Undermining position effects in choices from arrays, with implications for police lineups

Matthew A. Palmer, James D. Sauer, and Glenys A. Holt

University of Tasmania

Author note

Matthew Palmer and Glenys Holt, Division of Psychology, School of Medicine, University of Tasmania, Launceston, Tasmania, Australia. James Sauer, Division of Psychology, School of Medicine, University of Tasmania, Hobart, Tasmania, Australia.

We thank Peter Tranent, Kerri Magnussen, Miriam Rainsford, and Emily Palmer for help with data collection, and Maya Bar-Hillel for helpful comments on an earlier version of this article. This research was supported by Australian Research Council Grants DP0556876 and DP1093210 to N. Brewer et al. and DP140103746 to M. Palmer et al.

Correspondence concerning this article should be addressed to Matthew Palmer, Division of Psychology, School of Medicine, University of Tasmania, Locked Bag 1342, Launceston, TAS 7250, Australia. E-mail: matthew.palmer@utas.edu.au

Word count: 11,006

Abstract

Choices from arrays are often characterized by position effects, such as edge-aversion. We investigated position effects when participants attempted to pick a suspect from an array similar to a police photo lineup. A re-analysis of data from two large-scale field studies showed that choices made under realistic conditions—closely matching eyewitness identification decisions in police investigations—displayed edge-aversion and bias to choose from the top row (Study 1). In a series of experiments (Studies 2a-2c and 3), participants guessing the location of a suspect exhibited edge-aversion regardless of whether the lineup was constructed to maximize the chances of the suspect being picked, to ensure the suspect did not stand out, or randomly. Participants favored top locations only when the lineup was constructed to maximize the chances of the suspect being picked. In Studies 4 and 5, position effects disappeared when (a) response options were presented in an array with no obvious center, edges, or corners, and (b) instructions stated that the suspect was placed randomly. These findings show that position effects are influenced by a combination of task instructions and array shape. Randomizing the location of the suspect and modifying the shape of the lineup array may reduce misidentification.

Keywords: Choice under uncertainty; edge-aversion; eyewitness identification; position effects; visual array

Choices from arrays often exhibit position effects such as edge-aversion, whereby people favor middle options and avoid those at the edges (Bar-Hillel, 2015). Students guessing on a multiple-choice test (MCT) question choose options in central locations (*b*, *c*) rather than edge locations (*a*, *d*) approximately 70-80% of the time (Attali & Bar-Hillel, 2003; Berg & Rapaport, 1954). People favor the center and avoid the edges when choosing a product from a shelf, a seat to sit in, or which of a row of toilets to visit (Christenfeld, 1995; Shaw, Bergen, Brown, & Gallagher, 2000; Valenzuela & Raghubir, 2009).

Like the decisions described above, eyewitness identification decisions involve choosing from an array. In an identification test, a suspect is placed in a lineup with some known innocent fillers and the lineup is shown to a witness. If the witness picks the suspect from the lineup, it adds to evidence that the suspect is the culprit who committed the crime (Wells, 1993; Wells & Olson, 2002). Although lineups may be conducted with live lineup members standing in a row, in the U.S. it is now much more common for lineups to be presented to witnesses as an array of photographs on paper or a computer screen, for example in a 2 × 4 array (Police Executive Research Forum, 2013).

Edge-aversion is inconsequential for many of the decisions listed above, but this is not the case for eyewitness identification decisions. Eyewitness misidentification is considered the leading cause of wrongful imprisonment in the U.S. (Brewer & Wells, 2011; Garrett, 2011; Innocence Project, 2015), and studies by groups such as the U.S. National Institute of Justice and National Research Council have focused on understanding eyewitness identification decisions and developing procedures that improve their accuracy (National Institute of Justice Technical Working Group for Eyewitness Evidence, 2003; National Research Council, 2014). Position effects may be especially problematic in eyewitness identification decisions because witnesses tend to pick from lineups even when their memory for the culprit is poor, and when the lineup does not contain the culprit but instead contains an innocent suspect (e.g., Wells, 1993). Edge-aversion would not only contribute to error in identification decisions but—as we will argue—would likely increase the rate of mistaken identification of innocent suspects. In this research, we test whether edge-aversion occurs in eyewitness identification decisions, and build on previous research (Bar-Hillel, 2015; Falk, Falk, & Ayton, 2009) to investigate whether position effects can be undermined by modifying the way that response options are presented.

What causes edge-aversion?

Bar-Hillel (2015) developed a comprehensive framework for understanding position effects in choices from arrays. This framework illustrates how various mechanisms give rise to edge-aversion, and other position effects (e.g., under some circumstances, people favor the first and last options when selecting from a list; Dayan & Bar-Hillel, 2011; Ert & Fleischer, 2014).

Central locations are representative. For some decisions, edge-aversion is thought to occur because centrally-located options are more representative than edge ones and, therefore, come to mind more easily (Bar-Hillel, 2015; Bar-Hillel, Peer, & Acquisti, 2014). When there is no meaningful basis for choosing one option over any other in the array, decision makers favor the option that is most representative. For example, when asked to choose a number from within a specified range, people favor numbers towards the middle of the range over those at the ends (e.g., Kubovy & Psotka, 1976; Teigen, 1983). This tendency can be explained in terms of central numbers coming to mind more easily than edge ones as typical representations of the whole range of possible responses (Bar-Hillel, 2015).

It is important to note that in this context, *representativeness* refers specifically to how representative a particular location is of all possible locations in the array (Bar-Hillel, 2015). It does not refer to how representative or typical a response option is in terms of other properties. For example, response options on MCTs might be compared in terms of how well their content represents possible answers. Consider a MCT question: “What color is the background of the Australian flag?” One response option (*blue*) might be perceived as more representative of colors than other options (*crimson* or *jade*). Similarly, faces in an array might be compared in terms of how typical their features appear. Comparisons such as these are not included in the scope of “representativeness” in the present context; we refer to representativeness only in terms of the location of response options in an array.

Central locations are good hiding places. Position effects also occur for strategic reasons in choices that involve competitive interaction with another person, in which the decision maker tries to guess or predict another’s response on a given task. A classic example is the “battleships” game in which the seeker wins by correctly guessing the location chosen by the hider (Bar-Hillel, 2015). Edge-aversion occurs in such tasks: hiders and seekers in battleship-style games avoid prominent locations in the corners or edges of arrays, and favor more representative locations (Falk et al., 2009; Rubinstein, Tversky, & Heller, 1997). Edge-aversion also occurs in MCT questions: students answering questions and teachers constructing questions both avoid prominent locations (first and last), consistent with the notion that the teacher “hides” the answer to prevent an unknowledgeable student from guessing correctly.

These effects are best understood in terms of central locations being perceived as better hiding places than edge locations. When trying to hide a response, or guess where a response has been hidden, people avoid the most prominent locations in an array and favor locations perceived as more typical and representative (Bar-Hillel, 2015; Falk et al., 2009). Corners and edges are perceived as prominent and are, thus, avoided. In contrast, in coordination games, when tasks are cooperative (i.e., both players win if they can correctly guess each other’s choices) the opposite pattern is found: People favor the prominent locations, such as the edges and corners of arrays (Falk et al., 2009; Schelling, 1960).

Together, these results indicate that hiders and seekers share similar notions about which locations in an array are the most prominent and the most representative, and make use of these perceptions when guessing another's response.

Position effects in eyewitness identification tests

Like the tasks described in the preceding section, eyewitness identification decisions require the decision maker (the witness) to attempt to choose one specific alternative (the suspect) from among an array of options (the lineup members). However, there are some important differences between these tasks and identification decisions. Battleship games can be configured as competitive, zero-sum games (whereby one player's win is the other's loss) or cooperative games (whereby either both players win or both lose). Eyewitness identifications do not map neatly onto either of these scenarios. The crucial difference is that, unlike battleship games—and MCTs—there is no known correct answer for an identification decision. The police conducting the test have a suspect but do not know for certain whether this person is the perpetrator or innocent; ideally, the point of the test is to gather evidence. If the witness picks the suspect, it is evidence that the suspect might be the perpetrator. If the witness does not pick the suspect, it is evidence that the suspect might be innocent. The witness's decision is weighed along with all other evidence accumulated in the case to shape investigators' judgments about the likely guilt of their suspect. Thus, in conducting a lineup, the police are trying to ascertain the identity of the perpetrator; they do not stand to win or lose depending on the witnesses' identification decision.

Although identification decisions are not strictly competitive or cooperative, this does not preclude position effects in identification decisions. Witnesses may perceive lineup tasks as possessing some characteristics of competitive or cooperative tasks, depending on the assumptions made by the witnesses about the test. For example, a witness might assume that unbiased investigators want to provide a good test of the witness's memory for the perpetrator, and will "hide" the suspect in the lineup accordingly. Under such conditions, we would expect edge-aversion to occur. Alternatively, witnesses may assume that investigators are biased and want the suspect to be identified, and will place the suspect to maximize the chances of identification. Under these conditions, witnesses would be expected to favor prominent locations. One aim of the present research was to test whether information about lineup construction (i.e., fair or biased) influences edge-aversion in identification responses.

We emphasize that edge-aversion—or any other position effect—is unlikely to account for a large amount of variance in identification decisions. Being highly motivated to answer correctly, witnesses presumably try to base identification decisions on the degree of match between their memory of the culprit and the lineup members. If this does not provide sufficient basis for a decision (e.g., the witness may have a poor memory of the culprit), we might hope that witnesses will reject the lineup. However, there is ample evidence that, for a variety of reasons, witnesses sometimes identify a lineup member despite insufficient memorial evidence for doing so (e.g., Lindsay & Wells, 1985; Wells, 1984, 1993). For example, a witness might assume that the culprit must be somewhere in the lineup because police would not go to the trouble of organizing a lineup unless there was substantive corroborating evidence to implicate the suspect.

A witness who is predisposed to pick someone from a lineup, but cannot do so based on memory, might attempt to base a decision on some other cue that is perceived as a valid indicator of who the suspect might be, similar to the way cues are used in decisions under uncertainty in many domains (e.g., Gigerenzer & Goldstein, 1996; Gigerenzer, Hoffrage, & Kleinbölting, 1991; Kahneman & Frederick, 2002; Tversky & Kahneman, 1974). Witnesses are influenced by subtle behavioral cues from lineup administrators (Greathouse & Kovera, 2009; Haw & Fisher, 2004), which demonstrates that witnesses are sensitive to—and susceptible to—cues indicating who the lineup administrator would like them to pick.

Lacking cues from the lineup administrator, the witness may, for example, look for clues in the quality of lineup photos (does one photo have higher resolution than the others?) or try to infer personality characteristics from the appearance of lineup members (does one appear shiftier than the others? Flowe, 2012; Weigold & Wentura, 2004). This is where edge-aversion might come into play: Lacking a better cue, the witness might pick the location where they believe the suspect is most likely to appear in the array.

Undermining edge-aversion

There are two important reasons to try to minimize edge-aversion in eyewitness identification tests, even if it is unlikely to account for a large amount of variance in identification decisions. First, we can assume that a fair lineup administrator will want to minimize any source of bias in responses. Second, reducing edge-aversion will likely reduce the rate of misidentifications of innocent suspects. Edge-aversion can influence not only witnesses, but also lineup administrators. The person constructing the lineup often chooses the location of the suspect (this occurs in 31% of agencies in the U.S.; Police Executive Research Forum, 2013). In a survey of 220 police officers, the vast majority reported that "they usually place the suspect in the middle of both live (87%) and photographic lineups (81%)" (Wolgater, Malpass, & Burger, 1993, p. 641). If suspects are more likely to appear in central locations in a lineup, and witnesses with poor memories of the culprit are more likely to guess from central locations in a lineup, it follows that edge-aversion will systematically increase the likelihood that suspects will be misidentified from lineups by witnesses with poor memories. We note that this process may also lead to an increase in correct identifications of guilty suspects but—as we argue in the General Discussion—this does not negate the need to reduce misidentifications.

Random placement of response options. At first glance, it may be tempting to think that position effects could be mitigated simply by informing people that response options were arranged randomly in the array. Random arrangement suggests that the lineup administrator is simply trying to be fair (without trying to help or hinder the witness) and means that the correct answer has an equal chance of appearing in any position in the array.

However, this solution is unlikely to work because people show systematic biases in simulations of random patterns (e.g., Falk et al., 2009; Goodfellow, 1938; Rubinstein et al., 1997). When attempting to choose randomly from arrays, people exhibit edge-aversion, avoiding edge and corner locations and favoring central locations (Falk et al., 2009). These biases mimic those found in competitive choices, but for different reasons: People favor central locations in competitive tasks because they are perceived as the best hiding places, whereas they favor central locations in random choices because these come to mind most easily as representative of the range of possible responses (Bar-Hillel, 2015). Thus, informing participants that response options were arranged randomly will likely produce edge-aversion rather than mitigating position effects.

Modifying the shape of the array. Simply informing people about random arrangement of response options is unlikely to remove position effects, but this approach might be more successful if combined with modification of the shape of the array itself. If perceptions of a location's representativeness (and prominence) are determined by its proximity to edges and corners, then locations will be perceived as prominent to the extent that they are close to an edge or corner, and representative to the extent that they are away from edges and corners.

A logical extension of this reasoning is that it might be possible to undermine edge-aversion by modifying the shape of the array so that no particular location is closer to edges or corners than any other locations (e.g., in a circle). If we can remove the basis for perceiving some locations as more representative or more prominent than others, then all locations will be equally representative of a typical choice or a prominent choice. In turn, choices should be distributed evenly across all possible locations in the array, regardless of whether the witness perceives the lineup as arranged fairly, with bias, or randomly.

Overview of Experiments

We tested these ideas in a series of experiments. In Study 1, we analyzed data from two large field studies to examine position effects in eyewitness identification decisions made under realistic conditions, as might occur in police investigations. In Studies 2-5, we examined whether position effects vary with instructions about the nature of the task (i.e., whether the lineup was arranged to hide the suspect, make the suspect stand out, or randomly) and the shape of the array. Given that edge-aversion is most likely to arise under conditions in which the decision maker cannot base the decision on a better source of information, such as memory for the perpetrator (cf. Gigerenzer et al., 1991), these experiments involved very simple choices from arrays, where little or no information apart than position could be used as the basis for a decision.

These studies were motivated in part to investigate and find potential solutions for edge-aversion in police lineups. However, they will also inform our understanding of mechanisms that underpin systematic patterns in choices from arrays. If modification of the shape of an array does alleviate position effects, it would provide evidence that proximity to edges and corners plays a critical role in position effects (such as edge-aversion) and in biased perceptions of randomness (Bar-Hillel, 2015; Falk et al., 2009).

Study 1: Analysis of field experiment data

To test whether edge-aversion would occur in identification decisions made under realistic conditions—similar to what would occur in an actual police investigation—we re-analyzed data from two large (*N*s > 900) eyewitness identification field experiments (Palmer, Brewer, Weber, & Nagesh, 2013, Experiment 1; Sauer, Brewer, Zweck, & Weber, 2010). In each, participants viewed a target person and then attempted to identify that person from an

8-person photo-array (see Figure 1, panel B for an example). Critically, in both experiments location information was recorded for all positive identification decisions , including correct picks of the target person and incorrect picks of lineup fillers.

Based on the assumption that participants in these studies perceived the lineup to be administered fairly (i.e., the lineup administrator was not trying to maximize the chances of the suspect being picked), we expected responses to exhibit edge-aversion. We examined edge-aversion in two ways. First, we took data for target-absent lineups (i.e., lineups that did not contain the target person the participant had viewed earlier) in both studies and examined the proportion of incorrect picks made from center locations as opposed to edge locations. Second, we examined responses for target-present lineups (i.e., that contained the target person) in Palmer et al. (2013) and tested whether targets were more likely to be correctly identified when they were placed in center locations rather than edge locations. The latter analysis could not be conducted on the Sauer et al. (2010) data, because the location of the target in target-present lineups was held constant. Regarding the second analysis, one previous study has provided evidence that culprits are more likely to be correctly identified from center locations than edge locations. Using a 5-person live lineup, O'Connell and Synnott (2009) found that witnesses were more likely to correctly identify the culprit when placed in a central location in the lineup compared to the far left or far right.

[Insert Figure 1 here]

Method

Details of methodology can be found in Palmer et al., (2013) and Sauer et al. (2010); a brief summary is provided here. Participants in each study were members of the public recruited in public places. For Palmer et al. (2013) the sample size was *N* = 908 (517 female; mean age = 33 years, *SD* = 15). For Sauer et al. (2010), the sample size was *N* = 1063 (548 female; mean age = 29 years, *SD* = 14). In both experiments, each participant viewed a target person and later attempted to identify that person from a lineup of eight photos arranged in two rows of four. In Palmer et al., the delay between encoding and test was either a few minutes or approximately one week; in Sauer et al. the delay was either a few minutes or approximately three weeks.

In both experiments, participants viewed either a target-present lineup (containing the target person) or a target-absent lineup (not containing the target person). Prior to attempting an identification test, participants were warned that the person they were looking for may or may not be in the lineup, and were given the option of responding “not present” to indicate that they thought the person was not in the lineup.

Lineup construction. Both studies used multiple sets of stimuli. Palmer et al. (2013) used six student volunteers (four Caucasian females, one Caucasian male, one Asian female) as targets. For each target, two lineups were constructed: a target-present lineup comprising a photo of the target and photos of seven fillers, and a target-absent lineup in which the target was replaced with another filler. For each target, filler photos were chosen from a larger database of photos and were selected on the basis that they matched the description of the target person (Wells, Rydell, & Seelau, 1993). The suitability of fillers was established via a multi-step process (Palmer, Brewer, McKinnon, & Weber, 2010) in which one group of participants viewed the targets and provided a description of each, and a different group of participants rated how well each of the fillers matched the corresponding descriptions. This ensured that all fillers were plausible matches for the appearance of the perpetrator.

The location of the six targets was counterbalanced such that each target appeared in a different location in the lineup, excluding top-left and bottom-right. Across all stimuli, targets appeared in center locations in 248 trials and edge locations in 208 trials. For each set of photos, one filler was chosen at random to be the target replacement; this photo took the place of the target in target-absent lineups. The other seven fillers were placed randomly in the remaining locations in the lineup.

Sauer et al. (2010) used five different Caucasian female student volunteers as targets. For each target, the target-present lineup comprised a photo of the target and photos of seven fillers, and the target-absent lineup comprised photos of eight fillers. Filler photos were chosen from a larger database of photos and were selected on the basis that they matched the description of the target person, as determined by agreement between experimenters. For each set of photos, one filler was chosen arbitrarily to be the target replacement. For target-absent lineups (analyzed here), the target replacement always appeared in the top row second-from-right (the location of the target in target-present lineups), and the other seven fillers were randomly placed in the remaining locations in the lineup.

Results and Discussion

Target-present lineups. Targets were 1.63 times as likely to be correctly identified if they appeared in a center location compared to an edge location in the Palmer et al. (2013) study. Of 248 trials in which the target person appeared in a center location, the target was correctly identified in 167 (.67 [.61, .73]). Of 208 trials in which the target person appeared in an edge location, the target was correctly identified in 86 (.41 [.35, .48]). A 2 (location: center, edge) × 2 (accuracy) chi-square test indicated that accuracy was higher when the culprit appeared in center locations than edge ones, $\chi^2(1, N = 456) = 30.94$, $p < .001$.

Target-absent lineups. Across both studies, witnesses were 1.27 times as likely to make an incorrect identification from a center location as an edge location. The meta-analytic proportion of center responses was .56 [.51, .61] and variation between the studies was non-significant, $Q = 0.39$, $p = .532$. The Q statistic indexes heterogeneity across studies (Cochran, 1954) and was calculated using the *metaprop* function for R with default settings (Schwarzer, 2015).

We next examined the studies individually. Figure 2 (panel A) shows choices by location in each data set. Witnesses in Sauer et al. (2010) who viewed a target-absent lineup were 1.37 as likely to make an incorrect identification from a center location as an edge location. Of 194 incorrect identification responses from target-absent lineups, 112 were from center locations (.58 [.51, .65]), goodness-of-fit $\chi^2(1, N = 194) = 4.64$, $p = .031$. In Palmer et al. (2013), witnesses were 1.20 times as likely to make an incorrect identification from a center location as an edge location. Of 187 responses, 102 were from center locations (proportion = .55 [.47, .62]); this distribution did not differ significantly from uniform, goodness-of-fit $\chi^2(1, N = 187) = 1.55$, $p = .214$.

Taken together, these results provide evidence for position effects in an eyewitness identification task that closely approximates what might occur in police investigations. The data showed evidence of edge-aversion: Incorrect picks from target-absent lineups were more likely to occur from center than edge locations, and culprits were more likely to be identified when placed in a center location than an edge one (see also O'Connell & Synnott, 2009). Thus, when witnesses had viewed a target person—and, hence, were able to base identification decisions on the match between the lineup members and their memory for that person—they favored center locations over edge locations. Given lineup administrators' tendency to place suspects in central locations, this error systematically increases the risk of mistaken identification for innocent suspects in target-absent lineups.

There was also a bias to choose from the top row in target-absent lineups (see Figure 2, panel A). In Palmer et al. (2013), .60 [.53, .67] of choices were from the top row, goodness-of-fit $\chi^2(1, N = 187) = 7.32$, $p = .007$. In Sauer et al. (2010), .71 [.64, .77] of choices were from the top row, goodness-of-fit $\chi^2(1, N = 194) = 32.99$, $p < .001$. This bias was not anticipated. Although top-bias has been observed in choices from menus (Dayan & Bar-Hillel, 2011) and products on shelves (Valenzuela & Raghubir, 2015), these effects have been explained in terms of mechanisms that would not be expected to operate in lineup choices (e.g., beliefs that more valuable products are placed on top shelves). Nevertheless, the data showed a clear tendency for witnesses to favor the top row over the bottom row.

One limitation of these analyses is that they are based on experiments in which the location of lineup members was not counterbalanced. Ideally, each lineup member would have appeared equally often in each location in the lineup. However, we argue that the results obtained are unlikely to be due to the lack of counterbalancing, given that (1) each study used at least five sets of stimuli, (2) each filler was selected to be a plausible match for the target person, and (3) the location of fillers was randomly determined for each set of stimuli.

[Insert Figure 2 here]

Study 2: Position cues only

Study 1 provided evidence of position effects in eyewitness identification decisions made under realistic conditions. In Study 2, we used a more artificial task that allowed us to closely examine the influence of position effects on choices from an array. We showed participants an array of blank rectangles that represented eight photos in a lineup (see Figure 1, panel A). Photo-array lineups have become common in recent years—replacing traditional live lineups in many cases—and typically involve placing images of lineup members in an array of two or more rows. Participants were told that the lineup comprised one suspect and seven fillers and were asked to guess where the suspect would be placed. This task allowed us to examine the influence of position effects when location was the only available cue.

In Study 2, we also investigated whether edge-aversion in choosing from lineups varies depending on the instructions given to witnesses about how the lineup was arranged. We informed some participants that guidelines for constructing lineups require that the suspect is placed so that they do not stand out among the fillers (*fair lineup* condition). Other participants were informed that a police officer placed the suspect to maximize the chances that the suspect will be picked by the witness (*biased lineup* condition).

We conducted three versions of this experiment. Study 2a provided an initial test of position effects. Studies 2b and 2c included manipulation checks to ensure that participants read and processed information about how the lineup arrangement.[1] Study 2c also used alternative wording to rule out the possibility that the specific wording of instructions in Studies 2a and 2b may have prompted some participants to favor central locations.

Method

Participants were students at the University of Tasmania. Sample sizes were 123 for Study 2a, 64 for Study 2b, and 47 for Study 2c (37 female; aged 18 to 61 years, M = 26 years, SD = 8.5). Demographic data were not collected in Studies 2a and 2b.[2] Participants in all experiments volunteered their time and did not receive payment or course credit. In most cases, participation only required a few minutes.

Pencil-and-paper format was used to provide instructions and collect responses. Verbatim instructions and measures for all experiments are provided in the Supplemental Material. Participants were provided with a brief, written explanation of how identification tests work and then shown a hypothetical police lineup with eight blank squares in place of faces, arranged in two rows of four. The instructions stated that the lineup included one suspect and seven fillers (innocent people) and participants were asked to indicate where they thought the suspect would appear. We did not provide a "not present" response option because we were not asking participants to decide whether the perpetrator was in the lineup, but to choose the location of the suspect in the lineup.

We manipulated the written instructions about the lineup construction method. Participants in the *fair* condition were instructed that "the guidelines for constructing lineups say that, in order to ensure that the lineup is not biased, the suspect should be positioned so that they do not stand out amongst the fillers." Participants in the *biased* condition were told to "imagine the police officer wants to position the suspect within the lineup so as to maximize the chances that the witness will pick the suspect." The two different versions of instructions (fair and biased) were shuffled together before being distributed to participants.[3]

For Study 2b, materials and procedure were identical with the exception of a manipulation check question. After participants indicated which lineup member they thought was the suspect, participants turned over the page (so they could not see the lineup instructions) and were asked to: "Think back to the lineup on the previous page. How was the lineup constructed?" Participants were asked to tick one of two boxes marked "so that the suspect would not stand out from the other lineup members" and "to maximize the chances that the witness would pick the suspect".

For Study 2c, materials and procedure were identical to Study 2b except for the following changes to lineup instructions. The instructions in Studies 2a and 2b included some wording that may have prompted some witnesses to assume that the suspect must be in one of the central locations in the lineup (e.g., "the suspect should be positioned so that they do not stand out amongst the fillers"; "imagine the police officer wants to position the suspect within the lineup"). In Study 2c, we altered the instructions to remove this possibility. Instructions in the *fair* condition stated "To ensure that the lineup was fair, the police officer was instructed to arrange the photos so that the suspect did not stand out." Instructions in the *biased* condition stated "Imagine that the police officer arranged the photos to maximize the chances that the witness would pick the suspect." In both conditions, the instruction immediately after these statements read "Where do you think the police officer would place the suspect?" instead of "Where do you think the police officer would place the suspect in the lineup?" as in Studies 2a and 2b.

Results

Manipulation checks. Most participants responded correctly to the manipulation check in Study 2b (81% correct; $n = 51$ of 63; one person did not complete the manipulation check) and Study 2c (89% correct; $n = 42$ of 47). In Study 2b, accuracy did not differ between the fair (84% correct) and biased conditions (78% correct), $\chi^2 < 1$. In Study 2c, accuracy on the manipulation check was higher in the *fair* condition (100%; 24 of 24) than the *biased* condition (78%; 18 of 23), $\chi^2(1, N = 47) = 5.84$, $p = .016$.

Suspect choices. Figure 2 (panel B) shows response proportions for each of the eight lineup positions in each condition for Studies 2a-2c. Overall, there was clear evidence of edge-aversion. In each of the three experiments, participants were more than twice as likely to choose one of the four center locations compared to one of the four edge locations. The proportion of center choices in Study 2a was .76 [.68, .83], odds = 3.24. A goodness-of-fit test indicated a greater proportion of center responses than edge responses, $\chi^2(1, N = 123) = 34.35$, $p < .001$. In Study 2b, the proportion of center choices was .73 [.62, .83], odds = 2.76, goodness-of-fit $\chi^2(1, N = 64) = 14.06$, $p < .001$. In Study 2c, the proportion of center choices was .70 [.56, .81], odds = 2.36, goodness-of-fit $\chi^2(1, N = 47) = 7.68$, $p = .006$.

Instructions about lineup construction had minimal effect on edge-aversion: The proportion of central locations chosen did not differ between the *fair* and *biased* conditions in any of the three experiments (all χ^2 values < 1; see Figure 2, panel B, for proportions of choices in each condition). Importantly, these patterns did not change when we excluded participants who answered incorrectly on the manipulation checks. With these participants excluded, the proportion of central choices still did not differ between the *fair* and *biased* conditions in Studies 2b and 2c (χ^2 values < 1). This suggests that lack of information processing did not contribute to the similar rate of edge-aversion for fair and biased conditions.

Although edge-aversion occurred to a similar extent in both instruction conditions, the conditions differed in terms of bias to choose from the top row, with participants in the *biased* conditions—but not the *fair* conditions—favoring the top row (see Figure 2, panel B, for proportions by individual location). In Study 2a, locations in the top row were chosen more often in the *biased* condition (.69 [.57, .79]) than the *fair* condition (.49 [.37, .61]), χ^2(1, *N* = 123) = 5.19, *p* = .023. Similarly, in Study 2b, locations in the top row were chosen more often in the *biased* condition (.79 [.62, .89]) than the *fair* condition (.48 [.32, .65]), χ^2(1, *N* = 64) = 6.42, *p* = .011. In Study 1c, the same pattern emerged but the difference between the *biased* (.70[.49, .84]) and *fair* conditions (.50[.31, .69]) was non-significant, χ^2(1, *N* = 47) = 1.87, *p* = .172. The location second-from-right in the top row was especially popular; across Studies 2a-2c, this location was chosen by 35% of participants in the *biased* conditions (41 of 118) and 29% of participants overall (69 of 234).

Discussion

These results provide evidence of edge-aversion in a lineup task, consistent with the idea that participants viewing a lineup expect that the suspect is more likely to be placed in a center location than an edge location. Edge-aversion occurred regardless of whether participants were told that the lineup was constructed to maximize suspect choices (*biased*) or so that the suspect did not stand out (*fair*). This pattern was consistent across Studies 2a-2c.

Instructions did, however, affect the pattern of choices in another way. Locations in the top row were favored in the *biased* condition but not the *fair* condition. Again, this pattern occurred consistently across Studies 2a-2c. It is worth recalling that in Study 1, the top row was favored even though task instructions contained no information about the intentions of the lineup administrator when arranging the lineup members. The similarity between the results of Study 1 and those of Studies 2-4 suggests that, in the absence of explicit information to the contrary, witnesses likely assume that lineups are constructed to maximize the chances that the suspect will be picked.

Studies 2a-2c demonstrated position effects under the most basic conditions, in which participants had no information other than location in the array on which to base their responses. In Study 3, we test whether position effects occur when the physical appearance of lineup members can also act as a cue for choices.

Study 3: Lineup Arrays with Faces

The first aim of Study 3 was to replicate the results of Study 2 in a more realistic task in which cues other than array position were available. Rather than a set of rectangles representing photos in a lineup, participants were shown a set of eight photos arranged as a lineup and asked to guess which one was the suspect (see Figure 1, panel B for an example). As in Study 2, participants had no prior exposure to a suspect or any other faces in the lineup, and thus no memorial basis for a decision.

The second aim was to test whether a different type of instruction could undermine edge-aversion. In Study 3, some participants were informed that the lineup photos were arranged by a police officer attempting to construct a fair lineup (i.e., in which the suspect did not stand out from fillers) and some were informed that the lineup photos were arranged by a computer that placed them randomly. As outlined in the Introduction, systematic biases in perceptions of randomness might be expected to undermine the efficacy of such instructions and produce patterns of responses that closely match those found under fair conditions (e.g., Falk et al., 2009). However, this simple and intuitive possibility requires empirical testing.

All else being equal, information about random placement of lineup photos should, in theory, undermine edge-aversion because it implies that the suspect has an equal chance of appearing in any position in the lineup. Thus, there is no reason to think that a central position is more likely to contain the suspect. However, due to systematic biases in perceptions of randomness and simulation of random patterns, instructions about random placement might instead produce patterns of responses closely matching those found under fair conditions, with edges and corners avoided in favor of central locations (e.g., Falk et al., 2009).

The third aim was to examine the pattern of edge-aversion across a series of responses to different lineups. This was not our major focus; we were most interested in responses to the first lineup, which are most relevant from an applied perspective. Although witnesses sometimes view multiple lineups during police investigations for various reasons, it is much more common for witnesses to view only one lineup (Horry, Halford, Brewer, Milne, & Bull, 2014; Palmer, Brewer, & Weber, 2010; 2012). However, we were interested in whether edge-aversion across a series of lineup responses would follow the same pattern found in multiple-choice questions, whereby edge-aversion dissipates over a series of responses as people try to spread their guesses out across all possible options (Attali & Bar-Hillel, 2003). To investigate this, we asked participants to guess the suspect in each of a series of four lineups (involving different faces). As in multiple-choice tests, we expected edge-aversion to be strongest for an initial decision and get weaker across subsequent decisions.

Method

Participants (*N* = 73) comprised undergraduate students from the University of Portsmouth and University of Tasmania, and members of the public in Portsmouth, UK. Demographic data were not collected.

Participants were given some background information about identification tests and were shown a series of four photo-lineups, one lineup at a time. We used 2 × 4 arrays, with eight faces arranged in two rows of four on an A4 sheet of paper (see Figure 1, panel B). Each lineup contained eight photos that matched a particular physical description (e.g., Lineup 1: White male, aged late 30s to early 40s, bald, muscular build. Lineup 2: White female, aged late 30s to early 40s; long, wavy blond hair). The order of presentation of the four lineups and position of faces within each lineup were counterbalanced.

Participants were informed that each lineup contained one suspect and seven fillers (i.e., people who were known to be innocent) and were asked, for each lineup, to guess which face was the suspect. Participants were randomly allocated to the two information conditions. Participants in the *fair* condition (n = 37) were told that each lineup was constructed by a police officer who arranged the photos so that the suspect did not stand out from the other lineup members. Participants in the *random* condition (n = 36) were told that each lineup was constructed by a computer program that placed the photos randomly. As in Study 2, all instructions were provided in written form and the two versions were shuffled before being distributed to participants.

Results

First lineup viewed. As outlined earlier, we were most interested in participants' responses for the first lineup they viewed. The first lineup is where edge-aversion is most likely to occur and best matches what would likely happen in actual police investigations (where witnesses most often view only one lineup; e.g., Horry et al., 2014). Frequencies of responses in each of the eight positions for the first lineup are shown in Figure 2, panel C. We calculated edge-aversion based on the number of choices from the middle four positions compared to the outer four.

Overall, responses were more than twice as likely to be from one of the center four positions (.71 [.60, .80]) than the outer four positions (.29 [.20, .40]), goodness-of-fit $\chi^2(1, N = 73) = 13.16$, $p < .001$, odds = 2.48. Information about the method of lineup construction had minimal effect on the proportion of center responses to the first lineup viewed, with very similar proportions of center responses in the *fair* (.73 [.57, .85]) and *random* conditions (.69 [.53, .82]), $\chi^2(1) < 1$, $p = .739$.

Subsequent lineups. Response frequencies for each condition for lineups two to four appear in Supplemental Material (Figure S1). Information about the method of lineup construction had little effect on the proportion of center responses for lineups two to four, all χ^2 values < 2.31, all *p* values > .128.

The proportion of center responses was .63 [.52, .73] for the second lineup viewed, .44 [.33, .55] for the third lineup, and .58 [.46, .68] for the fourth lineup. A Cochran's *Q* test yielded a significant effect across the four responses, $Q(3) = 11.16$, $p = .011$. Follow-up pairwise comparisons revealed that the proportion of center choices was lower for the third lineup viewed than the first, $p = .007$. No other differences were statistically significant.

Discussion

Participants showed marked edge-aversion in their responses to the first lineup viewed. Thus, the edge-aversion effect found in Studies 2a-2c was replicated with a more realistic task in which participants have access to cues about the appearance of lineup members, as well as the position of lineup members within the photo-array. There was some evidence that edge-aversion decreased across participants' responses to the four lineups, a pattern previously found with multiple-choice tests (Attali & Bar-Hillel, 2003) and consistent with the notion that participants distributed their responses across different options over the series of decisions. However, from an applied viewpoint, the edge-aversion bias for initial responses is especially relevant to forensic settings, in which witnesses most often view only one lineup during a police investigation (e.g., Horry et al., 2014).

The emergence of edge-aversion under *fair* and *random* instruction conditions indicates that witnesses will tend to guess from center locations in a lineup regardless of how they think the lineup was constructed. In a brief follow-up study to test the effectiveness of the instruction manipulation, 83% (19 of 23) of participants answered a manipulation check correctly, suggesting that the similar levels of edge-aversion in the experimental conditions was likely not due to participants failing to process information about lineup construction. (See Supplemental Material for details.)

Study 4: Modifying the Shape of the Array

The results of Studies 1 to 3 show that edge-aversion occurs in responses to lineups, and that it cannot be attenuated simply by modifying instructions about how the lineup photos were arranged. Regardless of whether instructions stated that the lineup photos were arranged randomly, or to ensure the suspect does not stand out, or to maximize the chances that the suspect would be picked, participants avoided locations at the left and right edges of the array in favor of center locations.

In Studies 4 and 5, we explored a different strategy for trying to undermine edge-aversion. Our strategy was based on two assumptions: (1) that edge-aversion is based on avoiding prominent locations in favor of representative ones (Bar-Hillel, 2015), and (2) that the distinction between prominent and representative locations is based on proximity to prominent features of the array, such as edges, corners, and the center of the array. Given these assumptions, we reasoned that edge-aversion could be undermined by presenting response alternatives in a shape that does not have a clear center, or obvious corners or edges. In such an array, there would be no basis for perceiving some locations as closer to edge or center positions than others and, therefore, no basis for systematically avoiding some locations in favor of others.

To test this idea, we used a tilted circle array (see Figure 3). This arrangement was based on the notion of placing response options in a circle, then rotating the circle clockwise so that the top-bottom axis was angled from approximately 1 o'clock to 7 o'clock. Although there are other options for arranging response options without a clear center (e.g., a non-tilted circle; see Supplemental Material for examples from a pilot study), the tilted circle array has the added advantage of having no alternatives clearly appearing at the top-center, bottom-center, left-center, or right-center. We reasoned that this would minimize the chances of lineup choices being affected another type of position bias, such as favoring the left side (as found in face-matching tasks; Megreya, Bindemann, Harvard, & Burton, 2012).

[Insert Figure 3 here]

Method

Participants. Participants in Study 4 were 119 undergraduate students from the University of Tasmania (88 female; aged 18 to 51 years; *M* = 23 years, *SD* = 8.3) who completed the study in classroom settings under the supervision of an experimenter.

The procedure was similar to Study 2. Participants viewed an array of eight blank squares arranged in a tilted circle array (see Figure 3). Participants were informed that the squares represented an arrangement of photos to be used in a police lineup, and that one photo was of the police suspect and the other seven were known-to-be-innocent people. Participants were asked to indicate where they thought the suspect would be placed in a lineup by marking that square.

We manipulated information about lineup construction methods. In one version of the instructions, participants were told that the photos had been placed randomly in the lineup by a computer (*random* condition; *n* = 56). In the other version, participants were told that the photos had been arranged by a police officer who was trying to make the suspect stand out so that they would be picked (*biased* condition; *n* = 63). Instructions regarding the experiment and manipulation were provided via written information, and the two versions were shuffled before being distributed to participants.

Results

Figure 3 (panel A) shows the response proportions for each lineup position in each instruction condition. The pattern of responses across the eight positions differed markedly depending on instructions about array construction, $\chi^2(7) = 21.39$, *p* = .003. Participants in the biased condition showed a clear preference for expecting that the suspect would appear in one of the two positions at the top-right of the array. A goodness-of-fit test showed that the distribution of responses across the eight lineup positions differed from uniform, $\chi^2(7, N = 63) = 77.32$, $p < .001$.

In contrast, for participants who read that the photos were randomly arranged, responses were spread very evenly across the eight positions. A goodness-of-fit test showed that the distribution of responses across the eight lineup positions did not differ from uniform, $\chi^2(7, N = 56) = 2.00$, $p = .960$.

Discussion

With a lineup array arranged in a tilted circle shape, participants' choices varied markedly depending on instructions about how the array was constructed. Participants who were told that the lineup was arranged to maximize the chances of the suspect being selected clearly favored the two top-right locations. In contrast, those who were told that the lineup was constructed randomly by a computer did not exhibit any position effects, and spread their choices out evenly across the eight array locations.

In light of the results of Studies 2 and 3, these results lead to two important conclusions. First, the top-bias observed in Study 4 aligns with the top-bias found in Studies 2 and 3. In all three studies, participants favored locations at the top of the array when informed that the lineup was arranged to maximize the chances of the suspect being picked, but not when informed that the lineup was arranged randomly or to ensure the suspect did not stand out. This suggests that top-bias may hinge largely on information about how the array was constructed. Second, the absence of position effects under random placement instructions in Study 4 contrasts with the results of Studies 2 and 3, where edge-aversion persisted across variations in task instructions (including instructions about random placement in Study 3). This indicates that, as hypothesized, edge-aversion may hinge on the ability of choosers to distinguish locations in the array on the basis of their relative proximity to edges and corners. We expand on these issues in the General Discussion.

The results of Study 4 suggest that using a tilted-circle array is a viable way to minimize position effects in choosing from a photo array, provided that participants are told that the photos were placed randomly. In Study 5, we tested whether this result could be replicated with lineup photos instead of blank rectangles.

Study 5: Modified Array with Faces

Method

Participants (95 undergraduate students; 71 female; aged 18 to 61 years, M = 26 years, SD = 8.5) completed the study in classroom settings under the supervision of an experimenter. Participants viewed a lineup comprising eight photos of faces arranged in a tilted circle array. Participants received written instructions informing them that one photo was of the police suspect and the other seven were known-to-be-innocent people. Participants were then asked to indicate which face they thought was the suspect. All participants were told that the faces had been placed in the lineup randomly by a computer. Four sets of stimuli were used for the experiment, and faces within each set were counterbalanced such that each face appeared equally often in each position. Each participant viewed one lineup.

Results

Figure 3 (panel B) shows the proportion of choices for each position in the array. There was little evidence of position-based biases in lineup responses. A goodness-of-fit test showed that the distribution of responses across the eight lineup positions did not differ from uniform, $\chi^2(7, N = 95) = 2.94$, $p = .891$.

There was as slight tendency to favor the top four positions (.55 [.45, .64]) versus the bottom four positions (.45 [.36, .55]), and—on a left-right axis—to favor the four locations closer to the center over the locations towards the left and right sides (.54 [.44, .63]) versus the outer positions (.46 [.37, .56]). Neither of these tendencies approached statistical significance (goodness-of-fit χ^2s < 1, *p*s > .350) and both were much weaker than the edge-aversion bias found in participants' responses in Studies 2 and 3 (.70 of choices from central positions).

Importantly, the absence of position effects was not an artefact of counterbalancing faces across different locations within the array. If certain faces within each set of stimuli were heavily favored, the even distribution of choices across locations could simply reflect participants' preference for choosing those specific faces; as the faces were rotated through various locations in the lineup, the distribution of choices would follow suit. However, this was not the case: Goodness-of-fit tests for each stimulus set showed that responses did not differ significantly from a uniform distribution across the eight faces in each set (all χ^2s < 7.53, all *p* values > .32). Table S1 in the Supplemental Material contains frequencies and proportions for each face chosen in each stimulus set. Thus, the absence of position effects was not due to counterbalancing of frequently-chosen faces across locations.

Discussion

The results of Study 5 replicate those of the random instructions condition in Study 4. There was minimal evidence of edge-aversion when lineup photos were presented in a tilted circle array and participants were told that the photos were placed randomly. These results, together with those of Study 4, indicate that it is possible to arrange response options in a way that mitigates position effects.

Note that we did not follow Study 5 with another experiment using a task more closely approximating an identification test in a police investigation. Position effects are most likely to emerge when decision makers lack a more valid basis for a decision and, thus, choose based on location in the array (cf. Gigerenzer et al., 1991). The magnitude of position effects found in Studiess 1-3 is consistent with this idea; position effects were marked in simple tasks where participants had little or no other information to base a decision on (Studies 2-3) and more subtle under realistic conditions in which participants could base their decision on memory for the perpetrator (Study 1). In the same vein, the simple tasks used in Studies 4 and 5 provide a strict test of the effectiveness of the modified array. If position effects can be mitigated in simple tasks, there is no reason to expect them to emerge in more realistic tasks that are less conducive to position effects.

General Discussion

These studies demonstrate that choices from photo arrays are prone to two types of position effects: Center locations are favored over edges and corners (edge-aversion), and top-row locations are favored over bottom-row ones (top bias). Our data indicate that these biases vary systematically with characteristics of the task, and that it is possible to undermine position effects by modifying the shape of the array and the instructions provided about placement of options within the array. These results have implications for theoretical accounts of position effects in choices from arrays, and practical implications for the collection of eyewitness identification evidence in police investigations.

Edge-aversion occurred to a modest extent in tasks that closely aligned with identification decisions made in actual police investigations (Study 1) and to a pronounced extent in simpler tasks in which participants guessed from lineups despite having no memorial evidence to support a positive identification (Studies 2 and 3). This is consistent with the idea that witnesses attempt to base identification decisions on memorial evidence, but when this is not possible, witnesses who are predisposed to pick someone may use location in the lineup as cue for picking the lineup member they think is most likely to be the culprit (cf. Gigerenzer et al., 1991). Edge-aversion was also insensitive to variations in task instructions in our experiments. Participants favored center locations regardless of whether they were informed that the array was constructed to maximize the chances the suspect would be picked, to ensure that the suspect did not stand out from other lineup members, or that the options were placed randomly.

Top-bias, in contrast, did vary with information about task instructions. Participants favored locations in the top row when instructions implied that the lineup was arranged to maximize the chances that the suspect would be picked, but not when instructions implied that the lineup was arranged randomly or to ensure that the suspect did not stand out from fillers. This effect of instructions on top-bias occurred when options were presented in a 2 × 4 grid or a tilted-circle array.

This research represents an application of Bar-Hillel's (2015) framework for position effects to a new task. The edge-aversion found here in choosing from lineup arrays aligns well with previous demonstrations of edge-aversion in MCTs and hide-and-seek battleship tasks (Attali & Bar-Hillel, 2003; Falk et al., 2009). Thus, we show that some position effects already established in tasks that are strictly competitive and in which the correct answer is known, also occur in tasks that are not strictly competitive and in which the correct answer in not necessarily known.

Our results have implications for theoretical frameworks of position effects. This research extends on models of position effects in choices from arrays by showing that edge-aversion depends on the shape of the array. According to some prominent accounts (Bar-Hillel, 2015; Falk et al., 2009), one requirement for edge-aversion is that choosers have the capacity to distinguish between locations based on their relative proximity to key features of the array, such as edges and corners. Our research supports a logical extension of this principle: Because the shape of the array dictates the extent to which such distinctions can be made, array shape can also affect the extent to which biases such as edge-aversion occur. Distinguishing between locations in term of their proximity to edges and corners is easier for some array shapes (e.g., a 5 × 5 or 2 × 4 array) than others (e.g., a circle). In turn, position effects such as edge-aversion will be strongest for arrays that facilitate this distinction, and weak—or non-existent—for arrays that do not.

Note that this reasoning does not apply to top-bias. Whereas a necessary condition for edge-aversion is that choosers can distinguish between locations on the basis of relative proximity to edges and corners, top-bias requires that choosers can distinguish between locations based on proximity to the top of the array. Because the tilted-circle array shape did nothing to undermine this, choices still favored top locations (when instructions stated that the array was constructed to maximize suspect picks).

To our knowledge, this research provides the first demonstration that edge-aversion can be undermined by modifying the shape of the array. Our motivation for investigating this stemmed from the applied nature of the topic. Compared to choices from arrays in other applied settings (e.g., MCTs and battleship games), police lineups require consideration of a different set of issues. For example, when trying to minimize bias in choices for MCTs, the key consideration is to eliminate the possibility that position effects could give test takers an unfair advantage, resulting in score inflation (Attali & Bar-Hillel, 2003). From that perspective, arranging response options randomly is sufficient to solve the problem: If options are placed randomly, there is no possibility that test takers can gain an advantage by favoring center locations. With lineups, attempts to reduce bias must have a slightly different focus. Because (a) there is no know correct answer, and (b) misidentification errors carry potentially dire consequences, the aim is not merely to reduce the likelihood that poor witnesses will guess the location of the suspect (akin to removing any unfair advantage for MCT test takers) but to try to minimize any source of systematic error. This prompted us to test not only whether position effects occur in choices from photo arrays, but also to search for a way to eliminate them.

A second implication of our results concerns the role of representativeness in producing position effects. In Bar-Hillel's (2015) model, representativeness plays a crucial role in edge-aversion. When tasks are competitive and zero-sum (e.g., hide-and-seek), locations that are perceived as most representative of all possible locations in the array are favored. In contrast, when tasks are cooperative, representative locations are eschewed in favor of prominent ones. This framework implies a trade-off between locations that are favored under competitive conditions and those favored under cooperative conditions. Our results did not conform to this pattern. In Studies 1-3, edge-aversion occurred regardless of whether participants were told that the options were arranged to maximize suspect choices (similar to a cooperative task), so that the suspect did not stand out (similar to a competitive task), or randomly. According to a strict interpretation of Bar-Hillel's model, this would not be expected.

One way of resolving the apparent discrepancy between our results and predictions of the Bar-Hillel (2015) model is to assume that the trade-off in choices between competitive and cooperative choices is imperfect. Previous research provides some support for this notion. For example, in choices from a 5-by-5 array, the exact center location is easily the most frequently chosen in cooperative tasks, but is far from the least popular location in competitive tasks (Falk et al., 2009). Such results can be accommodated by a slightly relaxed interpretation of Bar-Hillel's model, involving an imperfect trade-off in the extent to which a given location is perceived as prominent versus representative. However, in our results, the lack of effect of instructions on edge-aversion was much more striking.

Another potential explanation for the absence of effects of instruction on edge-aversion relates to characteristics of the lineup task that make this task different to other choices from arrays. As noted earlier, lineup tasks (unlike MCTs and battleship games) do not have a known correct answer; the police do not know for certain whether their suspect committed the crime in question, and they are conducting the lineup as a step toward finding this out. Lineup tasks are also not strictly competitive or cooperative (i.e., the lineup administrator does not stand to win or lose if the witness chooses the suspect). These characteristics of the task may affect the role of perceived representativeness in position effects. For example, if choosers take into account that the suspect in the lineup may be innocent, they may be less inclined to try to work out where the suspect is likely to be than if they knew for certain that the perpetrator was somewhere in the lineup. In turn, the process of comparing locations based on relative representativeness—a key part of Bar-Hillel's (2015) model—would play less of a role in choices. In the context of Bar-Hillel's (2015) model, these possibilities are interesting in because they imply that the function of representativeness in position effects may vary depending on parameters of the task that have not previously been considered. In turn, this suggests that as Bar-Hillel's model is applied to a wider variety of choices, there will be scope to extend the model to incorporate additional factors that moderate the relationship between task conditions and position effects.

Applied Implications

From an applied perspective, there are two clear policies that can be implemented to mitigate problems associated with position bias in choosing from lineups. The first is to randomize the position of the suspect within the lineup, and tell witnesses that the lineup was arranged randomly. By doing so, lineup administrators can remove the possibility that edge-aversion will increase the rate of misidentification of innocent suspects. Even if some witnesses continue to guess from central locations, suspects would be no more likely to appear in these places than any other location in the lineup. As a result of research on position biases in MCTs (e.g., Attali & Bar-Hillel, 2003), randomization of response options in MCTs is now common practice. Given that lineup administrators choose the location of the suspect in many jurisdictions and most often place the suspect in a central location (Wolgater et al., 1993), implementing a policy mandating the random placement of suspects would be beneficial in reducing misidentification rates.

Providing information to witnesses about the random arrangement of lineup members is an important part of this recommendation. Apart from being truthful, such information would undermine any bias to choose from top locations in a photo array that might occur if witnesses assumed that the lineup was constructed to maximize the chances of a suspect identification. As noted earlier, the similarity in choosing patterns between Study 1 and the biased conditions of Studies 2-4 suggests that, in the absence of information to the contrary, witnesses likely assume that lineups are constructed to maximize the chances that the suspect will be picked. In turn, choices will be susceptible to top-bias. Including information about random placement in lineup instructions will mitigate this bias.

The second policy concerns presenting lineup members in a way that mitigates position effects in eyewitness identification. By presenting lineup photographs in an array that reduces the scope for distinguishing between location based on relative proximity to edges and corners, lineup administrators can minimize witnesses' tendencies to favor certain locations over others in the lineup. Although randomizing the location of the suspect is sufficient to counteract the possibility of inflated misidentification rates of innocent suspects, the use of a modified array represents an opportunity to remove an undesirable source of bias—and error—in identification decisions. Our research demonstrates that this can be achieved by using a tilted-circle arrangement; further research may uncover other types of arrays that are effective at minimizing position effects. Although a modified array for lineup photographs represents a departure from established identification test procedures, it would not be a difficult one to implement. In many jurisdictions, computer administration of lineups has become commonplace (e.g., Cutler, Daugherty, Babu, Hodges, Van Wallendael, 2009).

Lineup administrators would require no extra training, and the minimal costs involved make the use of modified arrays worthy of consideration as a measure for reducing errors.

In considering applied implications of this work, we highlight three caveats. First, although modified arrays can reduce position effects when lineup members are presented simultaneously—which is the most common method of presentation in the U.S., used in approximately 68% of cases (Police Executive Research Forum, 2013)—this approach is not applicable to some other methods, such as sequential presentation (whereby lineup members are shown one-at-a-time to witnesses; Lindsay & Wells, 1985).

Second, as well as reducing misidentification, randomizing the position of the suspect would likely reduce correct identification rates in cases where the lineup contains the perpetrator. In a general sense, this can be likened to the effect of sequential lineup presentation, which—compared to simultaneous presentation—reduces false and correct identification rates (e.g., Clark, 2012; Palmer & Brewer, 2012; Steblay, Dysart, & Wells, 2011). However, this potential loss of some correct identifications does not justify placing suspects in center locations. Interventions designed to reduce position effects should have minimal impact on witnesses who can base their decision on their memory of the perpetrator, but should reduce suspect identifications made by witnesses who cannot distinguish guilty suspects from innocent ones based on their memory (cf. Gigerenzer et al., 1991). Given that identification responses made by witnesses who cannot recognize the perpetrator are inherently unreliable, the loss of such responses will generally help—not hinder—police investigations. These responses are especially problematic in light of recent evidence that lineups conducted by police might contain the actual perpetrator only infrequently (estimated 35% in one large field study; Wixted, Mickes, Dunn, Clark, & Wells, 2016).

Finally, although the modification of lineup arrays to reduce position effects is one promising way of reducing misidentification, many other procedures have also been proven to reduce identification error (e.g., double-blind administration and the use of reminders that the lineup may not contain the culprit; Wells et al., 1998). Implementing such measures is crucial for minimizing identification error and the wrongful convictions that result from it.

Conclusion

This research demonstrates that choices from lineup arrays are subject to systematic position effects, and that these effects can be undermined by modifying the shape of the array. These findings have important practical implications for the conduct of eyewitness identification tests, and could potentially lay the foundations for reducing position effects in other important choices from arrays (e.g., multiple-choice tests and voting in elections).

References

Attali, Y., & Bar-Hillel, M. (2003). Guess where: The position of correct answers in multiple-choice test items as a psychometric variable. *Journal of Educational Measurement*, *40*, 109-128. doi:10.1111/j.1745-3984.2003.tb01099.x

Bar-Hillel, M. (2015). Position effects in choice from simultaneous displays: A conundrum solved. *Perspectives on Psychological Science*, *10*, 419-433. doi:10.1177/1745691615588092

Bar-Hillel, M., Peer, E., & Acquisti, A. (2014). "Heads or tails?"—A reachability bias in binary choice. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*, 1656–1663. doi:10.1037/xlm0000005

Berg, I. A., & Rapaport, G . M. (1954). Response bias in an unstructured questionnaire. *The Journal of Psychology*, *38*, 475-481. doi:10.1080/00223980.1954.9712954

Brewer, N. & Wells, G. L. (2011). Eyewitness identification. *Current Directions in Psychological Science*, *20*, 24-27. doi:10.1177/0963721410389169

Christenfeld, N. (1995). Choices from identical options. *Psychological Science*, *6*, 50-55. doi:10.1111/j.1467-9280.1995.tb00304.x

Clark, S. E. (2012). Costs and benefits of eyewitness identification reform: Psychological science and public policy. *Perspectives on Psychological Science*, *7*, 238-259. doi:10.1177/1745691612439584.

Cochran, W. G. (1954). The combination of estimates from different experiments. *Biometrics*, *10*, 101-129.

Cutler, B. L., Daugherty, B., Babu, S., Hodges, L., & Van Wallendael, L. R. (2009). Creating blind photoarrays using virtual human technology: A feasibility test. *Police Quarterly*, *12*, 289-300. doi:10.1177/1098611109339892

Dayan, E., & Bar-Hillel, M. (2011). Nudge to nobesity II: Menu positions influence food intake. *Judgment and Decision Making*, *6*, 333–342.

Ert, E., & Fleischer, A. (2014). Mere position effect in booking hotels online. *Journal of Travel Research*. Advance online publication. doi:10.1177/0047287514559035

Falk, R., Falk, R., & Ayton, P. (2009). Subjective patterns of randomness and choice: Some consequences of collective responses. *Journal of Experimental Psychology: Human Perception and Performance*, *35*, 203-224. doi:10.1037/0096-1523.35.1.203

Flowe, H. D. (2012). Do characteristics of faces that convey trustworthiness and dominance underlie perceptions of criminality? *PLoS ONE*, *7*, e37253. doi:10.1371

Garrett, B. (2011). *Convicting the Innocent: Where criminal prosecutions go wrong*. Cambridge, MA: Harvard University Press.

Gigerenzer, G., & Goldstein, D. G. (1996). Reasoning the fast and frugal way: Models of bounded rationality. *Psychological Review*, *103*, 650-669. doi:10.1037/0033-295X.103.4.650

Gigerenzer, G., Hoffrage, U., & Kleinbölting, H. (1991). Probabilistic mental models: A Brunswikian theory of confidence. *Psychological Review*, *98*, 506-528. doi:10.1037/0033-295X.98.4.506

Greathouse, S. M., & Kovera, M. B. (2009). Instruction bias and lineup presentation moderate the effects of administrator knowledge on eyewitness identification. *Law and Human Behaviour*, *33*, 70-82. doi:10.1007/s10979-008-9136-x

Haw, R. M., & Fisher, R. P. (2004). Effects of administrator-witness contact on eyewitness identification accuracy. *Journal of Applied Psychology*, *89*, 1106-1112. doi:10.1037/0021-9010.89.6.1106

Horry, R., Halford, P., Brewer, N., Milne, R., & Bull, R. (2014). Archival analyses of eyewitness identification test outcomes: What can they tell us about eyewitness memory? *Law and Human Behavior, 38,* 94-108. doi:10.1037/lhb0000060

Innocence Project. (2015). *Eyewitness misidentification.* Retrieved October 22, 2015, from http://www.innocenceproject.org/causes-wrongful-conviction/eyewitness-misidentification

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In T. Gilovich, D. Griffin & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp.49-81). New York: Cambridge University Press.

Kubovy, M., & Psotka, J. (1976). The predominance of seven and the apparent spontaneity of numerical choices. *Journal of Experimental Psychology: Human Perception and Performance*, *2*, 291–294. doi:10.1037/0096-1523.2.2.291

Lindsay, R. C. L., & Wells, G. L. (1985). Improving eyewitness identifications from lineups: Simultaneous versus sequential lineup presentation. *Journal of Applied Psychology, 70*, 556-564. doi:10.1037//0021-9010.70.3.556

Megreya, A. M., Bindemann, M., Harvard, C., & A. M. Burton. (2012). Identity-lineup location influences target selection: Evidence from eye movements. *Journal of Police and Criminal Psychology*, *27*, 167-178. doi:10.1007/s11896-011-9098-7

National Institute of Justice Technical Working Group for Eyewitness Evidence (2003). *Eyewitness Evidence: A Trainer's Manual for Law Enforcement.* Retrieved from https://www.ncjrs.gov/nij/eyewitness/188678.pdf

National Research Council (2014). *Identifying the culprit: Assessing eyewitness identification*. Washington, DC: The National Academies Press.

O'Connell, M., & Synnott, J. (2009). A position of influence: Variation in offender identification rates by location in a lineup. *Journal of Investigative Psychology and Offender Profiling*, *6*, 139-149. doi:10.1002/jip.102

Palmer, M. A., & Brewer, N. (2012). Sequential lineup presentation promotes less-biased criterion setting but does not improve discriminability. *Law and Human Behavior*, *36*, 247-255. doi:10.1037/h0093923

Palmer, M. A., Brewer, N., McKinnon, A. C., & Weber, N. (2010). Phenomenological reports diagnose accuracy of eyewitness identification decisions. *Acta Psychologica, 133*, 137-145. doi:10.1016/j.actpsy.2009.11.002

Palmer, M. A., Brewer, N., & Weber, N. (2010). Postidentification feedback affects subsequent eyewitness identification performance. *Journal of Experimental Psychology: Applied, 16,* 387-398. doi:10.1037/a0021034

Palmer, M. A., Brewer, N., & Weber, N. (2012). The information gained from witnesses' responses to an initial "blank" lineup. *Law and Human Behavior*, *36*, 439–4 47. doi:10.1037/h0093939

Palmer, M. A., Brewer, N., Weber, N., & Nagesh, A. (2013). The confidence-accuracy relationship for eyewitness identification decisions: Effects of exposure duration, retention interval, and divided attention. *Journal of Experimental Psychology: Applied*, *19*, 55-71. doi:10.1037/a0031602

Police Executive Research Forum. (2013). *A national survey of eyewitness identification procedures in law enforcement agencies*. Retrieved from http://www.policeforum.org/assets/docs/Free_Online_Documents/Eyewitness_Identification/a%20national%20survey%20of%20eyewitness%20identification%20procedures%20in%20law%20enforcement%20agencies%202013.pdf

Rubinstein, A., Tversky, A., & Heller, D. (1997). Naïve strategies in competitive games. In W. Guth (Ed.), *Understanding strategic interaction—Essays in honor of Reinhard Selten* (pp. 394–402). Berlin, Germany: Springer-Verlag.

Sauer, J. D., Brewer, N., Zweck, T., & Weber, N. (2010). The effect of retention interval on the confidence-accuracy relationship for eyewitness identification. *Law and Human Behavior*, *34*, 337-347. doi:10.1007/s10979-009-9192-x

Schelling, T. C. (1960). *The strategy of conflict*. Cambridge, MA: Harvard University Press.

Schwarzer, G. (2015). Package 'meta'. Retrieved 14 July, 2015 from: https://cran.r-project.org/web/packages/meta/meta.pdf

Shaw, J. I., Bergen, J. E., Brown, C. A., & Gallagher, M. E. (2000). Centrality preferences in choices among similar options. *The Journal of General Psychology*, *127*, 157-164. doi:10.1080/00221300009598575

Steblay, N. K., Dysart, J. E., & Wells, G. L. (2011). Seventy-two tests of the sequential lineup superiority effect: A meta-analysis and policy discussion. Psychology, Public Policy, and Law, 17, 99-139. doi:10.1037/a0021650

Technical Working Group for Eyewitness Evidence. (1999). *Eyewitness evidence: A guide for law enforcement*. Washington DC: U.S. Department of Justice, Office of Justice Programs.

Teigen, K. H. (1983). Studies in subjective probability I: Prediction of random events. *Scandinavian Journal of Psychology, 24*, 13–25. doi:10.1111/j.1467-9450.1983.tb00471.x

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185,* 1124-1131. doi:10.1126/science.185.4157.1124

Valenzuela, A., & Raghubir, P. (2009). Position-based beliefs: The center-stage effect. *Journal of Consumer Psychology*, *19*, 185-196. doi:10.1016/j.jcps.2009.02.011

Valenzuela, A., & Raghubir, P. (2015). Are consumers aware of top-bottom but not left-right inferences? Implications for shelf space positions. *Journal of Experimental Psychology: Applied*, *21*, 224-241. doi:10.1037/xap0000055

Weigold, A. & Wentura, D. (2004) Who's the one in trouble? experimental evidence for a 'psychic state' bias in lineups. *European Journal of Social Psychology*, *34*, 121-133. doi:10.1002/ejsp.193

Wells, G. L. (1984). The psychology of lineup identifications. *Journal of Applied Social Psychology*, *14*, 89-103. doi:10.1080/10683160500050666

Wells, G. L. (1993). What do we know about eyewitness identification? *American Psychologist*, *48*, 553-571. doi: 10.1037//0003-066X.48.5.553

Wells, G. L., & Olson, E. A. (2002). Eyewitness identification: Information gain from incriminating and exonerating behaviors. *Journal of Experimental Psychology: Applied*, *8*, 155-167. doi:10.1037/1076-898X.8.3.155

Wells, G. L., Rydell, S. M., & Seelau, E. P. (1993). The selection of distractors for eyewitness lineups. *Journal of Applied Psychology*, *78*, 835-844.

Wixted, J. T., Mickes, L., Dunn, J. C., Clark, S. E. & Wells, W. (2016). Estimating the reliability of eyewitness identifications from police lineups. *Proceedings of the National Academy of Sciences*, *113*, 304-309. doi:10.1073/pnas.1516814112

Wolgater, M. S., Malpass, R. S., & Burger, M. A. (1993). How police officers construct lineups: A national survey. *Proceedings of the Human Factors Society 37th Annual Meeting.* (pp. 640-644). Seattle, Washington: Human Factors Society.

Footnotes

[1] We thank an anonymous reviewer for suggesting this.

[2] Demographic data were not collected in Studies 2a, 2b, and 3 due to experimenter error. In a re-analysis of data from Studies 4 and 5, participants' sex and age had minimal effect on the pattern of responses and no effect on the qualitative outcomes of inferential tests.

[3] We use the terms *fair* and *biased* to refer to the intention of the person constructing the lineup. These terms do not imply an absence of bias when a lineup administrator places the suspect to not stand out in the lineup. As we argue in the General Discussion, random placement of the suspect (e.g., by a computer) is the best and perhaps only unbiased method for placing a suspect.

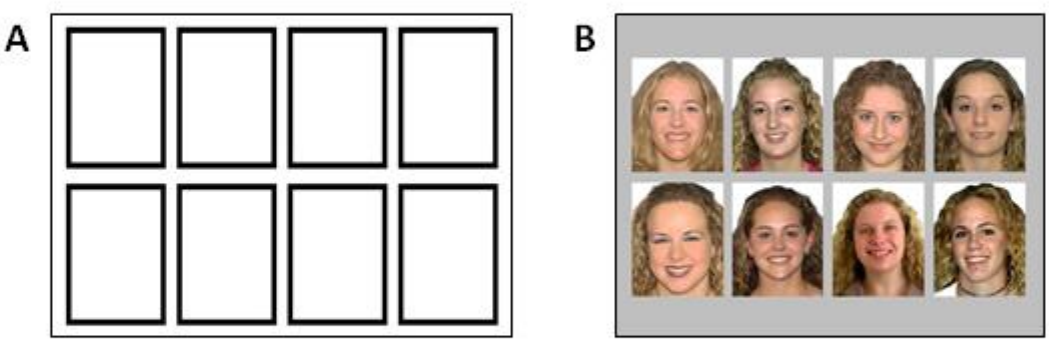

Figure 1. Examples of stimuli used in Studies 2a-2c (panel A), and Studies 1 and 3 (panel B).

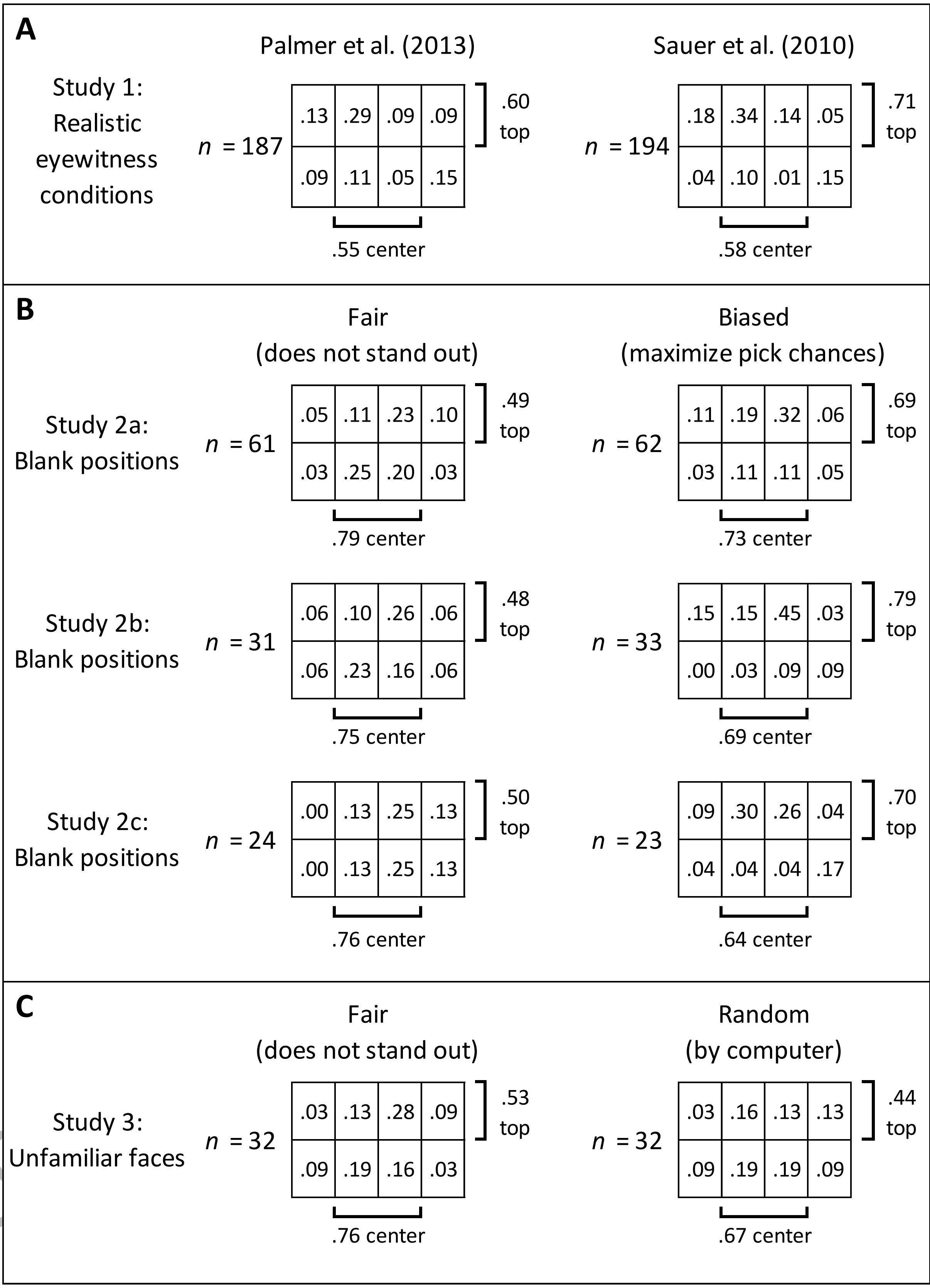

Figure 2. Response proportions for each lineup position in Study 1 (panel A), Studies 2a-2c (panel B), and Study 3 (panel C).

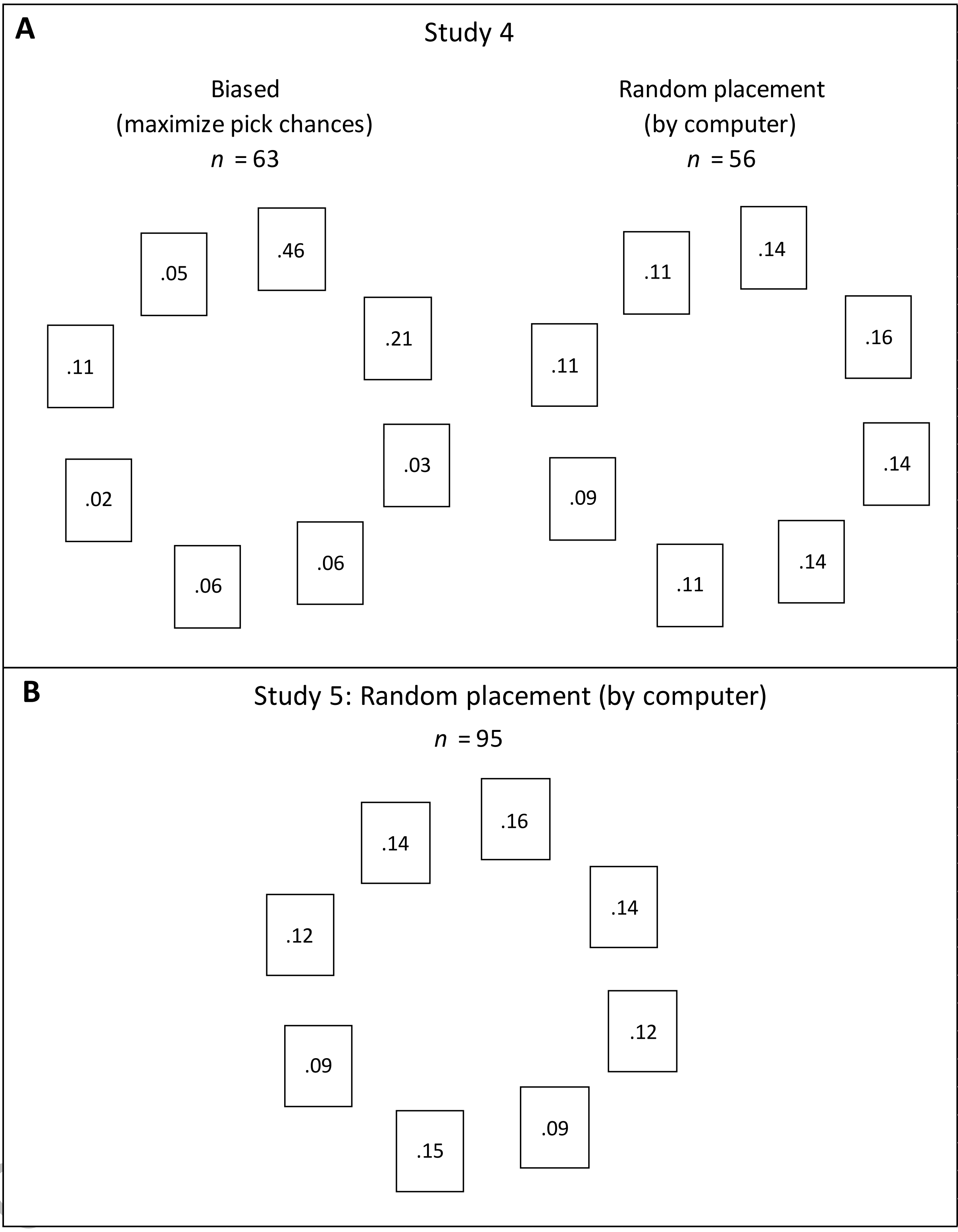

Figure 3. Proportions of responses for each lineup position in Studies 4 (panel A) and 5 (panel B).