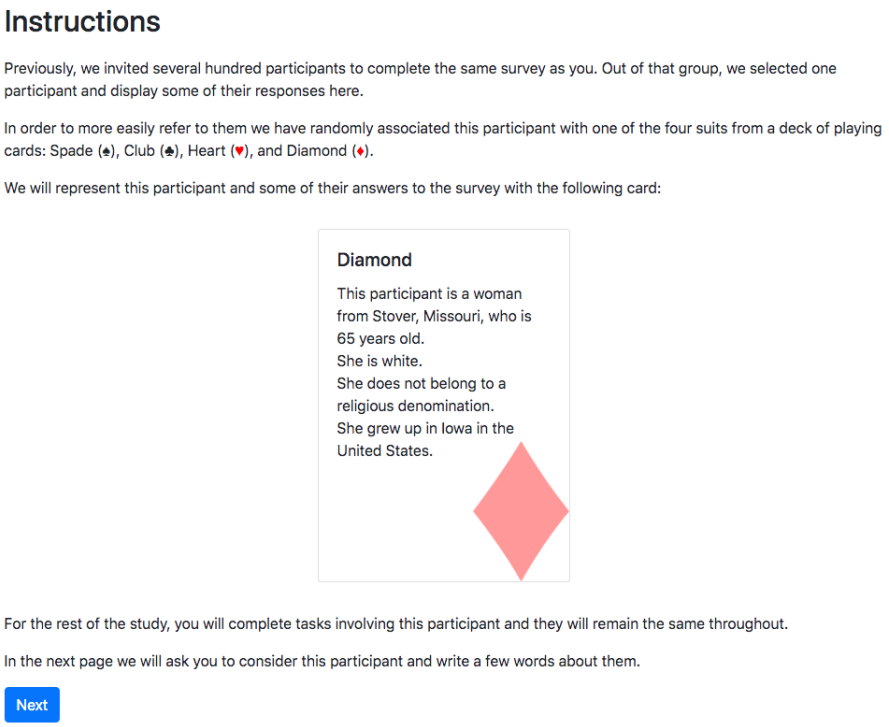



**Figure C1:** Presentation of the Target.

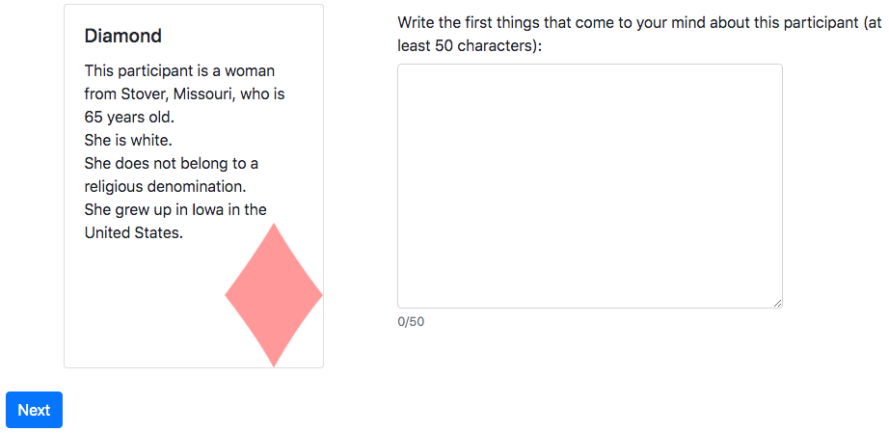
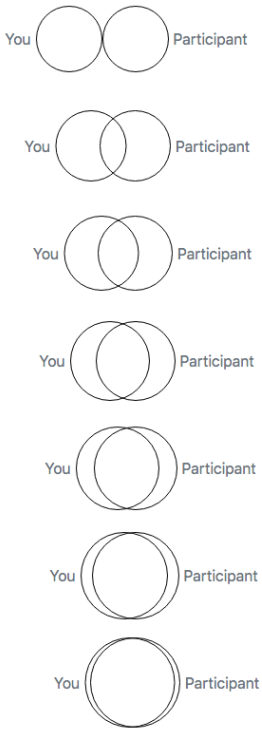



**Figure C2:** Target familiarization task.

## Instructions

We will now ask you to consider how connected you feel towards the participant.

More specifically, we will show you the following circles:




The overlap of the circles represents the connection you feel towards the other participant. For example, a stronger connection between you and the other participant would be represented by a greater overlap of the circles.

We will ask you to select a pair of circles that best represents the connection you feel toward the participant whose survey responses you just read.

You can practice on this page as much as you want.

Click the 'Next' button when you're ready.

Next

**Figure C3:** Standard IOS scale task instructions.

Select the pair of circles which indicate to what extent you and Diamond are connected.

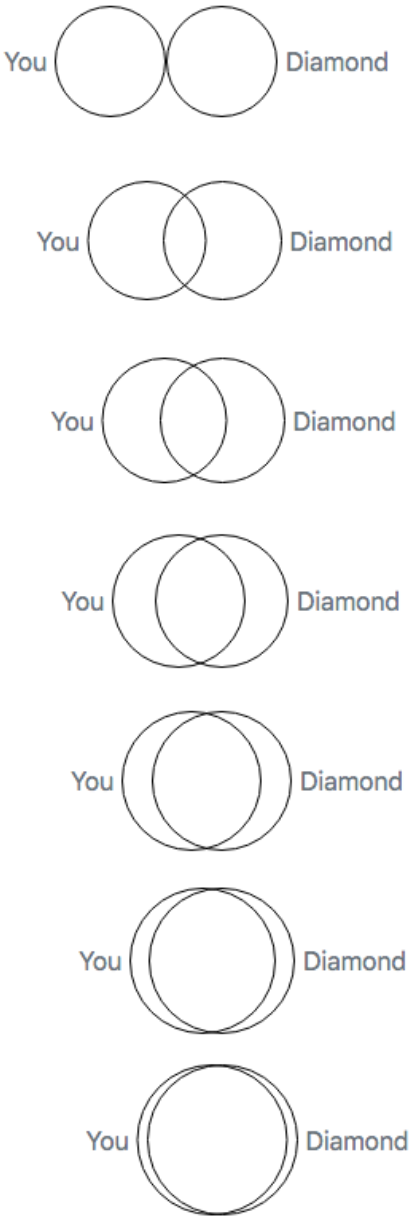



**Figure C4:** Standard IOS scale task.

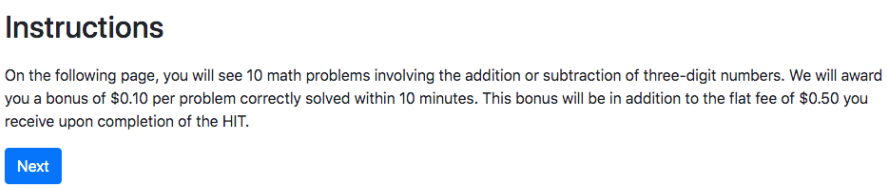



**Figure C5:** Filler task instructions.

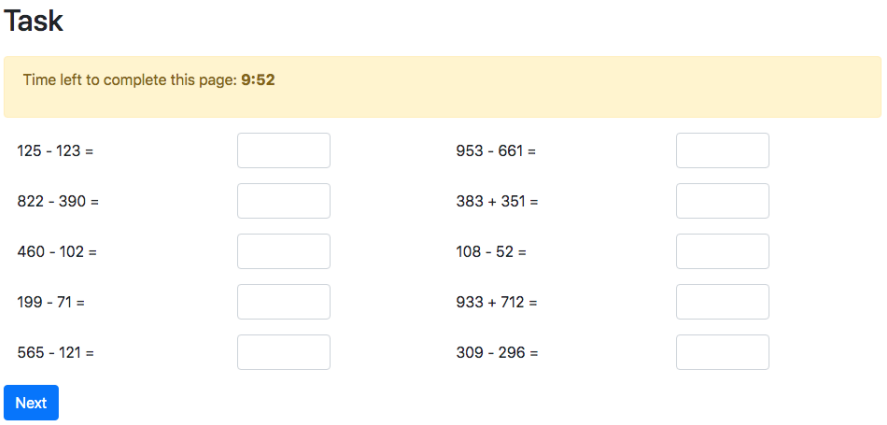



**Figure C6:** Filler task.

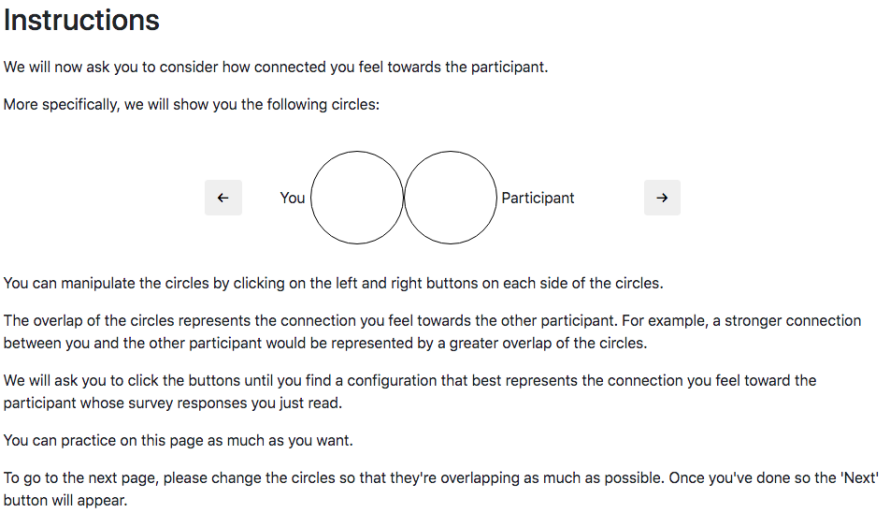



**Figure C7:** Step-Choice IOS task instructions.

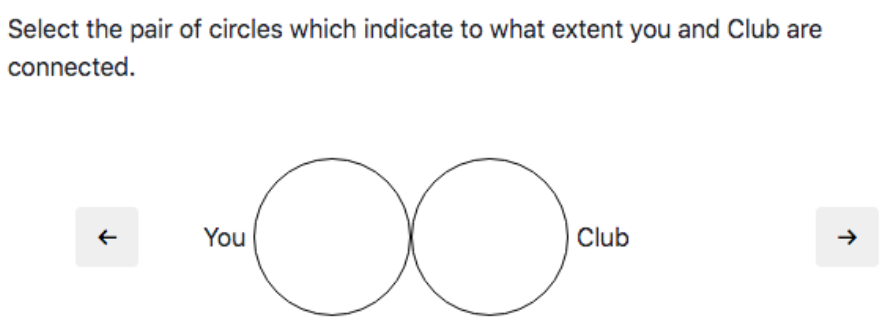



**Figure C8:** Step-Choice IOS task.

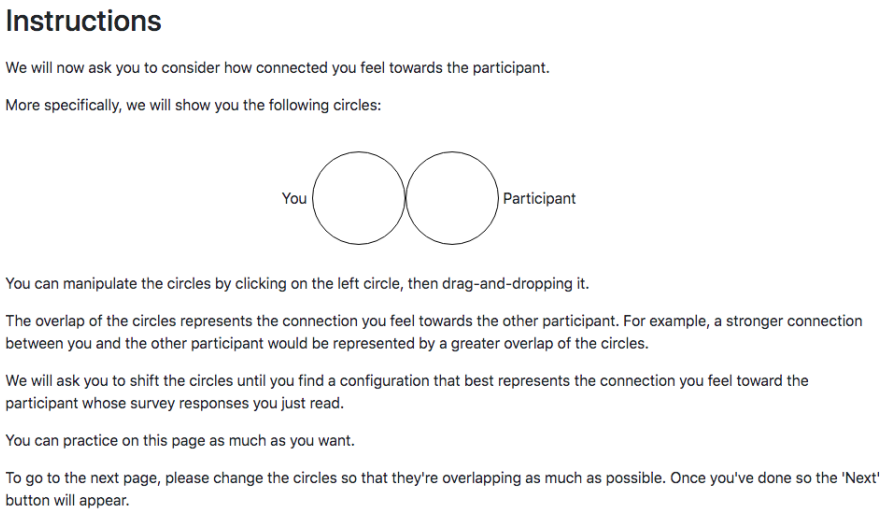



**Figure C9:** Continuous IOS scale task instructions.

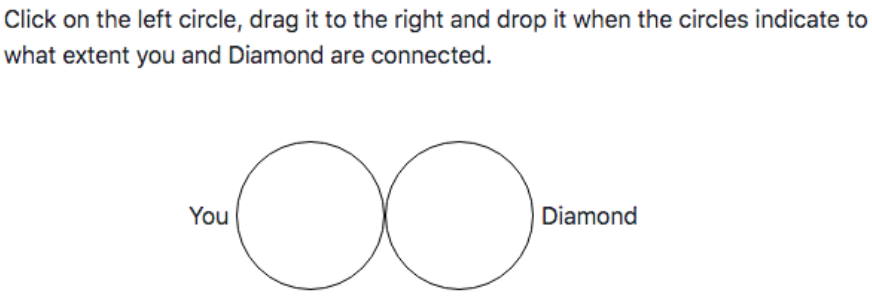



**Figure C10:** Continuous IOS task.