ANALYSIS OF POSITIONAL BIAS WITHIN MULTIPLE STIMULUS WITHOUT REPLACEMENT PREFERENCE ASSESSMENTS

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ABSTRACT

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Positional bias is a pattern of responding to a specific location that can be influenced by response effort and/or prior learning history. Within the contexts of preference assessments, positional bias create additional variables that make ascertaining true preferences within a preference assessment more difficult. Prior research on positional bias within preference assessments have focused primarily on its use in paired stimulus assessments due to the complex nature of the multiple-stimulus without replacement preference assessment. The present study is a secondary analysis that utilized four different methods to measure side bias and center bias for 19 young children with autism spectrum disorders. Results indicate that participants had varying degrees of biased responding but collectively engaged in little biased responding. Present study includes discussion of general patterns of responding, an analysis of the four methodologies, and general recommendations for the application of these methodologies.
Keywords: positional bias, side bias, center bias, MSWO, preference assessment

I know it’s a lot, and it’s the best I can do.
My gift is my thesis, and this one’s for you.

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INTRODUCTION

Individuals with autism spectrum disorder (ASD) have deficits in social and communication skills and may exhibit repetitive or restrictive interests in activities, objects, or routines (American Psychiatric Association, 2013). Additionally, individuals with ASD may be more likely to engage in problem behaviors than typically developing peers (Horner et al., 2002; McCarthy et al., 2010). Behavioral interventions, specifically early intensive behavioral interventions, are an effective treatment for children with ASD (Makrygianni & Reed, 2010; Reichow & Woolery, 2009).

Behavioral interventions that utilize reinforcers have been shown to address skill deficits (e.g., Karsten & Carr, 2009) and problem behaviors (e.g., Fisher et al., 1994; Lalli et al., 1999). Reinforcers, by definition, are stimuli, events, or conditions that increase the future probability of behavior they immediately follow (Catania, 2013). Since reinforcers can influence the likelihood of behaviors, they play a critical role in changing human behavior.

Due to difficulties in social and communication behaviors, individuals with ASD may experience difficulties expressing preferences for preferred stimuli, events, or activities that may function as reinforcers. Over the past 35 years, researchers have developed various procedures that use selection responses to assess a stimulus' relative preference and its implied effectiveness as a putative reinforcer. Types of preference assessment procedures include the single-stimulus (SS) preference assessment (Pace et al., 1985; Green et al., 1988), paired-stimulus (PS) preference assessment (Fisher et al., 1992), multiple stimulus with replacement (MSW) preference assessment (Windsor et al., 1994), and the multiple-stimulus without replacement (MSWO) preference assessment (DeLeon & Iwata, 1996). Although the procedures vary, all four of the beforementioned preference assessments include the presentation of one or more stimuli during a trial and the selection or non-selection of a stimulus during each trial. Based on each stimulus' selection frequency, researchers and practitioners could then infer an individual's preferences, and these assumptions would then be used to identify potential reinforcers. From these four procedures, research has found the MSWO and PS preference assessments to be the most effective and consistent methods to assess stimulus preference and identify reinforcers (Kang et al., 2013).

However, the validity of preference assessment results is subject to an individual's bias or "unaccounted for preference" (Baum, 1974, p. 233). Bias, once understood, can be considered as a quantitative description of behavior, and thus, is not inherently good nor bad. Rather, the impact of bias is related to the context in which the bias occurs. Consider an individual is told to copy a text. Typically, the individual's bias to write with one hand (i.e., left or right hand) would not matter as long as the text was copied; however, if the individual had to write on desks that accommodate only right-handed writing, then an individual's bias for writing with their left hand may make writing difficult.

One important bias to consider within a preference assessment is positional bias where selection is made due to preference for the stimulus' location (e.g., continuously selecting the leftmost stimulus; Bourret et al., 2012; Karsten et al., 2011). When an individual makes multiple selections from one side or location, it creates ambiguity for which specific variable is exerting more control over behavior. Theoretically during preference assessments, each stimulus in the array exerts a level of control over the selection behavior, and, in ideal situations, participants make selections based on their past learning histories with each stimulus and motivating operations.

Positional bias may be seen as a pattern of responding that has developed for two reasons: differences in response effort (Shabani et al., 2009; Zias, 2015) and/or through the individual's learning history with a specific location or relative area. Since positional bias is a byproduct of response effort and/or the individual's learning history, all individuals likely exert some degree of positional bias and, thus, selections generally are influenced to some degree by the interactions between the response efforts, motivating operations, and learning histories for both the individual stimuli and the stimulus position. However, positional bias becomes problematic when the positional bias exerts equal or more control over selection than preference for the stimulus during a preference assessment. Because preference assessments are intended to measure preference for specific stimuli, it would be difficult to ascertain which variable is exerting control over the selection, and thus, it affects the validity of the assessment (Karsten et al., 2011).

As of the writing of this study, we are aware of only two preference assessment studies (Bourret et al., 2012; Zias, 2015) that have analyzed positional bias within a preference assessment. However, both studies were conducted with paired-stimulus preference assessments, and there is only one study (Zias, 2015) that describe any potential method to measure positional bias within an MSWO preference assessment. This disparity is likely due to the difference in complexity between the two preference assessments. Compared to the PS preference assessment, which contains only two possible selections (i.e., left or right), the MSWO preference assessment provides additional variables that complicates the analysis and measurement of positional bias.

First, the MSWO allows for presentation of more than two stimuli at once. A complete round of an eight item MSWO would include six presentations with three or more stimuli. For these six presentations, dividing selections into left or right may not always be appropriate. This division of stimulus into left or right is specifically problematic when there are an odd number of stimuli as there is one stimulus that cannot be categorized as either left or right. Thus, another positional designation (e.g., center) is required at least for presentations with an odd number of stimuli and a center percentage should also be calculated.

Furthermore, MSWO procedures require that after each presentation, the selected stimulus is removed from the array before the next presentation of stimuli (DeLeon & Iwata, 1996). Because only one stimulus is removed after each presentation, the parity (i.e., even or odd) of the number of stimuli alternates (i.e., even, odd, even, etc.). As a result, at least every other MSWO presentation would require a center designation. A question arises on whether a center designation should be included only when there are an odd number of stimuli or whether every MSWO presentation should include a center designation. Currently, there is no research on how the inclusion or non-inclusion of a center designation affects bias calculations and whether which option provides more valid results.

Finally, the removal of a single stimulus after each presentation of stimuli further complicates bias calculations as the probability that a specific stimulus location is selected changes across each stimulus presentation. Specifically, after the removal of a stimulus, the probability that a stimulus location will be selected increases in the next presentation of stimuli. For instance, a participant only has a 12.5% probability to select the leftmost stimulus in an eight stimulus array but a 33.3% probability to select the leftmost stimulus in a three stimulus array. Thus, an analysis of bias should account for the changing probabilities, specifically when calculating center bias.

The purpose of this secondary data analysis is threefold: (1) develop initial measurement methods to quantify and code stimulus location within an MSWO, (2) apply these methods to attempt to analyze the positional bias of young children with ASD, and (3) compare positional bias, as indicated by outcomes obtained across these different measurement methods, between three different stimulus array compositions (i.e., tangible arrays, edible arrays, and combined tangible and edible arrays). This study aims to provide an initial understanding of the beforementioned variables that complicates the analysis of positional bias in an MSWO and aims to introduce an initial framework for a systematic measurement system of positional bias.

METHOD

Study Design

The current study is a secondary data analysis that analyzes recorded videos from Sipila-Thomas et al. (2021). For complete study design details including participant characteristics, participant randomization, and preference assessment conditions, readers should refer to Sipila-Thomas et al. (2021).

Participants

Videos for 21 preschool-aged children with ASD were coded and analyzed. Participants were excluded from this study if no videos were available for the participant. In total, 19 participants (16 males and 3 females) met inclusion criteria for this study. Participants were 2-5 years old and had a confirmed diagnosis of ASD.

In the Sipila-Thomas et al. (2021) study, participants completed MSWO preference assessments where they were repeatedly presented with an array of stimuli and provided the instruction to select one stimulus. To code these preference assessments and determine video and participant inclusion, the preference assessment was categorized into the following subcategories: (1) trial and (2) round. A *trial* is defined as any instance or opportunity where stimuli are presented to the participant, the participant was instructed to make a selection (except for representation of the selection instruction), and the participant either made a selection or did not make a selection. An MSWO *round* is defined as any instance the participant is presented with eight stimuli to select until all stimuli are selected or the session is terminated.

Participants were included in this study if they completed at least one full preference assessment. Specifically, participants had to complete all five MSWO rounds within the same array type (i.e., tangible, edible, or combined) and the participant must make a selection in at least six trials in all five MSWO rounds. This criterion for making a selection in at least six trials of a round was set because it marks Method 1's third potential selection (see below). Specifically, Method 1 only allowed for a maximum of three potential center selections in a round, and as a result, the center bias for this method was highly volatile. Because there are fewer opportunities to select a center option, the exclusion of any opportunity could significantly skew the participant's results away from their true center bias percentage.

Dependent Variables

Selection

While coding the videos, researchers recorded the stimulus selected in each trial of the preference assessment and the location of the stimulus in the array. A selection was defined as touching the stimulus with their hand after being instructed to make a selection. In very rare cases, a stimulus (e.g., a round pretzel) would move closer to the participant before the participant selected that stimulus. These selections were included based on the decision that practitioners, including the prior researchers, would likely count these instances as selections in typical preference assessment.

Stimulus Location Quantification

Four different methodologies were then used to quantify the location (i.e., left, right, or center) of each selected stimulus in each trial. Each method allocated what it designated as a left selection, right selection, and center selection in different ways and are described in more detail below. For all methods, the center designation was omitted when only two stimuli remained and no designations were given for one stimuli array.

To examine the effects of increasing the number of locations designated as center or side (i.e., left or right), designations for center and side were allocated in contrasting ways. Method 1 allowed for the least opportunities for a center selection with 3 possible selections while Method 3 allowed for the least opportunities for a side selection with 14 possible selections (i.e., 7 right selections and 7 left selections). Because Methods 1 and 3 minimize the number of possible center and side selections, respectively, these two methods may be interpreted as the two extremes for stimuli designations. In attempt to evaluate how additional selections may affect bias calculations, Method 2 and Method 4 systematically incorporated an additional opportunity for a center or side selection to be made, respectively. Below, each method is described in detail.

Method 1. Figure 1 illustrates how each stimulus in the array is coded in terms of location in Method 1. For each round, Method 1 allowed for 3 opportunities for a center selection and 32 opportunities for a left or right selection. In Method 1, all arrays with an even number of stimuli (i.e., 8, 6, 4, and 2) designate half of the stimuli as left and half of the stimuli as right, based on their location. In arrays with an odd number of stimuli, excluding an array of 1 (i.e., 7, 5, and 3), the stimulus in the direct center of the array was designated as the center, and the remaining stimuli were divided into left and right based on their locations. Method 1 allowed for only three trials with a center designation during each round.

Method 2. Figure 2 illustrates how each stimulus in the array is coded in terms of location in Method 2, which was first mentioned in Zias (2015). For each round, Method 2 allowed for 9 opportunities for a center selection and 26 opportunities for a left or right selection. Method 2 is similar to Method 1 such that arrays with an odd number of stimuli designated the direct center item as the center and divided the remaining stimuli into left and right designation based on its location. However, for arrays with an even number of stimuli, the two stimuli in the middle of the array were designated as center with the rest designated as left or right based on their location in the array. Unlike Method 1, Method 2 allowed for all six trials with at least 3 stimuli to have a center designation.

Method 3. Figure 3 illustrates how each stimulus in the array is coded in terms of location in Method 3. For each round, Method 3 allowed for 21 opportunities for a center selection and 14 opportunities for a left or right selection. For this method, trials with at least two stimuli designated the leftmost and rightmost stimuli as the left and right, respectively. The remaining stimuli were designated as center. The method was modeled to capture what may be referred to as an extreme side bias where the participant would continually select only the leftmost or rightmost item.

Method 4. Figure 4 illustrates how each stimulus in the array is coded in terms of location in Method 4. For each round, Method 4 allowed for 15 opportunities for a center selection and 20 opportunities for a left or right selection. For this method, the two leftmost and the two rightmost stimuli were designated as left and right, respectively, while the remaining stimuli were designated as center. On the 4^{th} trial, the number of stimuli designated as center equaled the number of stimuli on one side (i.e., 2 center stimuli and 2 right stimuli and 2 left stimuli). In order to ensure that the likelihood of selecting the center was still greater than or equal to the likelihood of making only a left or only a right selection on the 5^{th} trial, only the leftmost and rightmost stimuli would be designated as left and right, respectively, and the inner most side selections were redesignated as center.

Bias Percentages

After the stimulus locations were coded, two bias percentages (i.e., side bias percentage and center bias percentage) were calculated for each method. *Side bias percentage* was calculated by subtracting the side (i.e., left or right) with less selections from the side with more selections and dividing the difference by the number of trials with a possible side selection (Bourret et al., 2012). *Center bias percentage* was calculated by dividing the number of center selection by the number of trials with a possible center selection (Zias, 2015).

Because each method of bias measurement varied in the number of possible center selections available per assessment round, center bias percentages could not be directly compared. Thus, a *relative center bias* percentage was calculated. To calculate the relative center bias percentage, the difference between a participant's center bias percentage and the unbiased center percentage was divided by the unbiased center percentage. The unbiased center percentage is the mean probability of selecting the center in each trial of a round (see Table 1 to see the list of unbiased percentages).

Relative center bias percentages greater than 100% indicated that participant was more likely to make a center selection compared the unbiased percentage (e.g., a participant with a relative center bias percentage of 150% was 1.5 times more likely to make a center selection). Relative bias percentages less than 100% indicated the participant was less likely to make a center selection compared to the unbiased percentage. To calculate the reduced likelihood of making a center selection, relative center bias percentages less than 100% were subtracted from 100% (e.g., a participant with a relative center bias percentage of 90% would be 10% less likely to make a center selection).

It is important to note that although all methods differed in how each coded stimulus locations, all methods used the same equations to calculate the bias percentages.

Interobserver Agreement

The researchers calculated interobserver agreement (IOA) for at least 40% of preference assessments across array types and participants. Rounds were randomly selected through a random number generator. Some rounds were excluded from this study due to technical difficulties (e.g., battery depleting from the camera while recording), severe problem behavior affecting selection, changes in array presentation (e.g., additional stimulus, missing stimulus, and presenting stimuli vertically). If a round was selected for IOA but was excluded from this study, another random number was generated until an applicable round number was selected.

An independent observer reviewed video recordings and completed electronic data sheets marking both the stimulus selected and the location of the stimulus in the array. IOA was calculated using a trial-by-trial method where the number of trial agreements were divided by the total number of trials and was multiplied by 100 to yield a percentage for each MSWO round (Ledford & Gast, 2018). An agreement was defined as any instance when the two observers recorded that the participant selected the same stimulus and marked the same stimulus location on a given trial. A disagreement was defined as any instance when one observer recorded a stimulus or stimulus location that was different than what was recorded by a second observer on a given trial.

Mean IOA was 98.63% and ranged from 87.5% to 100%. Out of the 120 rounds (950 trials) reviewed, 13 rounds had one trial with a disagreement (87.5% IOA agreement) and no rounds had two or more disagreement. All 13 disagreements were related to stimulus locations and due to either obscured stimulus locations or errors reflecting stimulus locations relative to participant's perspective. Specifically, (1) due to the camera angles for some videos, the location of smaller stimuli (e.g., M&M or sticky hand) were obscured and had to be inferred by contextual factors (e.g., rotating stimuli during MSWO) and (2) because videos were primarily captured across from the participant and observers coded data based on the participant's perspective, disagreements were likely due to failure to mentally shift stimulus locations to reflect participant's perspective. For all trials with disagreements, the specific trial was reobserved and the correct stimulus and stimulus location was noted. Errors in primary data collection were resolved and resulting changes led to bias percentage changes of 6% or less.

Inter-Document Agreement

This study used two different data collection documents (i.e., data sheet and data analysis spreadsheet) to analyze and calculate participant bias. In order to ensure accuracy between these two data collection documents and the subsequent data output, inter-document agreement was collected. Inter-document agreement was calculated for at least 40% of rounds across participants and array type using a trial-by-trial basis, where the number of trial agreements was divided by the total number of trials and was multiplied by 100 to yield a percentage for each MSWO round (Ledford & Gast, 2018). Agreements were defined as instances where the two documents noted the same stimulus and marked the same stimulus location within the same trial. Disagreements were defined as any instances in which either the stimulus noted or the stimulus location differed between the two documents.

As mentioned before with IOA, if a round was selected for inter-document agreement and is later excluded from the summary, another random number was generated until an applicable round number was selected.

The mean inter-document agreement was 99.47% and ranged from 87.5% to 100%. Out of the 120 rounds (950 trials) reviewed, 5 rounds had 87.5% inter-document agreement and contained one trial with a transcription error (e.g., wrong stimulus marked or wrong location marked). Specifically, all five transcription errors were stimulus location errors where the stimulus location on the spreadsheet was transcribed one stimulus away its location on the data sheet. All five errors were resolved within the spreadsheet and resulting changes in bias percentages were 6% or less.

Procedures

Data Collection

Researchers compiled all available video recordings from Sipila-Thomas et al. (2021) study. Each video recording showed a participant's complete or partial completion of an MSWO preference assessment (i.e., tangible, edible, or combined).

Data collection was completed electronically (see Figure 5 for data sheet). Researchers observed each video recordings and, for each trial, noted the stimulus selected and its location within the array. Specifically, for each trial, researchers typed in the name of the selected stimulus and then inputted an "X" into the spot where the stimulus was selected. Because some videos were taken from different camera angles, researchers coded stimulus location from the participant's point of view. We chose the participant's perspective to ensure all data is collected in the same manner and to specifically note the participant's potential bias.

Data Analysis

After data were collected, researchers then transcribed the data onto a similarly formatted spreadsheet. For each trial, researchers typed in the name of the selected stimulus and then inputted a "1" to denote the location of the selected stimulus.

The spreadsheet was preprogrammed to code each selection location (i.e., left, right center, or none) and then outputted the number of left, right, and center selections for each of the four beforementioned methods (i.e., Method 1, Method 2, Method 3, and Method 4). The spreadsheet then inputted the frequencies of these selection locations to calculate the side bias percentage, center bias percentage and relative center bias percentage. The spreadsheet was preprogrammed to automatically calculate these percentages for each round, for the full preference assessment, and for the participant across the three full preference assessments.

After bias percentages were calculated, researchers then analyzed the data for participants who met the criterion for completing a full MSWO preference assessment (i.e., completing all five MSWO rounds within the same array type with a selection in at least six trials in all five rounds). Additional side and center bias analyses (i.e., overall) were conducted for all participants who completed three full MSWO preference assessments.

RESULTS

Tangible Array Bias Percentages

Table 2 displays the side bias percentages and relative center bias percentages for the 15 participants who completed a full MSWO preference assessment for the tangible array.

Method 1

When selections were coded using Method 1, all 15 participants engaged in side-biased responding (i.e., bias percentages not equal to 0.00%). A left-side bias (denoted by a negative percentage) was found in 8 participants with a bias range of -5.71% to -45.71%. A right-side bias (denoted by a positive percentage) was found in 7 participants with a bias range from 2.86% to 37.14%. In terms of bias deviations (i.e., deviation from 0.00%), 3 participants had a side bias deviation of 10% or less, 5 participants had a side bias deviation from 10.01% to 20%, and 7 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -4.90% (left-side bias).

In terms of relative center bias, 11 participants were more likely to make center selections than the unbiased center percentage (i.e., chance probability of selecting the center). Specifically, 2 participants were 115.01% to 130% more likely to make a center selection, and 9 participants were over 130% more likely to make a center selection. In contrast, 4 participants were less likely to make a center selection than the unbiased center percentage. Specifically, 3 participants were less than 15% less likely to make a center selection, and 1 participant was 30.01% to 45% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 146.17%.

Method 2

When selections were coded using Method 2, 14 participants engaged in side-biased responding, and 1 participant did not engage in side-biased responding (i.e., bias percentage equal to 0.00%). A left-side bias was found in 8 participants with a bias range of -8.57% to -37.14%. A right-side bias was found in 6 participants with a bias range from 5.71% to 31.43%. For participants who engaged in side-biased responding, 4 participants had a side bias deviation of 10% or less, 3 participants had a side bias deviation from 10.01% to 20%, and 7 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -4.91% (left-side bias).

In terms of relative center bias, 11 participants were more likely to make center selections than the unbiased center percentage. Specifically, 4 participants were 100.01% to 115% more likely to make a center selection, 2 participants were 115.01% to 130% more likely to make a center selection, and 5 participants were over 130% more likely to make a center selection. In contrast, 4 participants were less likely to make a center selection than the unbiased center percentage. Specifically, all 4 participants were less than 15% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 124.38%.

Method 3

When selections were coded using Method 3, all 15 participants engaged in biased responding. A left-side bias was found in 6 participants with a bias range of -5.71% to -25.71%. A right-side bias was found in 9 participants with a bias range from 2.86% to 25.71%. In terms of bias deviations, 4 participants had a side bias deviation of 10% or less, 6 participants had a side bias deviation from 10.01% to 20%, and 5 participants had a side bias deviation greater than

20%. When all selections were averaged, the mean side bias percentage was 0.61% (right-side bias).

In terms of relative center bias, 12 participants were more likely to make center selections than the unbiased center percentage. Specifically, 4 participants were 100.01% to 115% more likely to make a center selection, 6 participants were 115.01% to 130% more likely to make a center selection, and 2 participants were over 130% more likely to make a center selection. In contrast, 3 participants were less likely to make a center selection than the unbiased center percentage. Specifically, 2 participants were less than 15% less likely to make a center selection, and 1 participant was 15.01% to 30% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 114.85%.

Method 4

When selections were coded using Method 4, all 15 participants engaged in side-biased responding. A left-side bias was found in 8 participants with a bias range of -5.71% to -31.43%. A right-side bias was found in 7 participants with a bias range from 2.86% to 28.57%. In terms of bias deviations, 3 participants had a side bias deviation of 10% or less, 8 participants had a side bias deviation from 10.01% to 20%, and 4 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -2.64% (left-side bias).

In terms of relative center bias, 12 participants were more likely to make center selections than the unbiased center percentage. Specifically, 2 participants were 100.01% to 115% more likely to make a center selection, 6 participants were 115.01% to 130% more likely to make a center selection, and 4 participants were over 130% more likely to make a center selection. In contrast, 3 participants were less likely to make a center selection than the unbiased center percentage. Specifically, all 3 participants were less than 15% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 122.74%.

Edible Array Bias Percentages

Table 3 displays the side bias percentages and relative center bias percentages for the 12 participants who completed a full MSWO preference assessment for the edible array.

Method 1

When selections were coded using Method 1, all 12 participants engaged in side-biased responding. A left-side bias was found in 8 participants with a bias range of -2.86% to -40.00%. A right-side bias was found in 4 participants with a bias range from 5.71% to 25.71%. In terms of bias deviations, 4 participants had a side bias deviation of 10% or less, 1 participant had a side bias deviation from 10.01% to 20%, and 7 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -13.30% (left-side bias).

In terms of relative center bias, 6 participants were more likely to make center selections than the unbiased center percentage. Specifically, 5 participants were 115.01% to 130% more likely to make a center selection, and 1 participant was 130% more likely to make a center selection. In contrast, 4 participants were less likely to make a center selection than the unbiased center percentage. Specifically, 2 participants were less than 15% less likely to make a center selection, and 2 participants were 30.01% to 45% less likely to make a center selection. Furthermore, 2 participants did not make any center selections. When all selections were averaged, the mean relative center bias percentage was 86.42%.

Method 2

When selections were coded using Method 2, all 12 participants engaged in side-biased responding. A left-side bias was found in 7 participants with a bias range of -5.71% to -40.00%. A right-side bias was found in 5 participants with a bias range from 5.71% to 14.29%. In terms of bias deviations, 4 participants had a side bias deviation of 10% or less, 2 participants had a side bias deviation from 10.01% to 20%, and 6 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -13.29% (left-side bias).

In terms of relative center bias, 6 participants were more likely to make center selections than the unbiased center percentage. Specifically, 3 participants were 100.01% to 115% more likely to make a center selection, and 3 participants were over 130% more likely to make a center selection. In contrast, 6 participants were less likely to make a center selection than the unbiased center percentage. Specifically, 3 participants were less than 15% less likely to make a center selection, 1 participant was 15.01% to 30% less likely to make a center selection, and 2 participants were 30.01% to 45% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 104.29%.

Method 3

When selections were coded using Method 3, 11 participants engaged in side-biased responding, and 1 participant did not display a side bias. A left-side bias was found in 7 participants with a bias range of -14.29% to -34.29%. A right-side bias was found in 4 participants with a bias range from 5.71% to 20.59%. For participants who displayed a side bias, 2 participants had a side bias deviation of 10% or less, 4 participants had a side bias deviation from 10.01% to 20%, and 5 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -9.95% (left-side bias).

In terms of relative center bias, 5 participants were more likely to make center selections than the unbiased center percentage. Specifically, 4 participants were 100.01% to 115% more likely to make a center selection, and 1 participant was 115.01% to 130% more likely to make a center selection. In contrast, 7 participants were less likely to make a center selection than the unbiased center percentage. Specifically, 2 participants were less than 15% less likely to make a center selection, 3 participants were 15.01% to 30% less likely to make a center selection, 2 participants were 30.01% to 45% less likely to make a center selection, and 1 participant was over 45% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 91.19%.

Method 4

When selections were coded using Method 4, all 12 participants engaged in side-biased responding. A left-side bias was found in 8 participants with a bias range of -5.71% to -34.29%. A right-side bias was found in 4 participants with a bias range from 11.43% to 11.76%. In terms of bias deviations, 3 participants had a side bias deviation of 10% or less, 4 participants had a side bias deviation from 10.01% to 20%, and 5 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -12.12% (left-side bias).

In terms of relative center bias, 7 participants were more likely to make center selections than the unbiased center percentage. Specifically, 6 participants were 100.01% to 115% more likely to make a center selection, and 1 participant was 115.01% to 130% more likely to make a center selection. In contrast, 5 participants were less likely to make a center selection than the unbiased center percentage. Specifically, 1 participant was less than 15% less likely to make a center selection, 1 participant was 15.01% to 30% less likely to make a center selection, 2 participants were 30.01% to 45% less likely to make a center selection, and 1 participant was over 45% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 92.80%.

Combined Array Bias Percentages

Table 4 displays the side bias percentages and relative center bias percentages for the 13 participants who completed a full MSWO preference assessment for the combined array.

Method 1

When selections were coded using Method 1, all 13 participants engaged in side-biased responding. A left-side bias was found in 8 participants with a bias range of -5.71% to -26.47%. A right-side bias was found in 5 participants with a bias range from 14.29% to 42.86%. In terms of bias deviations, 3 participants had a side bias deviation of 10% or less, 3 participants had a side bias deviation from 10.01% to 20%, and 7 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -0.50% (left-side bias).

In terms of relative center bias, 6 participants were more likely to make center selections than the unbiased center percentage. Specifically, 2 participants were 115.01% to 130% more likely to make a center selection, and 4 participant was over 130% more likely to make a center selection. In contrast, 7 participants were less likely to make a center selection than the unbiased center percentage. Specifically, 5 participants were less than 15% less likely to make a center selection, and 3 participants were 30.01% to 45% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 113.96%.

Method 2

When selections were coded using Method 2, all 13 participants engaged in side-biased responding. A left-side bias was found in 8 participants with a bias range of -2.86% to -22.86%. A right-side bias was found in 5 participants with a bias range from 2.86% to 40.00%. In terms of bias deviations, 6 participants had a side bias deviation of 10% or less, 2 participants had a side bias deviation from 10.01% to 20%, and 5 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -2.46% (left-side bias).

In terms of relative center bias, 9 participants were more likely to make center selections than the unbiased center percentage. Specifically, 5 participants were 100.01% to 115% more likely to make a center selection, 1 participant was 115.01% to 130% more likely to make a center selection, and 3 participants were over 130% more likely to make a center selection. In contrast, 4 participants were less likely to make a center selection than the unbiased center percentage. Specifically, 1 participant was less than 15% less likely to make a center selection, 1 participant was 15.01% to 30% less likely to make a center selection, 2 participants were 30.01% to 45% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 105.89%.

Method 3

When selections were coded using Method 3, 12 participants engaged in side-biased responding, and 1 participant did not engage in side-biased responding. A left-side bias was found in 6 participants with a bias range of -2.94% to -14.29%. A right-side bias was found in 6 participants with a bias range from 2.86% to 22.86%. For participants who displayed a side bias, 8 participants had a side bias deviation of 10% or less, 4 participants had a side bias deviation from 10.01% to 20%, and 1 participant had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was 0.65% (right-side bias).

In terms of relative center bias, 8 participants were more likely to make center selections than the unbiased center percentage. Specifically, 5 participants were 100.01% to 115% more likely to make a center selection, and 3 participants were more 115.01% to 130% more likely to make a center selection. In contrast, 5 participants were less likely to make a center selection than the unbiased center percentage, and all 5 participants were less than 15% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 105.76%.

Method 4

When selections were coded using Method 4, 12 participants engaged in side-biased responding, and 1 participant did not engage in side-biased responding. A left-side bias was found in 7 participants with a bias range of -5.71% to -17.14%. A right-side bias was found in 5 participants with a bias range from 5.71% to 37.14%. For participants who displayed a side bias, 6 participants had a side bias deviation of 10% or less, 4 participants had a side bias deviation from 10.01% to 20%, and 2 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was 1.32% (right-side bias).

In terms of relative center bias, 11 participants were more likely to make center selections than the unbiased center percentage. Specifically, 5 participants were 100.01% to 115% more likely to make a center selection, 3 participants were 115.01% to 130% more likely to make a center selection, and 3 participants were over 130% more likely to make a center selection. In contrast, 2 participants were less likely to make a center selection than the unbiased center percentage, and both participants were 30.01% to 45% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 110.79%.

Overall Bias Percentages

Table 5 displays the overall bias percentages for the 9 participants who completed a full MSWO preference assessment for all three arrays.

Method 1

When selections were coded using Method 1, all 9 participants engaged in side-biased responding. A left-side bias was found in 6 participants with a bias range of -1.90% to -25.71%. A right-side bias was found in 3 participants with a bias range from 2.86% to 20.95%. In terms of bias deviations, 4 participants had a side bias deviation of 10% or less, 2 participants had a side bias deviation from 10.01% to 20%, and 3 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -3.93% (left-side bias).

In terms of relative center bias, 5 participants were more likely to make center selections than the unbiased center percentage. Specifically, 1 participant was 100.01% to 115% more likely to make a center selection, 1 participant was 115.01% to 130% more likely to make a center selection, and 3 participants were over 130% more likely to make a center selection. In contrast, 4 participants were less likely to make a center selection than the unbiased center percentage. Specifically, 1 participant was less than 15% less likely to make a center selection, and 3 participants were 15.01% to 30% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 110.84%.

Method 2

When selections were coded using Method 2, all 9 participants engaged in side-biased responding. A left-side bias was found in 6 participants with a bias range of -2.86% to -23.81%. A right-side bias was found in 3 participants with a bias range from 6.73% to 13.33%. In terms of bias deviations, 3 participants had a side bias deviation of 10% or less, 4 participants had a side bias deviation from 10.01% to 20%, and 2 participants had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -5.19% (left-side bias).

In terms of relative center bias, 6 participants were more likely to make center selections than the unbiased center percentage. Specifically, 4 participants were 100.01% to 115% more likely to make a center selection, and 2 participants were 115.01% to 130% more likely to make a center selection. In contrast, 3 participants were less likely to make a center selection than the unbiased center percentage. Specifically, 2 participants were less than 15% less likely to make a center selection and 1 participant was within 15.01% to 30% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 107.02%.

Method 3

When selections were coded using Method 3, 6 participants engaged in side-biased responding, and 3 participants did not engage in side-biased responding. A left-side bias was found in 3 participants with a bias range of -3.81% to -20.00%. A right-side bias was found in 3 participants with a bias range from 8.57% to 13.33%. For participants who displayed a side bias, 3 participants had a side bias deviation of 10% or less, and 3 participants had a side bias deviation from 10.01% to 20%. When all selections were averaged, the mean side bias percentage was -1.06% (left-side bias).

In terms of relative center bias, 4 participants were more likely to make center selections than the unbiased center percentage. Specifically, 2 participants were 100.01% to 115% more likely to make a center selection, and 2 participants were 115.01% to 130% more likely to make a center selection. In contrast, 5 participants were less likely to make a center selection than the unbiased center percentage, and all 5 participants were less than 15% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 104.75%.

Method 4

When selections were coded using Method 4, all 9 participants engaged in side-biased responding. A left-side bias was found in 5 participants with a bias range of -2.86% to -22.86%. A right-side bias was found in 4 participants with a bias range from 0.95% to 20.00%. In terms of bias deviations, 4 participants had a side bias deviation of 10% or less, 4 participants had a side bias deviation from 10.01% to 20%, and 1 participant had a side bias deviation greater than 20%. When all selections were averaged, the mean side bias percentage was -2.55% (left-side bias).

In terms of relative center bias, 6 participants were more likely to make center selections than the unbiased center percentage. Specifically, 3 participants were 100.01% to 115% more likely to make a center selection, and 3 participants were 115.01% to 130% more likely to make a center selection. In contrast, 3 participants were less likely to make a center selection than the unbiased center percentage, and all 3 participants were less than 15% less likely to make a center selection. When all selections were averaged, the mean relative center bias percentage was 109.16%.

DISCUSSION

Because there is no prior research of positional bias within an MSWO, the current study provided four initial methods to quantify stimulus locations and calculate positional bias percentages for the MSWO. These methods were then used to secondarily analyze the positional bias percentages for the young children with ASD who participated in Sipila-Thomas et al.'s (2021) MSWO displacement study.

Due to the structure in which the data was analyzed, the results of this study provide a finding that occurs between-subjects (i.e., bias percentages varied between subjects within the same array and method combination) and two findings that occur within-subjects (i.e., bias percentages varied between methods or array type for the same participant). Specifically, the results of this study suggest that (1) within the same array type and method combination, individual participants varied in their level of biased responding, (2) the method in which the stimulus location is coded affected the bias percentage output, and (3) although the edible array may elicit higher levels of biased responding, relative to tangible or combined arrays, arrays, on average, tended to elicit low levels of biased responding.

Participant-Related Findings

Within the same method/array type, participants varied on their degree of biased responding and participants varied on which side biased responding occurred. Specifically, amongst all method and array type combinations (e.g., Method 1/Tangible, Method 2/ Tangible, and Method 2/Edible), there were participants who engaged in higher or lower degrees of biased responding for both center and side selections and there were no uniform side bias or center preference between all participants. This variability amongst bias percentages indicates that although participants were within the same age range and were all diagnosed with ASD, there is still heterogeneity amongst participants and emphasize the importance of knowing the individual, their preferences, and their learning histories. Because individuals do not respond uniformly, knowledge about specific individuals should inform and influence one's decision making process when selecting and/or conducting a preference assessment. Practitioners who are informed about their client's preferences, skill sets, and biases may be better equipped to utilize decision making algorithms (e.g., Karsten et al., 2011; Virues-Ortega et al., 2014). For instance, practitioners who know their client well may know the client's highly preferred stimuli in the preference assessment, may conduct paired stimulus preference assessments for participants with limited scanning skills, and may present stimuli vertically for participants with who frequently engage in side-biased responding. Because preference assessments are typically utilized to select putative reinforcers for behavioral interventions and prior research has shown that higher preferred reinforcers can lead to increased responding (Morris & Vollmer, 2020a) or faster skill acquisition (Morris & Vollmer, 2020b), it is important that practitioners utilize the most appropriate preference assessment and make the necessary modifications to identify the most potent putative reinforcers.

Method-Related Findings

Side Bias Findings

Within the same array type and participant, there was a common side bias pattern where Method 1 tended to output higher side bias percentages while Method 3 tended to output lower side bias percentages. Methods 2 and 4 tended to fall in between Methods 1 and 3 with Method 2 outputting higher side bias percentages more frequently. The difference between side bias percentages is notable as all side bias percentages were calculated using the same equations and the relative center bias percentage allowed for standardized comparisons amongst different methods. Thus, variations in bias percentages can be attributed to how each method quantified each stimulus location.

One explanation for these findings could be based on the number of center and side designations per trial. These results correlate with the number of center and side designations and suggest that the opportunities for a center selection may mediate side bias percentages to some degree. Methods 1 and 2 allowed for the most opportunities for a side selection while Methods 3 and 4 allowed for the least opportunities for a side selection. This correlation between side bias percentages and the number of side designation may be mediated by the fact that center selections still impact side bias calculations.

At first glance, a participant with one left selection and six center selections would appear to have a 100% left-side bias as the participant never made any right-side selections. However, when calculating the side bias percentage, the participant actually had a 14% left-side bias. Although the number of center selections does not affect the difference between left and right selections, these trials where a center selection occurred included a left/right designation and were factored into the denominator of the equation, which resulted in a lower side bias percentage. Because the number of center designations may affect the likelihood of a center selection, methods with more center designations may likely lead to more center selection and thus more likely to output a lower bias percentage.

Relatedly, the location of center and side designations are also important to consider. When analyzing participant and array combinations with high side bias ranges (i.e., over a 20% difference between the highest bias percentage and lowest side bias percentage), we find that these seven participant and array combinations (i.e., Participant 1’s combined, Participant 2’s edible, Participant 9’s combined, Participant 10’s tangible, Participant 18’s combined, Participant 19's combined, and Participant 27's tangible) were more likely to select the second leftmost or second rightmost stimulus. Compared to participants with side bias ranges less than 6%, participants with high side bias ranges, on average, were less likely to select the center by for all methods except Method 3 and notably selected the stimulus next to the leftmost or rightmost stimulus in 2.4 more trials out of 30 trials. Unlike the other three methods, Method 3 always designated stimuli not the leftmost and rightmost stimulus as center. Because participants with higher side bias percentages were more likely to select the stimulus next to the leftmost or rightmost stimulus, this may explain why Method 3 resulted in lower side bias percentages as, compared to the other methods, Method 3 had more center selections than side selections.

Furthermore, the designation of the center also seems to affect calculations of side bias when participants whose selections were more evenly distributed. Six participant and array type combinations where methods outputted different side bias directions (i.e., one or more methods indicate left bias while other methods indicate right bias; e.g., Participant 11's combined). In all combinations, participants who had differing side bias directions tended to distribute their selection responses evenly across multiple stimulus locations, but variations with side bias percentages seemed to vary based on how the stimulus selection locations were quantified. Specifically, these differences occurred because some stimuli selections were designated as left or right for some methods but center for other methods. Since the selections were more evenly distributed, these different designations account for the slight deviations in percentages. For instance, for the combined array, Participant 11 tended to select the stimulus closest to the leftmost stimulus in many trials and Methods 1, 2, and 4 reported a left bias. However, because Method 3 is not sensitive to these "left" locations, it outputted more rightmost selections than leftmost selections and thus a right-side bias. In contrast, for the edible array, Participant 15 selected the centermost left item on trial 4, which had six stimuli, in four out of the five MSWO rounds. Unlike Methods 2, 3, and 4 which reported a right side bias and designated the centermost left on trial 4 as center, Method 1 designated this stimulus as left and reported a left side bias because of this different designation.

Relative Center Bias Findings

In terms of relative center bias, Method 1 most frequently outputted the highest relative center bias percentage (22 times), followed by Method 4 (10 times) and then Methods 2 and 3 (7 times each). Method 3 most frequently outputted the lowest relative center bias percentage (19 times), followed by Methods 1 (18 times), Method 2 (8 time), and Method 4 (3 times). Generally, Methods 2, 3, and 4 tended to be closer in range with one another compared to Method 1, which tended to have more significant relative center percentage differences than the other three methods. Specifically, Method 1 tended to provide a relative center bias percentage that had at least a 30% difference from the next closest relative center bias percentage (e.g., Participant 1's tangible relative center bias or Participant 15's tangible relative center bias). Because Method 1 incorporated only three opportunities to select the center, it provided only half of the opportunities than the other three methods and was more prone to volatility. One additional or one fewer center selection for Method 1 would result in a 30% change in relative center bias percentage (i.e., 1 selection divided by 3.38, the mean number of center selections based on probability). Because a single selection or non-selection could skew the bias percentages significantly, this result suggests that methods to quantify stimulus selections should aim to incorporate a center selection within most, if not all, potential trials in order to decrease the volatility in relative center bias percentages.

Results also indicate the difference between Zias' (2015) center bias percentage and the relative center bias percentage. For instance, Participant 2's center selection frequency for the edible array was similar between Methods 2, 3, and 4 as it outputted 14, 19, and 15 center selections for the array, respectively. Based on these results, one may think that Method 2 would result in the lowest center bias percentage and Zias' (2015) center bias percentage measure supports this notion as Participant 2's edible array would output a center bias of 46.67% (i.e., 14/30) for Method 2, 63.33% (i.e., 19/30) for Method 3, and 50.00% (i.e.,15/30) for Method 4. However, when considering the relative center bias percentage, Method 2 (159.27%) had a higher percentage than those of Methods 3 (106.62%) and 4 (111.36%). This difference arose due to the differences in the probability for these selections. Specifically, the number of center options per trial varied based on methods, and Method 2 had fewer center options per trial than Methods 3 and 4. As a result, the probability of selecting a center designated by Method 2 was much lower than Methods 3 or 4, and thus, resulted in a higher relative center bias percentage.

Zias' (2015) center bias percentage measure provides a simplified calculation for calculating center bias. Specifically, this method calculates the probability of selecting the center in a static manner and provides limited descriptive data (i.e., number of center selections and percentage of trials with center selection). In contrast, the relative center bias measure offers two main benefits: (1) an adaptive measure that incorporates probability and 2) provides a standardized scale for comparison. As mentioned above, the relative center bias percentages measure incorporates the mean probability for a center selection in its calculations and thus, is a robust measure that should adjust to changes in data calculations (e.g., different designations of stimulus locations or different number of starting stimuli in array). Furthermore, because the relative center bias percentage measure is divided by the unbiased center value (i.e., mean probability of a center selection across all trials of a round), this measure is normalized based on probability of selection, and thus, allows for comparisons not only between different methods to calculate center bias but also across participants. The ability to draw comparisons is beneficial for this line of research as this paper provides a framework for a uniform way to compare different methodologies and define bias categories based on participant data.

Array Type-Related Findings

In terms of findings specific to the type of array, participants, on average, did not engage in differing levels of biased responding across most array types. It is interesting to note that participants, on average, tended to engage in higher percentages of side-biased responding for the edible array (i.e., percentages ranged from -9.95% to -13.30%) and tended to engage in higher percentages of center-biased responding for the tangible array (i.e., percentages ranged from 114.85% to 146.16%). These patterns remained, with slightly lower bias percentages, even when analyzing each array type with only participants who completed all array types (see Tables 5, 6, 7, and 8). Due to the limited nature of this study, it is important to state that we cannot assess whether the level of biased responding for these two array types are significant nor can we hypothesize whether the tangible or edible stimuli elicit more of a specific type of biased responding. Future research could investigate whether participants are more likely to engage in biased responding by conducting multiple MSWO preference assessments with edible arrays or tangible arrays, and if more biased responding occurs, further analyze whether these patterns occur with highly preferred stimuli, less preferred stimuli, and/or a combination of both.

Another finding from this study is that participants, on average, did not seem to engage in high degrees of side-biased (i.e., percentages ranged from -2.68% to 1.98%) or center-biased responding (i.e., percentages ranged from 105.89% to 113.96%) for the combined tangible and edible array. Although some participants did engage in higher levels of biased responding than others, when compared to the other array types, the bias percentages for this combined array were similar or collectively lower than the other arrays across all methods. This result is notable as the combined array type can be viewed as an array with the most preferred stimuli as the array contains the top four stimuli from both the tangible and the edible arrays. Thus, these results may suggest that relative preference of stimuli may not always be correlated with highly biased responding.

Limitations and Future Directions

The results of this study are supported by the analysis for 200 MSWO rounds across 40 participant/array type combinations. However, it is important to note that all of these findings and results are correlational in nature as the researchers did not directly manipulate the way in which stimuli were presented. Thus, we can only provide descriptive information about the positional bias percentages and cannot conclude causal relationships between specific variables (e.g., array type and the occurrence of positional bias).

One limitation of this study is that the data were based on available video recordings of previously conducted preference assessments. As a result, this study could directly observe all participant's preference assessments and could not control for the actions of the original researchers. This was problematic as some participants were missing videos or videos were ended early due to technical electronic difficulties (e.g., camera's battery depleting). Additionally, some participants engaged in selections similar to an extreme side bias pattern (i.e., consistently selected the leftmost or rightmost stimulus); however, many of these participants were excluded from the study due to the previous researchers (i.e., Sipila-Thomas et al., 2021) modifying the array (e.g., presenting the stimuli vertically). If the previous researchers did not change the presentation of the array, the results of this study may have differed due to the inclusion of these participants. To address this limitation, future research should conduct their own preference assessments without intervening on client selections and then replicate this analysis process to obtain a more holistic range of participant bias.

A second limitation is that this study did not incorporate a way to determine what patterns or percentages of side and center bias are significant. The results of this study focused first on analyzing the positional bias percentages that were outputted by each method and then looked at the selection patterns based on these positional bias percentages without reference to whether the selections seemed bias or unbiased. As a result, this study did not aim to classify the nominal levels of bias (e.g., low, medium, high) and only presented the data using bias ranges in order to help organize and describe the data. For the sake of initial discussion, the authors of this paper have provided suggestions for categorization and initial percentages for each category. For side bias, the authors suggest (1) low for side bias percentages less than 10%, (2) moderate for side bias percentages between 10 and 20%, and (3) high for side bias percentages above 20%. For relative center bias, the authors suggest (1) low for relative center bias percentages between 85% and 115%, (2) moderate for relative center bias percentages between 70% and 85% or between 115% and 130%, and 3) high for relative center bias percentages below 70% or above 130%.

Future research should work towards assessing and refining the utility of these specific methods and categories. Future researcher should assess and refine each measure’s ability to identify specific bias patterns. Once measurements can detect and are sensitive to these biased patterns, research should then focus on refining these bias level categories by showing practitioners various patterns of selections and having the practitioner rate these levels of bias for each pattern. Researchers can then refine the bias level categories based on these responses and the corresponding bias percentages from the measurement tool.

Finally, this study only analyzed positional bias percentages after the completion of a single full MSWO preference assessment. Although each full MSWO preference assessment contained five MSWO rounds, we cannot conclude the stability of the collected bias percentages. Future research should collect and analyze positional bias across individual MSWO preference assessments and repeated MSWO preference assessments to determine the extent to which bias percentages are stable and the required number of MSWO rounds or preference assessments to establish stable bias percentages. Similar to research on preference stability, this line of research would provide practical utility as it would provide guidelines for whether bias percentages could be determined using abbreviated MSWO preference assessments or whether repeated MSWO preference assessments are required to determine a participant's bias percentages.

General Recommendations

Based on the results of this study, the authors make the general recommendation to use either Methods 2 or 4 when wanting to analyze general positional bias or to develop a measurement system that initially incorporates multiple opportunities for a center and side selection. Methods 1 and 3 can be viewed as the boundaries for stimulus location designations as (1) Method 1 allowed for the most opportunities for a left or right selection and the least opportunities for a center selection while (2) Method 3 allowed for the least opportunities for a left or right selection and the most opportunities for a center selection. Thus, Method 1 and 3 were more likely to be oversensitive (e.g., Method 1 tends to have significantly higher relative center bias percentages when there are multiple center selections in a round) or insensitive (e.g., Method 1 was insensitive to the selection of the centermost stimuli in arrays with an even number of stimuli and Method 3 was insensitive to the selection of stimuli next to the leftmost or rightmost stimulus) to specific stimulus locations. Our findings suggest Methods 2 and 4 seem to be more sensitive to these stimulus locations and address the flaws with Methods 1 and 3, respectively.

Because Method 1 contained fewer opportunities for a center selection, it tended to have increased volatility in terms of relative center bias. Therefore, we do not recommend its practice as it may only have utility in research focused on broader measurements of left or right biases akin to a PS preference assessment and requires a center designation solely because the centermost stimulus cannot be distributed evenly between left and right (e.g., research that compares whether participants with side-biased responding during PS preference assessments engaged in similar side-biased responding within an MSWO). Similar to Method 1, Method 2 allowed for more opportunities for a left or right selection but had more stable relative center bias percentages as it allowed for at least one opportunity for a center selection in all six trials with at least three stimuli.

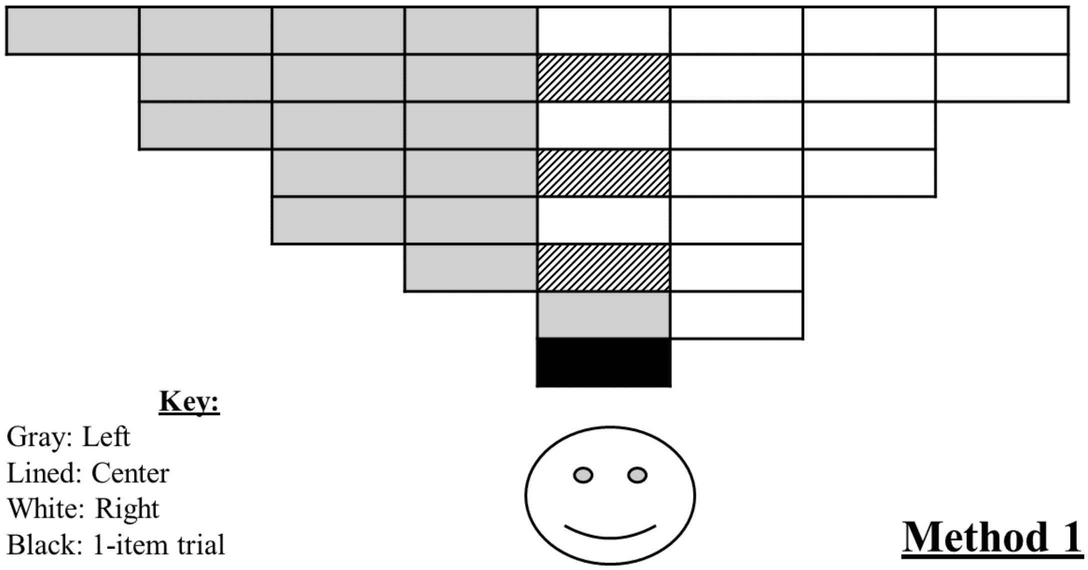
Method 3 by design was not sensitive to selections outside of the leftmost or rightmost selections, and compared to the other methods, Method 3 tended to produce lower side bias percentages as it was insensitive specifically to the selections of stimuli next to the leftmost and rightmost stimuli. Therefore, we do not recommend Method 3 to be used in practice as it may only have utility in research focused on measuring extreme side-biased responding (i.e., selection of leftmost or rightmost stimulus). Unlike Method 3, Method 4 included an additional opportunity for a left or right selection and thus, was more sensitive to the selection of stimuli next to the leftmost or rightmost stimuli.

When considering whether to use Method 2 or 4, the authors recommend determining how many stimuli will be designated as left and right because Methods 2 and 4 differ on how many stimuli it initially designates as left and right. Method 2 initially designates 3 stimuli as left and 3 stimuli as right before gradually decreasing the number of left and right stimuli. Method 4 initially designates 2 stimuli as left and 2 stimuli as right before gradually decreasing the number of left and right stimuli. Because Method 2 contains fewer opportunities for center selections, it would be more appropriate for researchers not as concerned with a center bias and want to calculate more generalized side bias percentages. On the other hand, Method 4 would be more appropriate for those who want to measure both side and center bias as Method 4 has a similar number of side designations and center designations.

APPENDIX

Figure 1.

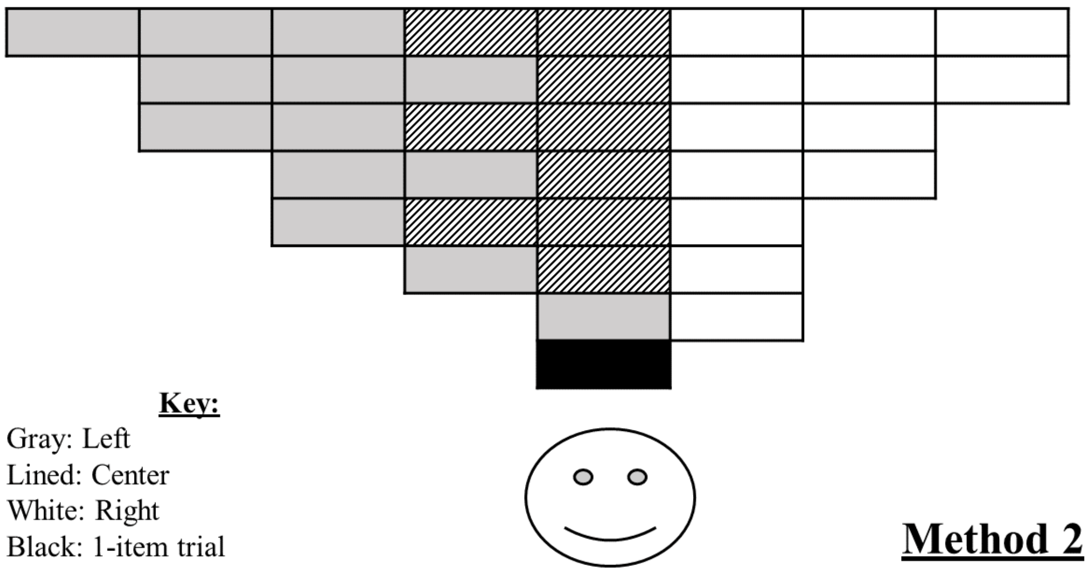
Method 1's Designation of Stimulus Locations



Note. Depiction of how stimulus locations were designated by Method 1. The face depicted the location of the participant during each trial. Arrays with an even number of stimuli were divided evenly into left and right sections. Arrays with an odd number of stimuli designated the centermost stimulus as center and then divided the remaining stimuli into left or right. There were 3 opportunities for a center selection and 32 opportunities for a left or right selection. The unbiased center percentage for Method 1 was 22.54%.

Figure 2.

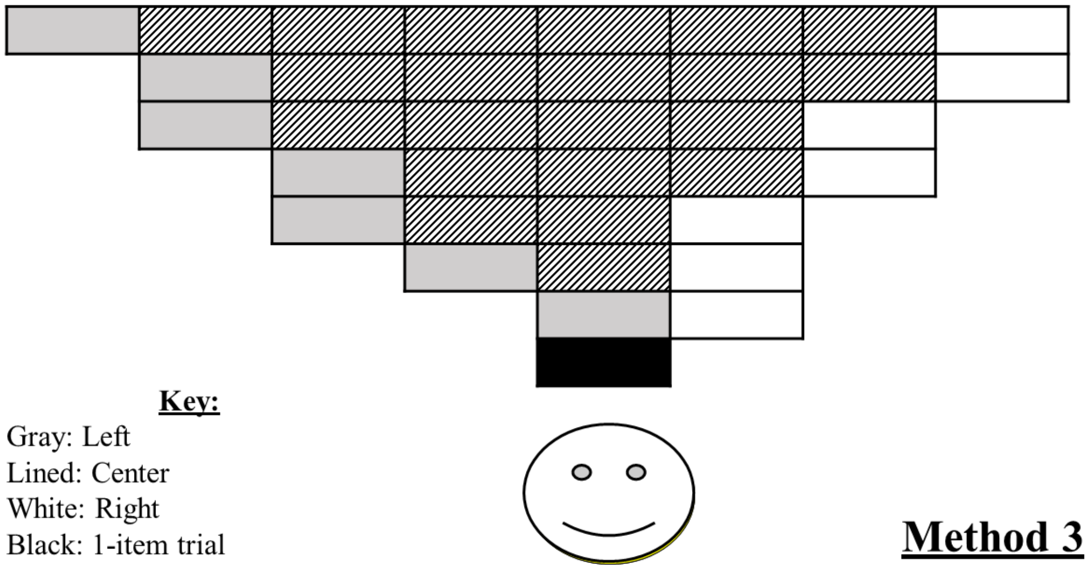
Method 2's Designation of Stimulus Locations



Note. Depiction of how stimulus locations were designated by Method 2 as described by Zias (2015). The face depicted the location of the participant during each trial. This method is similar to Method 1 but allows for a center selection in all trials with at least 3 stimuli. Arrays with an even number of stimuli designated the two centermost stimuli as center and then divided the remaining stimuli into left or right. Arrays with an odd number of stimuli designated the centermost stimulus as center and then divided the remaining stimuli into left or right. There were 9 opportunities for a center selection and 26 opportunities for a left or right selection. The unbiased center percentage for Method 2 was 29.33%.

Figure 3.

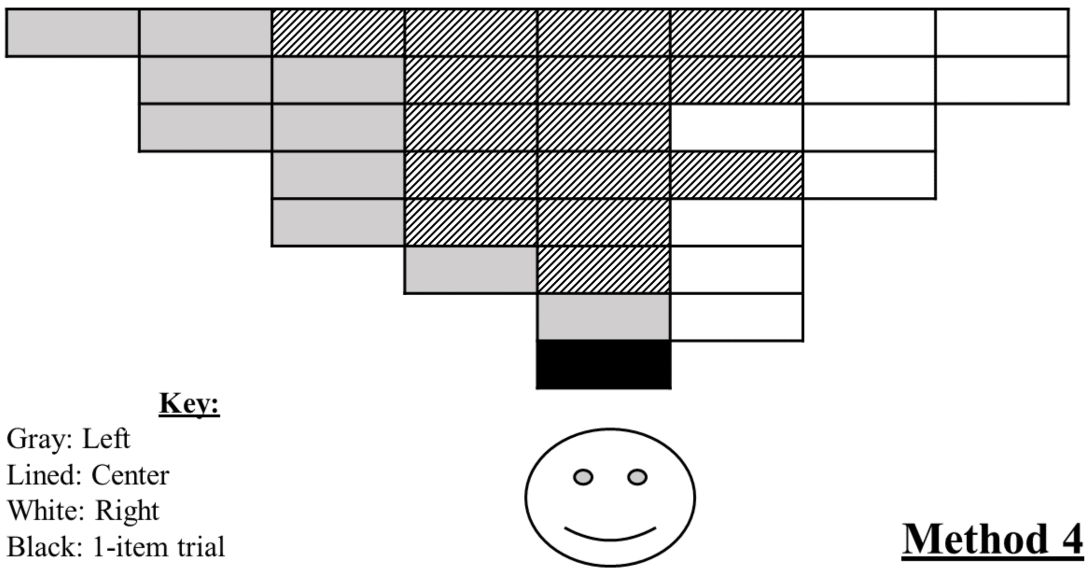
Method 3's Designation of Stimulus Locations



Note. Depiction of how stimulus locations were designated by Method 3. The face depicted the location of the participant during each trial. This method illustrated the pattern that would be found with participants who engaged in an extreme side bias. The leftmost stimulus was designated as left and the rightmost stimulus is designated as right. Stimuli between the leftmost and the rightmost stimuli were designated as center. There were 21 opportunities for a center selection and 14 opportunities for a left or right selection. The unbiased center percentage for Method 3 was 59.40%.

Figure 4.

Method 4's Designation of Stimulus Locations



Note. Depiction of how stimulus locations were designated by Method 4. The face depicted the location of the participant during each trial. This method was similar to Method 3 but incorporates additional left and right designations in the initial trials. The two leftmost stimuli were designated as left and the two rightmost stimuli were designated as right while the remaining stimuli in between were designated as center. On the trial after the number of stimuli in the center was equal to the number of stimuli on one side (Trial 4), only the leftmost stimulus was designated as left and only the rightmost stimulus was designated as right. There were 15 opportunities for a center selection and 20 opportunities for a left or right selection. The unbiased center percentage for Method 4 was 44.92%.

Table 1.

Unbiased Percentages for All 4 Methods

Unbiased % Type	Method 1	Method 2	Method 3	Method 4
Unbiased Center %	22.54%	29.33%	59.40%	44.92%
Unbiased Side %	0.00%	0.00%	0.00%	0.00%

Note. Table 1 provides the unbiased percentages for each method. The unbiased center percentages were based on the average probability that a center selection would be made in a round. This was calculated by finding the mean probability of selecting the center (i.e., adding the probabilities of a center selection for each trial and dividing the sum by the number of trials with a potential center selection). This value was then used to find the relative unbiased center percentage by dividing a participant's bias percentage for each method by the method's unbiased center percentage. Unbiased side percentage for all methods was 0.00% and depicts that the participant engaged in left selections and right selections equally.

Figure 5.

Data Collection Sheet

Participant: _______ Data Collector: _____

Type of Stimulus Array: (Edible Tangible Combined) Date: __________ Time:_____

Round 1

Trial #	Stimulus Selected	Stimulus Location
1		__ __ __ __ __ __ __ __
2		__ __ __ __ __ __ __
3		__ __ __ __ __ __
4		__ __ __ __ __
5		__ __ __ __
6		__ __ __
7		__ __
8		__

Round 4

Trial #	Stimulus Selected	Stimulus Location
1		__ __ __ __ __ __ __ __
2		__ __ __ __ __ __ __
3		__ __ __ __ __ __
4		__ __ __ __ __
5		__ __ __ __
6		__ __ __
7		__ __
8		__

Round 2

Trial #	Stimulus Selected	Stimulus Location
1		__ __ __ __ __ __ __ __
2		__ __ __ __ __ __ __
3		__ __ __ __ __ __
4		__ __ __ __ __
5		__ __ __ __
6		__ __ __
7		__ __
8		__

Round 5

Trial #	Stimulus Selected	Stimulus Location
1		__ __ __ __ __ __ __ __
2		__ __ __ __ __ __ __
3		__ __ __ __ __ __
4		__ __ __ __ __
5		__ __ __ __
6		__ __ __
7		__ __
8		__

Round 3

Trial #	Stimulus Selected	Stimulus Location
1		__ __ __ __ __ __ __ __
2		__ __ __ __ __ __ __
3		__ __ __ __ __ __
4		__ __ __ __ __
5		__ __ __ __
6		__ __ __
7		__ __
8		__

Instructions: For each trial where a stimulus was selected, note the stimulus that was selected and then mark the "__" with an "X" (i.e., "_X_") to represent the location of the selected stimulus in the array (with the participant assumed to being facing the stimuli from under Trial 8). For trials where no stimulus was selected or that was not conducted, write N/A for stimulus selected and do not mark any "__".

Note. This data sheet was completed electronically for each of the three stimulus array types. For each trial, researchers noted the stimulus selected and placed an "X" to denote the location of the stimulus in the array. For trials with no selections, the item was marked as "N/A" and no location was marked for selection. Selections were marked as if the participant was assumed to be facing the array from below Trial 8.

Table 2.

Bias Percentages for Participants Who Completed Tangible MSWO Assessment

	Method 1		Method 2		Method 3		Method 4	
Pt	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
1	-14.29%	237.04%	-8.57%	159.27%	2.86%	123.46%	-5.71%	126.21%
3	-11.43%	148.15%	-22.86%	125.14%	-22.86%	129.07%	-17.14%	126.21%
4	-17.14%	148.15%	-14.29%	91.01%	-11.43%	95.40%	-14.29%	103.93%
6	-37.14%	237.04%	-25.71%	159.27%	-25.71%	145.90%	-25.71%	163.33%
9	-28.57%	207.41%	-22.86%	193.40%	-11.43%	117.85%	-14.29%	148.48%
10	-34.29%	148.15%	-37.14%	113.77%	-17.14%	129.07%	-31.43%	118.79%
11	11.43%	148.15%	20.00%	136.52%	22.86%	117.85%	17.14%	126.21%
12	37.14%	118.52%	31.43%	91.01%	25.71%	89.79%	28.57%	96.51%
13	29.41%	118.52%	23.53%	113.77%	17.65%	112.23%	14.71%	126.21%
14	-5.71%	88.89%	-8.57%	91.01%	5.71%	106.62%	-11.43%	96.51%
15	11.43%	88.89%	5.71%	125.14%	5.71%	140.29%	8.57%	133.63%
16	22.86%	207.41%	11.43%	170.65%	14.29%	123.46%	11.43%	155.90%
17	2.86%	59.26%	5.71%	102.39%	20.00%	112.23%	17.14%	126.21%
26	5.71%	148.15%	0.00%	102.39%	8.57%	78.56%	2.86%	89.09%
27	-45.71%	88.89%	-31.43%	91.01%	-25.71%	101.01%	-25.71%	103.93%
Mean	**-4.90%**	**146.17%**	**-4.91%**	**124.38%**	**0.61%**	**114.85%**	**-3.02%**	**122.74%**

Note. Bias percentages for the 15 participants who met inclusion criteria for the tangible array. For side bias, negative values indicate a left bias and positive values indicate a right bias. For relative center bias (denoted by R Center), values compare how likely a participant selected a center location compared to what is expected based on average probability.

Table 3.

Bias Percentages for Participants Who Completed Edible MSWO Assessment

	Method 1		Method 2		Method 3		Method 4	
Pt	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
1	25.71%	118.52%	14.29%	91.01%	11.43%	84.18%	11.43%	96.51%
2	-48.57%	118.52%	-37.14%	159.27%	-22.86%	106.62%	-34.29%	111.36%
3	-25.71%	118.52%	-25.71%	113.77%	-20.00%	101.01%	-20.00%	103.93%
9	14.71%	88.89%	11.76%	91.01%	20.59%	106.62%	11.76%	103.93%
11	8.57%	118.52%	5.88%	113.77%	0.00%	117.85%	-5.71%	111.36%
12	5.71%	148.15%	5.71%	102.39%	5.71%	95.40%	11.43%	111.36%
14	-31.43%	59.26%	-28.57%	56.88%	-17.14%	61.73%	-25.71%	59.39%
15	-8.57%	118.52%	2.86%	136.52%	2.86%	112.23%	5.71%	126.21%
17	-31.43%	59.26%	-25.71%	91.01%	-28.57%	84.18%	-31.43%	74.24%
18	-40.00%	88.89%	-40.00%	79.64%	-22.86%	95.40%	-25.71%	103.93%
26	-2.86%	0.00%	-5.71%	159.27%	-14.29%	44.89%	-8.57%	44.54%
27	-25.71%	0.00%	-37.14%	56.88%	-34.29%	84.18%	-34.29%	66.82%
Mean	**-13.30%**	**86.42%**	**-13.29%**	**104.29%**	**-9.95%**	**91.19%**	**-12.12%**	**92.80%**

Note. Table 3 includes the bias percentages for the 12 participants who met inclusion criteria for the edible array. For side bias, negative values indicate a left bias and positive values indicate a right bias. For relative center bias (denoted by R Center), values compare how likely a participant selected a center location compared to what is expected based on average probability.

Table 4.

Bias Percentages for Participants Who Completed Combined MSWO Assessment

	Method 1		Method 2		Method 3		Method 4	
Pt	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
1	34.29%	88.89%	28.57%	56.88%	14.29%	89.79%	25.71%	59.39%
3	-25.71%	177.78%	-22.86%	102.39%	-11.43%	95.40%	-8.57%	103.93%
8	-22.86%	207.41%	-14.29%	159.27%	-5.71%	129.07%	-17.14%	141.05%
9	-28.57%	88.89%	-22.86%	102.39%	-8.57%	101.01%	-14.29%	118.78%
10	-5.71%	88.89%	-5.71%	102.39%	-14.29%	89.79%	-14.29%	103.93%
11	-11.43%	148.15%	-5.71%	125.14%	2.86%	123.46%	-8.57%	133.63%
12	20.00%	59.26%	2.86%	91.01%	8.57%	112.23%	20.00%	103.93%
14	17.14%	88.89%	5.71%	147.90%	2.86%	112.23%	5.71%	141.05%
15	-8.57%	59.26%	-17.14%	56.88%	-8.57%	112.23%	-8.57%	111.36%
17	14.29%	118.52%	2.86%	136.52%	8.57%	101.01%	5.71%	126.21%
18	-26.47%	88.89%	-20.59%	102.39%	-2.94%	117.85%	0.00%	118.78%
19	42.86%	118.52%	40.00%	79.64%	22.86%	95.40%	37.14%	59.39%
27	-5.71%	148.15%	-2.86%	113.77%	0.00%	95.40%	-5.71%	111.36%
Mean	**-0.50%**	**113.96%**	**-2.46%**	**105.89%**	**0.65%**	**105.76%**	**1.32%**	**110.79%**

Note. Bias percentages for the 13 participants who met inclusion criteria for the combined array. For side bias, negative values indicate a left bias and positive values indicate a right bias. For relative center bias (denoted by R Center), values compare how likely a participant selected a center location compared to what is expected based on average probability.

Table 5.

Overall Bias Percentages for Participants Who Completed All 3 MSWO Assessments

	Method 1		**Method 2**		**Method 3**		**Method 4**	
Pt	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
1	15.24%	148.15%	11.43%	102.39%	9.52%	99.14%	10.48%	94.04%
3	-20.95%	148.15%	-23.81%	113.77%	-18.10%	108.49%	-15.24%	111.36%
9	-14.42%	128.40%	-11.54%	128.93%	0.00%	108.49%	-5.77%	123.73%
11	2.86%	138.27%	6.73%	125.14%	8.57%	119.72%	0.95%	123.73%
12	20.95%	108.64%	13.33%	94.80%	13.33%	99.14%	20.00%	103.93%
14	-6.67%	79.01%	-10.48%	98.60%	-2.86%	93.53%	-10.48%	98.99%
15	-1.90%	88.89%	-2.86%	106.18%	0.00%	121.59%	1.90%	123.73%
17	-4.76%	79.01%	-5.71%	109.97%	0.00%	99.14%	-2.86%	108.88%
27	-25.71%	79.01%	-23.81%	83.43%	-20.00%	93.53%	-21.90%	94.04%
Mean	**-3.93%**	**110.84%**	**-5.19%**	**107.02%**	**-1.06%**	**104.75%**	**-2.55%**	**109.16%**

Note. Table 5 includes the bias percentages for the 9 participants who met inclusion criteria for all three arrays (i.e., tangible, edible, and combined array). The bias percentages depicted here are based on all of the participant's selections across all of the three array types. For side bias, negative values indicate a left bias and positive values indicate a right bias. For relative center bias (denoted by R Center), values compare how likely a participant selected a center location compared to what is expected based on average probability.

Table 6.

Tangible Bias Percentages for Participants Who Completed All 3 MSWO Assessments

	Method 1		Method 2		Method 3		Method 4	
Pt	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
1	-14.29%	237.04%	-8.57%	159.27%	2.86%	123.46%	-5.71%	126.21%
3	-11.43%	148.15%	-22.86%	125.14%	-22.86%	129.07%	-17.14%	126.21%
9	-28.57%	207.41%	-22.86%	193.40%	-11.43%	117.85%	-14.29%	148.48%
11	11.43%	148.15%	20.00%	136.52%	22.86%	117.85%	17.14%	126.21%
12	37.14%	118.52%	31.43%	91.01%	25.71%	89.79%	28.57%	96.51%
14	-5.71%	88.89%	-8.57%	91.01%	5.71%	106.62%	-11.43%	96.51%
15	11.43%	88.89%	5.71%	125.14%	5.71%	140.29%	8.57%	133.63%
17	2.86%	59.26%	5.71%	102.39%	20.00%	112.23%	17.14%	126.21%
27	-45.71%	88.89%	-31.43%	91.01%	-25.71%	101.01%	-25.71%	103.93%
Mean	**-4.76%**	**131.69%**	**-3.49%**	**123.88%**	**2.54%**	**115.35%**	**-0.32%**	**120.43%**

Note. Table 6 includes the bias percentages for the tangible array and includes only the 9 participants who met inclusion criteria for all three arrays (i.e., tangible, edible, and combined array). For side bias, negative values indicate a left bias and positive values indicate a right bias. For relative center bias (denoted by R Center), values compare how likely a participant selected a center location compared to what is expected based on average probability.

Table 7.

Edible Bias Percentages for Participants Who Completed All 3 MSWO Assessments

	Method 1		**Method 2**		**Method 3**		**Method 4**	
Pt	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
1	25.71%	118.52%	14.29%	91.01%	11.43%	84.18%	11.43%	96.51%
3	-25.71%	118.52%	-25.71%	113.77%	-20.00%	101.01%	-20.00%	103.93%
9	14.71%	88.89%	11.76%	91.01%	20.59%	106.62%	11.76%	103.93%
11	8.57%	118.52%	5.88%	113.77%	0.00%	117.85%	-5.71%	111.36%
12	5.71%	148.15%	5.71%	102.39%	5.71%	95.40%	11.43%	111.36%
14	-31.43%	59.26%	-28.57%	56.88%	-17.14%	61.73%	-25.71%	59.39%
15	-8.57%	118.52%	2.86%	136.52%	2.86%	112.23%	5.71%	126.21%
17	-31.43%	59.26%	-25.71%	91.01%	-28.57%	84.18%	-31.43%	74.24%
27	-25.71%	0.00%	-37.14%	56.88%	-34.29%	84.18%	-34.29%	66.82%
Mean	**-7.57%**	**86.42%**	**-8.51%**	**104.29%**	**-6.60%**	**91.19%**	**-8.53%**	**92.80%**

Note. Table 7 includes the bias percentages for the edible array and includes only the 9 participants who met inclusion criteria for all three arrays (i.e., tangible, edible, and combined array). For side bias, negative values indicate a left bias and positive values indicate a right bias. For relative center bias (denoted by R Center), values compare how likely a participant selected a center location compared to what is expected based on average probability.

Table 8.

Combined Bias Percentages for Participants Who Completed All 3 MSWO Assessments

	Method 1		Method 2		Method 3		Method 4	
Pt	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
1	34.29%	88.89%	28.57%	56.88%	14.29%	89.79%	25.71%	59.39%
3	-25.71%	177.78%	-22.86%	102.39%	-11.43%	95.40%	-8.57%	103.93%
9	-28.57%	88.89%	-22.86%	102.39%	-8.57%	101.01%	-14.29%	118.78%
11	-11.43%	148.15%	-5.71%	125.14%	2.86%	123.46%	25.71%	133.63%
12	20.00%	59.26%	2.86%	91.01%	8.57%	112.23%	20.00%	103.93%
14	17.14%	88.89%	5.71%	147.90%	2.86%	112.23%	5.71%	141.05%
15	-8.57%	59.26%	-17.14%	56.88%	-8.57%	112.23%	-8.57%	118.78%
17	14.29%	118.52%	2.86%	136.52%	8.57%	101.01%	5.71%	126.21%
27	-5.71%	148.15%	-2.86%	113.77%	0.00%	95.40%	-5.71%	111.36%
Mean	**0.64%**	**108.64%**	**-3.49%**	**103.65%**	**0.95%**	**104.75%**	**5.08%**	**113.01%**

Note. Table 8 includes the bias percentages for the combined array and includes only the 9 participants who met inclusion criteria for all three arrays (i.e., tangible, edible, and combined array). For side bias, negative values indicate a left bias and positive values indicate a right bias. For relative center bias (denoted by R Center), values compare how likely a participant selected a center location compared to what is expected based on average probability.

Table 9.

Bias Percentages for Participants 1, 2, and 3

		Method 1		Method 2		Method 3		Method 4	
Pt		**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
1	Tangible	-14.29%	237.04%	-8.57%	159.27%	2.86%	123.46%	-5.71%	126.21%
	Edible	25.71%	118.52%	14.29%	91.01%	11.43%	84.18%	11.43%	96.51%
	Combined	34.29%	88.89%	28.57%	56.88%	14.29%	89.79%	25.71%	59.39%
	Overall	15.24%	148.15%	11.43%	102.39%	9.52%	99.14%	10.48%	94.04%
2	Tangible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Edible	-48.57%	118.52%	-37.14%	159.27%	-22.86%	106.62%	-34.29%	111.36%
	Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	Tangible	-11.43%	148.15%	-22.86%	125.14%	-22.86%	129.07%	-17.14%	126.21%
	Edible	-25.71%	118.52%	-25.71%	113.77%	-20.00%	101.01%	-20.00%	103.93%
	Combined	-25.71%	177.78%	-22.86%	102.39%	-11.43%	95.40%	-8.57%	103.93%
	Overall	-20.95%	148.15%	-23.81%	113.77%	-18.10%	108.49%	-15.24%	111.36%

Note. Table 9 displays all the bias percentages for array types that Participants 1, 2, and 3 met the inclusion criteria. *N/A* denotes that participant did not meet the inclusion criteria for that array type. Negative values indicate a left bias and positive values indicate a right bias. Relative center bias (denoted by R Center) informs likelihood of participant to select center location relative to probability.

Table 10.

Bias Percentages for Participants 4, 6, and 8

		Method 1		Method 2		Method 3		Method 4	
Pt		**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
4	Tangible	-17.14%	148.15%	-14.29%	91.01%	-11.43%	95.40%	-14.29%	103.93%
	Edible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	Tangible	-37.14%	237.04%	-25.71%	159.27%	-25.71%	145.90%	-25.71%	163.33%
	Edible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	Tangible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Edible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Combined	-22.86%	207.41%	-14.29%	159.27%	-5.71%	129.07%	-17.14%	141.05%
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note. Table 10 displays all the bias percentages for array types that Participants 4, 6, and 8 met the inclusion criteria. N/A denotes that participant did not meet the inclusion criteria for that array type. Negative values indicate a left bias and positive values indicate a right bias. Relative center bias (denoted by R Center) informs likelihood of participant to select center location relative to probability.

Table 11.

Bias Percentages for Participants 9, 10, and 11

		Method 1		Method 2		Method 3		Method 4	
Pt		Side	R Center	Side	R Center	Side	R Center	Side	R Center
9	Tangible	-28.57%	207.41%	-22.86%	193.40%	-11.43%	117.85%	-14.29%	148.48%
	Edible	14.71%	88.89%	11.76%	91.01%	20.59%	106.62%	11.76%	103.93%
	Combined	-28.57%	88.89%	-22.86%	102.39%	-8.57%	101.01%	-14.29%	118.78%
	Overall	-14.42%	128.40%	-11.54%	128.93%	0.00%	108.49%	-5.77%	123.73%
10	Tangible	-34.29%	148.15%	-37.14%	113.77%	-17.14%	129.07%	-31.43%	118.79%
	Edible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Combined	-5.71%	88.89%	-5.71%	102.39%	-14.29%	89.79%	-14.29%	103.93%
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11	Tangible	11.43%	148.15%	20.00%	136.52%	22.86%	117.85%	17.14%	126.21%
	Edible	8.57%	118.52%	5.88%	113.77%	0.00%	117.85%	-5.71%	111.36%
	Combined	-11.43%	148.15%	-5.71%	125.14%	2.86%	123.46%	-8.57%	133.63%
	Overall	2.86%	138.27%	6.73%	125.14%	8.57%	119.72%	0.95%	123.73%

Note. Table 11 displays all the bias percentages for array types that Participants 9, 10, and 11 met the inclusion criteria. *N/A* denotes that participant did not meet the inclusion criteria for that array type. Negative values indicate a left bias and positive values indicate a right bias. Relative center bias (denoted by R Center) informs likelihood of participant to select center location relative to probability.

Table 12.

Bias Percentages for Participants 12, 13, and 14

Pt		Method 1		Method 2		Method 3		Method 4	
		Side	R Center	Side	R Center	Side	R Center	Side	R Center
12	Tangible	37.14%	118.52%	31.43%	91.01%	25.71%	89.79%	28.57%	96.51%
	Edible	5.71%	148.15%	5.71%	102.39%	5.71%	95.40%	11.43%	111.36%
	Combined	20.00%	59.26%	2.86%	91.01%	8.57%	112.23%	20.00%	103.93%
	Overall	20.95%	108.64%	13.33%	94.80%	13.33%	99.14%	20.00%	103.93%
13	Tangible	29.41%	118.52%	23.53%	113.77%	17.65%	112.23%	14.71%	126.21%
	Edible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14	Tangible	-5.71%	88.89%	-8.57%	91.01%	5.71%	106.62%	-11.43%	96.51%
	Edible	-31.43%	59.26%	-28.57%	56.88%	-17.14%	61.73%	-25.71%	59.39%
	Combined	17.14%	88.89%	5.71%	147.90%	2.86%	112.23%	5.71%	141.05%
	Overall	-6.67%	79.01%	-10.48%	98.60%	-2.86%	93.53%	-10.48%	98.99%

Note. Table 12 displays all the bias percentages for array types that Participants 12, 13, and 14 met the inclusion criteria. *N/A* denotes that participant did not meet the inclusion criteria for that array type. Negative values indicate a left bias and positive values indicate a right bias. Relative center bias (denoted by R Center) informs likelihood of participant to select center location relative to probability.

Table 13.

Bias Percentages for Participants 15, 16, and 17

Pt		Method 1		Method 2		Method 3		Method 4	
		Side	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
15	Tangible	11.43%	88.89%	5.71%	125.14%	5.71%	140.29%	8.57%	133.63%
	Edible	-8.57%	118.52%	2.86%	136.52%	2.86%	112.23%	5.71%	126.21%
	Combined	-8.57%	59.26%	-17.14%	56.88%	-8.57%	112.23%	-8.57%	118.78%
	Overall	-1.90%	88.89%	-2.86%	106.18%	0.00%	121.59%	1.90%	123.73%
16	Tangible	22.86%	207.41%	11.43%	170.65%	14.29%	123.46%	11.43%	155.90%
	Edible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	Tangible	2.86%	59.26%	5.71%	102.39%	20.00%	112.23%	17.14%	126.21%
	Edible	-31.43%	59.26%	-25.71%	91.01%	-28.57%	84.18%	-31.43%	74.24%
	Combined	14.29%	118.52%	2.86%	136.52%	8.57%	101.01%	5.71%	126.21%
	Overall	-4.76%	79.01%	-5.71%	109.97%	0.00%	99.14%	-2.86%	108.88%

Note. Table 13 displays all the bias percentages for array types that Participants 15, 16, and 17 met the inclusion criteria. *N/A* denotes that participant did not meet the inclusion criteria for that array type. Negative values indicate a left bias and positive values indicate a right bias. Relative center bias (denoted by R Center) informs likelihood of participant to select center location relative to probability.

Table 14.

Bias Percentages for Participants 18, 19, and 26

		Method 1		Method 2		Method 3		Method 4	
Pt		**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**	**Side**	**R Center**
18	Tangible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Edible	-40.00%	88.89%	-40.00%	79.64%	-22.86%	95.40%	-25.71%	103.93%
	Combined	-26.47%	88.89%	-20.59%	102.39%	-2.94%	117.85%	0.00%	118.78%
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	Tangible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Edible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Combined	42.86%	118.52%	40.00%	79.64%	22.86%	95.40%	37.14%	59.39%
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
26	Tangible	5.71%	148.15%	0.00%	102.39%	8.57%	78.56%	2.86%	89.09%
	Edible	-2.86%	0.00%	-5.71%	159.27%	-14.29%	44.89%	-8.57%	44.54%
	Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note. Table 14 displays all the bias percentages for array types that Participants 18, 19, 26, and 27 met the inclusion criteria. *N/A* denotes that participant did not meet the inclusion criteria for that array type. Negative values indicate a left bias and positive values indicate a right bias. Relative center bias (denoted by R Center) informs likelihood of participant to select center location relative to probability.

Table 15.

Bias Percentages for Participant 27

Pt		Method 1		Method 2		Method 3		Method 4	
		Side	R Center	Side	R Center	Side	R Center	Side	R Center
27	Tangible	-45.71%	88.89%	-31.43%	91.01%	-25.71%	101.01%	-25.71%	103.93%
	Edible	-25.71%	0.00%	-37.14%	56.88%	-34.29%	84.18%	-34.29%	66.82%
	Combined	-5.71%	148.15%	-2.86%	113.77%	0.00%	95.40%	-5.71%	111.36%
	Overall	-25.71%	79.01%	-23.81%	83.43%	-20.00%	93.53%	-21.90%	94.04%

Note. Table 15 displays all the bias percentages for array types that Participants 27 met the inclusion criteria. *N/A* denotes that participant did not meet the inclusion criteria for that array type. Negative values indicate a left bias and positive values indicate a right bias. Relative center bias (denoted by R Center) informs likelihood of participant to select center location relative to probability.

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