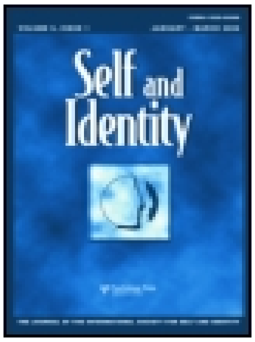

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The function of vertical and horizontal space to social group identity

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ABSTRACT

Where an object or person is located in space can communicate important attributes, such as power, agency, or status. We theorized that people may use location to convey messages about social groups. In four studies, we examined whether women and men express ingroup bias or stereotypical bias in their placement of and memory for gendered objects. In Study 1, participants placed objects symbolizing their ingroup *higher* but not further left than objects symbolizing their outgroup. Vertical ingroup-bias emerged consistently in spatial placement (Studies 2 and 4) but not spatial memory (Studies 3 and 4). We discuss the influence of gender identity, the role of automaticity, and the value of vertical versus horizontal spatial location in communicating group bias.

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Vertical location; gender identity; ingroup bias; spatial agency bias

Where an object or image appears in space may seem arbitrary, but past work has shown that where someone is located in space conveys meaningful information to perceivers about that person's power (i.e., how much influence they have over others; Giessner & Schubert, 2007; Schubert, 2005; Zanolie et al., 2012) and agency (i.e., how independent, self-directed, and assertive they are; Maass et al., 2009; Suitner & Maass, 2007). In languages written from left to right, leftward horizontal locations convey that a person has more agency, consistent with the trend for agents to come before objects in a sentence (e.g., "Peggy saw a gorilla"; Maass et al., 2009, 2014; Suitner & Maass, 2007, 2011). For example, people perceive acts of aggression as more powerful when the instigator is to the left of the victim and a soccer goal as faster when the player is moving from left to right (Maass et al., 2007). Conversely, in languages like Arabic written from right to left, *rightward* horizontal locations convey agency (Maass et al., 2014). Therefore, Italian speakers write from left to right and tend to draw an aggressive interaction with the aggressor to the left of the victim, whereas Arabic speakers write from right to left and tend to draw that same interaction with the aggressor to the *right* of the victim (Maass et al., 2014).

Just as with horizontality, a large body of literature suggests that vertical spatial location also conveys meaningful information to perceivers (e.g., Landau et al., 2010; Meier & Robinson, 2004; Schubert, 2005; Tang et al., 2018). For example, objects and

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people located high in space or viewed at an upward angle are attributed more power and status than those located low in space or viewed at a downward angle – even when those people are situated in environments with visual complexity (Giessner et al., 2011; Lamer & Weisbuch, 2019; Schubert, 2005; Zanolie et al., 2012). The association between vertical location and power can be observed in common phrases in many languages. For example, in American English, people use phrases such as "climbing the *ladder* of success," "being promoted *above* your peers," or "being *high* in the hierarchy." In Italian, people use phrases like "sottomettere qualcuno" (literally, "put somebody *under*") and "conosco gente ai piani alti che si dà da fare per me" (meaning "I know people *high* up pulling strings for me"). Powerful words like director or general even direct attention upwards in space while powerless words like servant or follower direct attention downwards (Zanolie et al., 2012).

It is reasonable that spatial location is prevalent and influential given its importance to cognitive processing. Location is prioritized in the visual system such that spatial localization begins at some of the earliest stages of the visual cortical hierarchy (Engel et al., 1997; Holmes, 1945; Serences & Yantis, 2006). In fact, humans and animals alike can learn associations between an object's location and its appearance in a single experimental session (Ciaramitaro et al., 2001; Sridharan et al., 2013). Drawing from this convergent body of work, we hypothesized that spatial location may be a valuable means of conveying socially meaningful messages such as group value. Indeed, horizontal and vertical biases have been observed in how groups are spatially positioned in various cultural media (Hegarty et al., 2010; Lamer & Weisbuch, 2019; Suitner & Maass, 2007). Here, in a series of four studies, we examined whether spatial biases may be observed through the coordinate positioning of objects that symbolize women versus objects that symbolize men. Specifically, we had two competing hypotheses: (a) Ingroup Bias: that people would exhibit ingroup bias in spatial positioning or (b) Stereotypical Bias: that people would exhibit stereotype-consistent bias in spatial positioning. Ingroup bias would yield a pattern in which women would place feminine symbols (e.g., ballet shoes) higher and further left than masculine symbols (e.g., a soccer ball), whereas men would place masculine symbols higher and further left than feminine symbols. Conversely, stereotypical bias would yield a pattern in which both women and men would place masculine symbols higher and further left than feminine symbols.

Stereotypical placement bias

There are reasons to believe that either of these patterns may emerge. For example, research on group-based differences in spatial placement suggests that patterns observed in social environments tend to be consistent with stereotypes. For example, in cartoon pairs of women and men, men tend to be presented to the left and women to the right when the man in the couple is perceived to be more agentic than the woman (Maass et al., 2009). The same pattern is true of graphical depictions of scientific data in which bars depicting men are more likely to appear on the left and bars depicting women are more likely to appear on the right (Hegarty et al., 2010). Research suggests that exposure to this pattern subsequently reinforces gender stereotypes among perceivers (Suitner, Maass, Ronconi et al., 2017). Similar patterns of stereotypical bias have been noted regarding vertical location. Recently published work documents a pattern of male spatial elevation in which images of men are located higher than images of women in popular US magazines (Lamer & Weisbuch, 2019). Subsequent exposure to this pattern in the lab reinforced participants' gender stereotypical beliefs that men are more powerful and dominant than women. Patterns of spatial placement may, therefore, reify established gender stereotypes. Both women and men may spatially advantage masculine objects.

It may seem counterintuitive that women would place masculine objects high in space. Yet, members of low-power groups sometimes adopt culturally prevalent negative beliefs about their own groups (e.g., Brescoll et al., 2013; Calogero & Jost, 2011; Kay et al., 2009; Moss-Racusin et al., 2012; Rudman & Glick, 2001; Spence & Buckner, 2000). For example, women exhibit similarly strong implicit associations between men and power, are similarly biased against female (vs. male) job applicants, and endorse gender stereotypes with similar frequency as men do (Moss-Racusin et al., 2012; Rudman & Glick, 2001; Spence & Buckner, 2000). Therefore, it is possible that both women and men spatially advantage objects symbolizing men.

Ingroup bias

However, it is also possible that women and men will spatially advantage their ingroups. For example, in past work on spatial cues, researchers have found evidence consistent with an ingroup bias. In analyses of Spatial Agency Bias in portraits, female painters did not exhibit biases favoring men; they were equally likely to paint women in agentic horizontal orientations as they were to paint men in agentic horizontal orientations (Suitner & Maass, 2007). Similarly, in magazines, Lamer and Weisbuch (2019) report preliminary evidence that the pattern of male spatial elevation in which images of men appeared higher than images of women was stronger among magazines with male than female editors. Culturally prevalent patterns of stereotypical bias may reflect inequitable distributions of power and spatial placement may be skewed to advantage the *ingroup*, even for members of low-power groups.

It is advantageous for people to exhibit ingroup preferences because people derive self-esteem from the value of the groups they identify with and tend to like ingroup members who exhibit ingroup bias more than those who act in an egalitarian manner (Cadinu & Cerchioni, 2001; Castelli et al., 2008; Crocker et al., 2003; Reinhard et al., 2009; Tajfel & Turner, 1979). Group affiliations thus predict that people will have biased behavior, attitudes, and memory that favor their ingroups. For example, people expect members of their ingroup to behave more favorably than members of an outgroup and their memory is biased accordingly; people remember negative behaviors performed by an outgroup member better than negative behaviors performed by an ingroup member and therefore generate illusory correlations between groups and their behavior (Howard & Rothbart, 1980; Schaller, 1991). People are also more likely to vote for political candidates of their own gender than the other gender (Hoyt et al., 2009; Plutzer & Zipp, 1996), interpret intentions of ingroup members more positively than those of outgroup members (Correll et al., 2002; Jones et al., 1999; Payne, 2001), and are more likely to reward work they think was completed by someone of their own gender than the other gender (Bian et al., 2017).

The importance of subtle cues to group value

Yet explicit group-based biases and outgroup harassment are typically considered unacceptable by current social standards (Barreto & Ellemers, 2005; Devine et al., 2002). This is not always true and blatant bias can still sometimes be observed in the general population (e.g., Kteily et al., 2015; Miller, 2014). However, when group value corresponds to social group identities historically associated with inequality (e.g., gender, race, sexual orientation), people are substantially less likely to explicitly express them. In contemporary Western cultures, gender-stereotypic statements are often met with swift condemnation. Accordingly, people are on average tentative to make explicit sexist or racist statements and provide alternative explanations for instances when they do exhibit group-based preferences (Barreto & Ellemers, 2005; Devine et al., 2002).

Yet, that does not mean group-based biases disappear. Instead, social psychologists have suggested that group biases are expressed through more subtle, automatic, or covert means such as nonverbal behavior, language construction, and mental representation (Lloyd et al., 2017; Maass et al., 1989; Von Hippel et al., 1997; Weisbuch, Seery et al., 2009; Weisbuch, Sinclair et al., 2009). For example, children encode positive information about members of minimally assigned ingroups (but not outgroups) and college students spontaneously respond more positively to an anxious speaker if told that they share a political affiliation (Dunham et al., 2011; Weisbuch & Ambady, 2008). Research on those with white racial identities suggests that these individuals more strongly associate white with good than black with good, sit farther away from a black than a white interviewee, and selectively follow the eye gaze of white individuals more than black individuals (Pavan et al., 2011; Weisbuch et al., 2017; Williams, 1964; Word et al., 1974). Thus, although people may be unlikely to verbally say biased statements (to bolster their self-esteem or reify existing stereotypes), they may continue to exhibit group bias in more nuanced ways.

Automaticity

Spatially advantaging one group over the other may be subtle, but not necessarily automatic. This is an important distinction to make. Automatic behaviors are those that occur without processing capacity needs or intention, whereas controlled behaviors are those that reflect an individual's intentions but are therefore limited by processing capacity (Govorun & Payne, 2006; Jacoby, 1991). Automatic and controlled processes often co-occur and contribute to the ways that group bias is expressed. For example, researchers have teased apart automatic and controlled components guiding individuals' behavior in weapon identification tasks (Correll et al., 2015; Payne, 2001) and recognition memory (Hense et al., 1995; Jacoby, 1991). When respondents do not face a time constraint, controlled processes are especially likely to contribute to behavior. However, as time becomes more restricted, people are less able to inhibit undesirable responses and behavior is more likely to reflect automatic processing.

Group bias in spatial location may operate through both automatic and controlled mechanisms. For example, placing an object in space requires deliberation and intent, even if people are unaware of their reasoning for aesthetic preference. Controlled and automatic processes guiding aesthetic preference are both likely to be operating in such instances. In other tasks, the role of automaticity may be more pronounced. For example, research in cognitive and social psychology has long examined the role of automaticity in spatial memory (Richardson & Spivey, 2000). People encode information about where objects and faces are located in space even when spatial information is irrelevant to the task at hand (Fitousi, 2017; Richardson & Spivey, 2000; Shadoin & Ellis, 1992). Encoding spatial information may be adaptive because perceivers learn stimulus probabilities for reward or threat (Biederman et al., 1982; Ciaramitaro et al., 2001; Druker & Anderson, 2010; Fiser & Aslin, 2016). Even metaphorical associations, such as those between vertical location and positivity, can shift spatial memory such that perceivers recall positive objects as being higher than they were, but negative objects as being lower than they were (Crawford et al., 2006). Stereotype knowledge (not necessarily personal beliefs) predicts biases on automatic outcomes like the shooter task (Banse et al., 2010; Correll et al., 2002). Thus we reasoned that stereotypical bias may be more likely on automatic than controlled tasks.

Here, we examine the role of both controlled and automatic components in group-based spatial bias using two different kinds of tasks: placement and memory. In Studies 1, 2, and 4, participants place objects in space; there is no time constraint in this task and participants are allowed to rearrange objects until they are pleased with their final product. Conversely, in Studies 3 and 4, participants are asked to perform a free recall of gendered objects. They are only allowed to view the objects for a short amount of time (30 s) and then asked to recall placement. Both of these tasks likely employ automatic *and* controlled components; tasks are rarely process-pure. However, consistent with past research, we theorize that the latter free-recall tasks involving spatial memory likely draw more on automatic processes than does the former object placement task.

The current studies

In this series of studies, we were interested in why patterns of spatial gender bias exist (Hegarty et al., 2010; Lamer & Weisbuch, 2019; Suitner & Maass, 2007). What may account for culturally prevalent depictions of men being higher than or to the left of women? We proposed that the use of spatial location in communicating gender bias may contribute to the persistence of these subtle cultural patterns. Specifically, we hypothesized that people may either (a) arrange their environments to bolster their ingroup gender identity or (b) arrange objects consistent with current gender stereotypes – with masculine objects higher or further left than feminine objects.

In Study 1, we tested for stereotypical bias and ingroup bias in the placement of feminine and masculine objects as moderated by different aspects of gender identity (i.e., how positively one feels about their gender identity, how central gender is to the self, and ties to ingroup members). In Study 2, we manipulated the salience of gender identity to test for an ingroup identity bias on spatial placement. In Study 3, we tested for evidence of gendered spatial bias in memory, given that this spatial memory task is likely to engage more automatic processes. In Study 4, we compared spatial memory and spatial placement tasks to replicate and extend effects with a high-powered sample. We also include a measure of gender stereotyping in this last study as a potential moderator of spatial bias.

Study 1: ingroup bias in object placement

In this first study, we were interested in how perceivers placed stereotypically feminine and masculine images in space as a function of their own gender. Specifically, participants were asked to complete an aesthetic arrangement task by placing feminine and masculine magnets (e.g., a ballerina or a soccer player) on a virtual refrigerator. We were interested in the extent to which participants spatially advantaged magnets symbolizing the ingroup relative to magnets symbolizing the outgroup. We hypothesized that people would either (a) spatially advantage magnets that symbolized the ingroup by placing them high and leftward relative to magnets that symbolize the outgroup or (b) spatially advantage masculine magnets to replicate prevalent cultural patterns. We tested aspects of gender identity (ingroup ties, affect, centrality) as a moderator of any observed spatial bias.

Methods

Participants and setting

Participants were recruited from Amazon's Mechanical Turk and paid for their participation in the 10-minute experiment. The study was approved by the institutional review board at the University of Padua and was conducted using Qualtrics. The final sample consisted of 187 participants (57% women) located in the US, ranging in age from 19 to 77 with quartiles at 30, 38, and 50.[1] We estimated a conservatively small effect size (d =.20), for which initial power analyses using G*POWER (Faul et al., 2007) suggested collecting 199 participants for an independent sample t-test. We met this number of participants prior to exclusions. However, after data collection, we opted to use multilevel models as these are more appropriate to the methodological design given that responses are nested within stimuli and subjects.[2]

Materials

Spatial placement task

The goal of this task was to quantify where participants would place objects symbolizing femininity and masculinity. Participants were shown a blank refrigerator (410 x 737 pixels) and asked to place each of eight magnets (four feminine/masculine pairs). The magnets were presented to the participant in random order. Magnets (100 x 63 pixels) were pretested and we chose the four magnet pairs that were most similar on valence but polarized in gender-typicality.

Magnet pretesting

We selected 60 images for pretesting that ranged in gender stereotypicality. We selected images that could be cropped to look like refrigerator magnets and that fell into five different categories: animals, nature, paintings, bikes, cars, and athletics. We chose images so that selected pairs could be matched on art style, color scheme (e.g., black-white vs color), and image complexity (e.g., with white background or not). Once we had selected these images, we standardized them to be the same in height and width (100 pixels wide x 63 pixels high). Furthermore, we cropped each feminine image so that the target (e.g., a kitten) was centered and facing the same direction as its masculine counterpart (e.g., a lizard).

Participants (66% women) were 32 volunteers ranging in age from 22 to 59 with quartiles at 23, 24, and 48. They rated each of the magnets in random order twice. The first time they saw the magnets, they were asked to rate them on gender (from 1 to 7;

whether extremely feminine was 1 or 7 was counterbalanced between participants). The second time participants saw the magnets, they were asked to rate them on valence (from 1 to 7; whether extremely positive was 1 or 7 was counterbalanced between participants). We selected four magnet pairs that were different in terms of gender stereotypicality but close to the midpoint on valence. See Table 1 for a list of these stimuli and their gender and valence ratings.

We chose refrigerator magnets because they mitigated many potential issues present when encountering actual women and men. The vertical location of women and men encountered in person, for example, is often constrained by average sex and gender differences in height (Touraille, 2013; Zheng et al., 2013). Magnets can be scaled such that feminine and masculine objects – even women and men – are the same size and can be located anywhere in space. Here, all magnets were the same size and, depending on counterbalancing condition, were facing toward the right or left (some examples of magnet images are shown later in Figure 4).

Procedure

Participants were told that their arrangements would be rated by another set of participants for aesthetic appeal. They could rearrange their magnets until they were pleased with their final arrangement. Participants were not, however, allowed to exclude any of the magnets from the fridge. There were four different versions of the task varying the direction of the images (e.g., ballerina/soccer player looking right or left) and which side of the refrigerator the handle was located on. Spatial placement scores here were calculated by computing the horizontal and vertical location in pixels as a percentage of the width and length of the refrigerator, respectively. Higher values mean that the magnet was placed further right or lower on the refrigerator.

Social identity scale

Participants completed a measure of social identity adapted to gender (Cameron, 2004). This scale includes three subscales: centrality, ingroup ties, and ingroup affect. Participants responded to questions like "I often think about the fact that I am a woman/man" and "In general, I'm glad to be a woman/man" on a scale from 1, Strongly Disagree, to 6, Strongly Disagree. We tested each of these subscales as potential moderators of spatial bias. Past

Table 1. Pretest ratings for each of the selected magnet pairs.

Magnet	Gender Stereotypicality	Valence
Animals		
Kitten	5.41 (1.62)	4.56 (1.98)
Lizard	3.63 (1.54)	4.09 (1.89)
Bicycles		
Feminine	5.28 (1.69)	4.06 (1.93)
Masculine	3.25 (1.68)	4.31 (1.67)
Cars		
Minivan	4.59 (1.88)	3.88 (1.95)
Sports Car	3.06 (1.72)	3.75 (1.65)
Paintings		
Ballerina	4.84 (1.44)	4.41 (1.64)
Soccer Player	3.03 (1.86)	3.41 (1.92)

work supports the distinctiveness of these dimensions for women and men. These subscales have demonstrated high reliability (α ranging from .76 to .84 for ingroup ties, here: .83; from .67 to .78 for centrality, here: .78; from .77 to .82 for ingroup affect, here: .86).

Procedure

Participants completed an informed consent and indicated their age and gender to allow for proper wording of additional measures (see Appendix). Participants completed the Spatial Placement Task and then rated each of the magnets on gender stereotypicality from 1 (Extremely Masculine) to 7 (Extremely Feminine).[3] All participants then completed the Social Identity Scale, questions about their experience taking the study, and a brief demographics questionnaire before receiving a debriefing about the purpose of the study.

Results

Vertical placement

Because placement data were nested within person and within stimuli, a cross-classified mixed model was the most appropriate fit to the data. Cross-classified mixed models are well suited to data that contain two random effects like that of subject and stimuli (Judd et al., 2012, 2017). Furthermore, multilevel models are more robust to Type I error and allow researchers to generalize beyond the particular sample of stimuli and participants used by accounting for individual variance of items and subjects (Judd et al., 2012, 2017; Westfall et al., 2015). Thus, we estimated mixed effect models to examine whether the participant's gender and magnet rating influenced magnet placement. Mixed models were estimated in R (R Core Team, 2017) with the lme4 package (Bates et al., 2015) using Satterthwaite approximate degrees of freedom (i.e., lmerTest; Kuznetsova et al., 2017).[4] Ratings were analyzed as a function of participant gender (woman (1) vs. man (−1); contrast-coded), centered magnet ratings (higher values indicated more femininity), and the interaction of the two. Random intercepts of subject and stimuli were included in the model.[5]

We had two competing hypotheses: ingroup spatial bias or stereotypical spatial bias. An ingroup spatial bias would be observed through an interaction of participant gender and magnet gender, whereas a stereotypical spatial bias would be observed through the main effect of magnet gender. Consistent with ingroup bias, the interaction of participant gender and magnet gender on vertical placement was significant, $b = -2.63$, $se = .30$, $t(1359.14) = -8.69$, $p < .001$. Women placed magnets higher on the refrigerator that they perceived as more feminine, $b = -2.75$, $se = .54$, $t(282.68) = -5.06$, $p < .001$. In contrast, men placed magnets higher on the fridge that they perceived as more *masculine,* $b = 2.50$, $se = .58$, $t(409.55) = 4.34$, $p = .002$. See Figure 1. There were no main effects of participant gender or magnet gender (*ps*>.582). Furthermore, there was no significant difference between these two slopes, $b = -.13$, $se = .47$, $t(192.03) = -.27$, $p = .787$, indicating that women and men had similar ingroup bias.

We next added each subscale of social identity to the model as a predictor to test whether this factor moderated ingroup spatial bias. We first added ingroup affect to the model. There was a significant interactive effect of magnet rating, participant gender, and

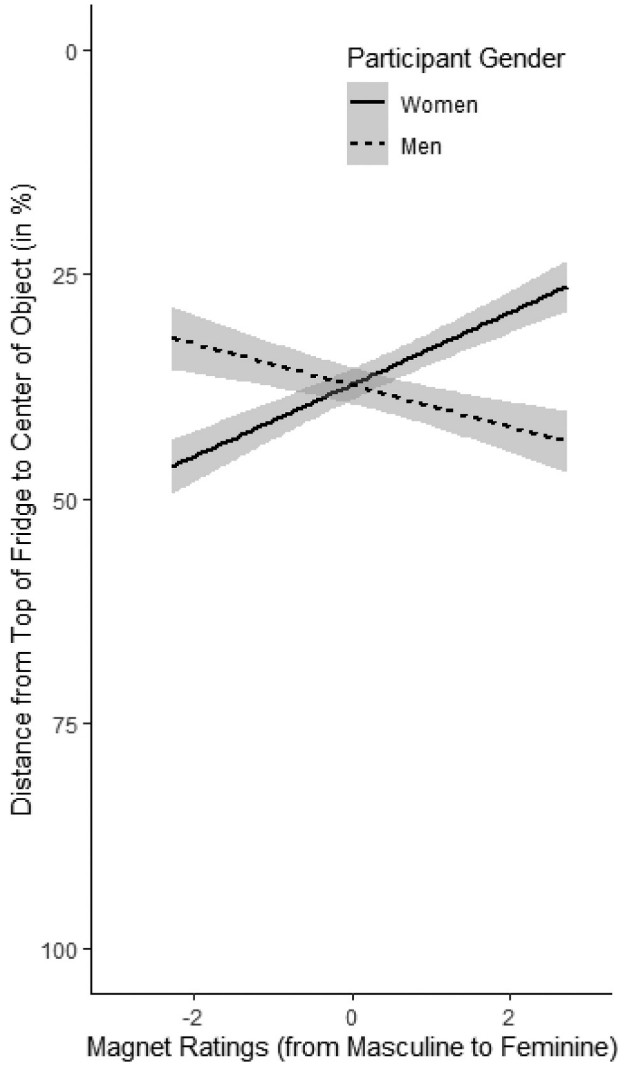

Figure 1. Average placement of magnets by women and men based on how masculine or feminine the magnets were rated.

ingroup affect on ingroup bias, b = 1.66, se = .49, t(1345.08) = 3.36, p < .001. Women, b = –.97, se = .44, t(1346.11) = –2.19, p = .029, and men, b = .69, se = .22, t(1345.11) = 3.17, p = .002, with stronger ingroup affect exhibited more vertical ingroup bias. There was also a marginal interactive effect of magnet rating, participant gender, and ingroup ties, b = .75, se = .39, t(1356.38) = 1.93, p = .054. Specifically, men, b = .44, se = .18, t(1344.88) = 2.40, p = .017, but not women, b = –.30, se = .34, t(1360.70) = –.90, p = .370, with stronger ingroup ties exhibited more vertical ingroup bias. Finally, there was a significant interactive effect of magnet rating, participant gender, and gender centrality, b = 1.19, se = .39, t(1357.22) = 3.07, p = .002. Men, b = .80, se = .20, t(1399.99) = 4.10, p < .001, but not women, b = –.38, se = .33, t(1342.99) = –1.15, p = .250, who considered gender more central to their identity exhibited more vertical ingroup bias. Thus, gender identity can in part account for the expression of vertical ingroup bias. Ingroup bias was strongest among women with high ingroup affect and among men with high ingroup affect, ingroup ties, or centrality.

Horizontal placement

We then tested these same predictions with horizontal placement. The interaction of participant gender and magnet gender on horizontal placement was not significant, $b = -.001$, $se = .003$, $t(1492) = -.29$, $p = .776$. Nor were there were main effects of participant gender or magnet gender ($ps > .250$). Gender ingroup affect ($b = -.0003$, $se = .003$, $t(1483.00) = -.10$, $p = .919$), ingroup ties, ($b = .002$, $se = .002$, $t(1488.00) = .96$, $p = .335$), and gender centrality ($b = .003$, $se = .002$, $t(1485.00) = 1.38$, $p = .169$) did not moderate horizontal ingroup placement.

Discussion

We had theorized that people express bias in their placement of objects that symbolize women and men. Specifically, we posed two alternative hypotheses: (1) gender stereotypical bias – that people would place masculine objects higher than feminine objects – and (2) ingroup bias – that people would place ingroup objects higher than outgroup objects. In this study, women placed feminine things higher in space, whereas men placed masculine things higher in space. Vertical location can communicate power (Giessner & Schubert, 2007; Hall et al., 2005; Lamer & Weisbuch, 2019; Landau et al., 2011, 2010; Schubert, 2005) and recent research suggests that vertical placement may be biased toward certain groups (e.g., in popular US magazines; Lamer & Weisbuch, 2019). Yet it is unclear why such spatial patterns may exist. Here we identified one possible mechanism: People use vertical placement to express ingroup bias.

However, for men, placement that favors the ingroup is the same as placement consistent with gender stereotypes. It is possible that one or both mechanisms are guiding men's behavior since men's pattern of placement could be supported by either hypothesis. We observed evidence that self-reported gender identity was involved in spatial placement for both women and men: ingroup affect (and to a lesser extent gender centrality and ingroup ties) moderated the extent to which women and men expressed ingroup spatial placement. Thus, we next experimentally manipulated gender identity to assess changes in placement: To the extent that ingroup spatial bias is guided by one's gender identity, we expected to be able to modulate it by threatening individuals' perceived prototypicality with their gender group.

Study 2: placement bias under social identity threat

Social identity theory conceptualizes an individual's prototypicality within a group as malleable (Haslam et al., 1995; Tajfel & Turner, 1979). Feeling as if one is far from the group prototype prompts an individual to feel uncertain about their identity, especially if this results in feeling close to the prototype of an outgroup (e.g. Haslam et al., 1995; Jetten et al., 2002). People are motivated to reduce uncertainty about the self and may do so by increasing prototypicality in a meaningful social group (Hohman et al., 2017).

Increasing prototypicality can take numerous forms including favoring prototypical (vs. nonprototypical) group members or expressing ingroup bias (e.g., Schmitt & Branscombe, 2001). We reasoned that if gender identity was related to how people placed gendered objects, that shifting individuals' gender prototypicality would also shift their placement behavior. The salience of a prototypicality threat depends on the value of ingroup membership and consequence of peripheral status, making a prototypicality threat important to individuals that identify with high-status groups (Schmitt & Branscombe, 2001). Not feeling prototypical can motivate individuals to exhibit ingroup-biased behaviors by way of self-uncertainty (Hohman et al., 2017) and those motivated to defend group status are especially likely to exhibit ingroup bias in the face of prototypicality threat (Jetten et al., 1997). We reasoned that prototypicality threat and affirmation would modulate the likelihood that people would exhibit ingroup spatial bias *if* this behavior was related to gender identity. In this study, participants were assigned to one of three conditions: threat, affirmation, or control and asked to complete the same spatial placement task as was used in Study 1.

Consistent with social identity theory, threat should impact members of high- and low-status groups differently because the consequences of being peripheral in a high-status group are greater than being peripheral in a low-status group (Haslam et al., 1995; Hohman et al., 2017; Jetten et al., 1997). Being told that you are not a prototypical member of a high-status group (i.e., men) should elicit stronger responses than being told that you are not a prototypical member of a low-status group (i.e., women). Similarly, being told that you *are* a prototypical member of a high-status group should elicit stronger responses than being told you are a prototypical member of a low-status group. For example, men tend to respond particularly strongly to changes in their perceived gender prototypicality. A man told he is dissimilar from other men (and thereby similar to women) is more likely to sexually harass a woman by sending her pornography, is more likely to express support for war, and is more likely to blame a woman for the circumstances of her assault than a man whose social identity has been affirmed (Hunt & Gonsalkorale, 2014; Maass et al., 2003; Munsch & Willer, 2012; Willer et al., 2013). Women tend to respond much more weakly to prototypicality threat than men (Munsch & Willer, 2012; Vandello et al., 2008). Due to gender-based status differences in many modern societies, rejecting femininity imbues power to both women and men, even though women must also reject their ingroup (Munsch & Willer, 2012). In fact, telling a woman she is not like other women or is not a "girly girl" is often considered a compliment. Thus, we did not expect women to respond strongly to prototypicality threat.

Nonetheless, in Study 2, we assessed both women's and men's group spatial bias in response to gender identity threat, affirmation, or control. We expected that any response to gender prototypicality threat would be observed more so among men than women given the precarious nature of masculinity and the relative status of men and women in US culture which is where our sample was drawn from for this study (Brandt, 2011; Graf et al., 2019; Moore & Shackman, 1996; Munsch & Willer, 2012; Vandello et al., 2008) rendering prototypicality threat a useful mechanism to assess the role of gender identity in motivating spatial placement bias. We tested for effects on both the vertical and horizontal dimension to replicate and extend findings from Study 1.

Methods

Participants and setting

Students were recruited from the Psychology Department at a US mid-western private university. Participants were paid for their participation in the 30-minute experiment. The study was approved by the university Institutional Review Board. The lab session was conducted using Qualtrics with each student in their own room for the duration of the experiment. The final sample consisted of 239 participants (71% women), ranging in age from 18 to 35 with quartiles at 19, 19, and 21.[6] We aimed for 256 participants based on power analyses of a conservatively small effect size (f^2 = .03) and *a priori* decided to stop data collection once this number was reached or once the academic quarter had concluded – whichever came first. After data

collection was complete, we shifted to use multi-level models for analysis to replicate Study 1 and to generalize beyond the particular sample of participants and stimuli used.[7]

Materials

Prototypicality threat

To induce gender identity threat, participants first completed a shortened 12-item version of the Bem Sex Role Inventory (Bem, 1974; Vafaei et al., 2014) and were then provided fictitious feedback with their score (for similar manipulations, see Maass et al., 2003; Munsch & Willer, 2012; Schmitt & Branscombe, 2001; Vandello et al., 2008). Participants were assigned to the threat, affirmation, or control condition. In the control condition, they received no feedback on how they scored relative to others of their gender and they did not see the graph of the distributions. They did, however, respond to the Bem Sex Role Inventory. In the other two conditions, participants were shown their score along with what they were told was the average distributions for women and men of their age (see Figure 2). In order to ensure that the participant read and understood their score, they were asked to plot it along the x-axis of the distributions. In the threat condition, the score shown was close to the end of the normal distribution and participants were told "*your score is outside of the average range for your gender*." In the affirmation condition, the score shown was close to the middle of the normal distribution and participants were told "*your score is within the average range for your gender.*"

Procedure

When participants first arrived at the lab, they completed informed consent and indicated their age and gender to allow for proper randomization into feedback condition. Participants completed the Bem Sex Role Inventory and were randomly assigned to receive threatening feedback, affirming feedback, or no feedback. All participants then completed the spatial placement task and a brief demographics questionnaire before an experimenter fully debriefed them about the purpose of the study and nature of the personality feedback.[8]

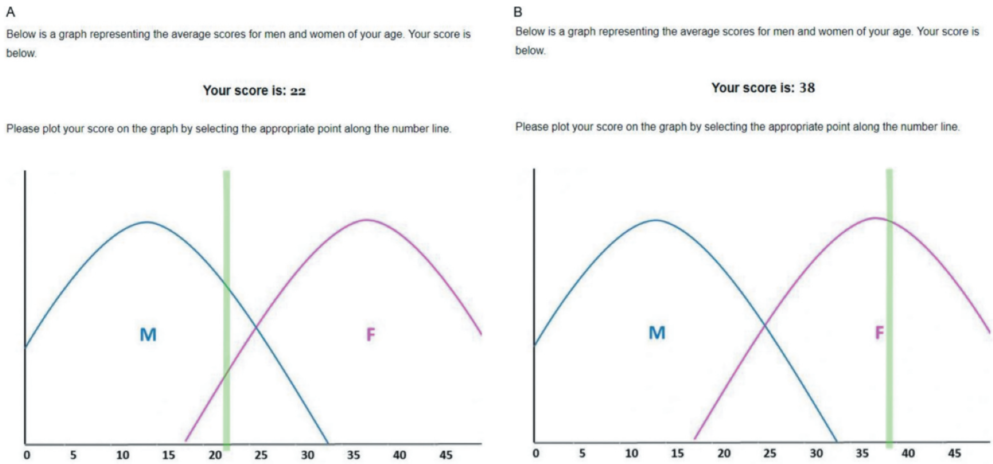

Figure 2. Example feedback provided to women participants in Studies 2 and 3. Panel A provides identity-threatening feedback, whereas Panel B provides identity affirming feedback. Whether the distribution of women's scores was higher or lower (i.e., to the left or right) than that of men's scores was counterbalanced across participants. Thus, whether threatening feedback was associated with a higher or lower absolute value was counterbalanced.

Results

Vertical placement

We again estimated cross-classified mixed models to examine whether the participant's gender, magnet rating, and gender identity threat condition influenced where the participant positioned the magnet. Vertical placement was nested within the subject and the stimuli; we, therefore, analyzed the data as a function of participant gender (woman (1) vs. man (−1); contrast-coded), centered magnet ratings (higher values indicated more femininity), condition (threat (1) vs. affirmation (0) and control (1) vs. affirmation (0); dummy-coded), and all higher-order interactions. There was a marginal main effect of participant gender, $b = .03$, $se = .01$, $t(233.10) = 1.80$, $p = .073$; a main effect of magnet rating, $b = -.02$, $se = .007$, $t(974.00) = -2.21$, $p = .027$; and a marginal two-way interaction of the two, $b = -.01$, $se = .006$, $t(1718.00) = -1.91$, $p = .056$. However, we hesitate to interpret these effects given that they are qualified by three-way interactions with each of the two dummy-coded condition variables. Specifically, participant gender and magnet rating interacted with threat (vs. affirmation), $b = -.02$, $se = .009$, $t(1743.00) = -2.05$, $p = .040$, and control (vs. affirmation), $b = -.02$, $se = .009$, $t(1773.00) = -2.41$, $p = .016$. Women exhibited an ingroup bias in spatial placement regardless of prototypicality threat condition (magnet by threat condition interactions for women: $ps > .204$; see Figure 3). Men, on the other hand, were significantly impacted by condition (magnet by threat condition interactions for men: $ps < .042$). They exhibited an ingroup bias in vertical placement when threatened or not given any feedback, but not when affirmed. Thus, affirmation mitigated men's ingroup bias but had no impact on women's ingroup bias.

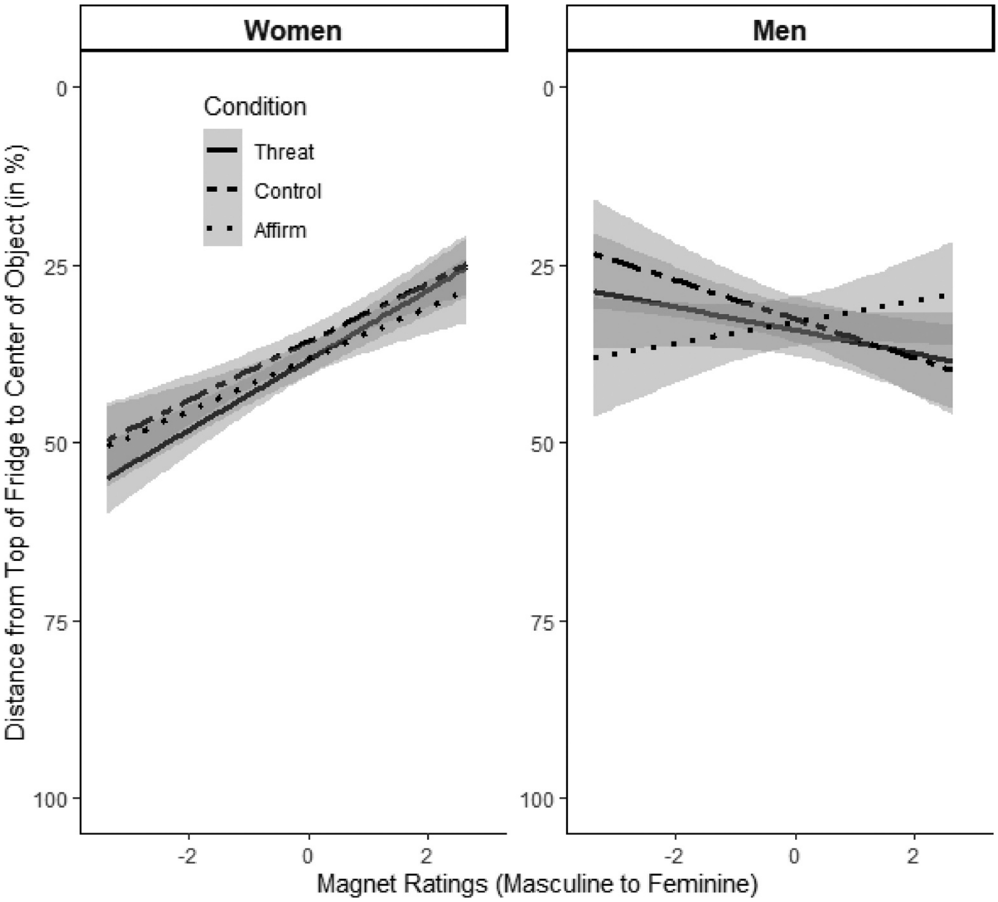

Figure 3. Magnet placement in Study 2 for women (left panel) and men (right panel). Women placed feminine magnets higher than masculine magnets regardless of condition, whereas men placed masculine magnets higher than feminine magnets only in the threat and control condition. In the affirmation condition, men placed feminine magnets higher than masculine magnets.

Horizontal placement

We tested horizontal placement of the magnets using the same predictors in a cross-classified model. No effects emerged except for a main effect of threat (vs. affirmation) such that people placed magnets farther to the right when threatened than affirmed, $b = 3.96$, $se = 1.47$, $t(1894.00) = 2.68$, $p = .007$. The interactions of participant gender and magnet rating with threat (vs. affirmation), $b = -.71$, $se = .94$, $t(1895.36) = -.76$, $p = .447$, and with control (vs. affirmation), $b = -.66$, $se = .96$, $t(1894.14) = -.76$, $p = .447$, were not significant.

Discussion

We theorized that people would draw from stereotypes or ingroup identity to place gendered objects. Men could have placed masculine objects higher because their gender identity was important, because they endorsed gender stereotypes, or both. We expected

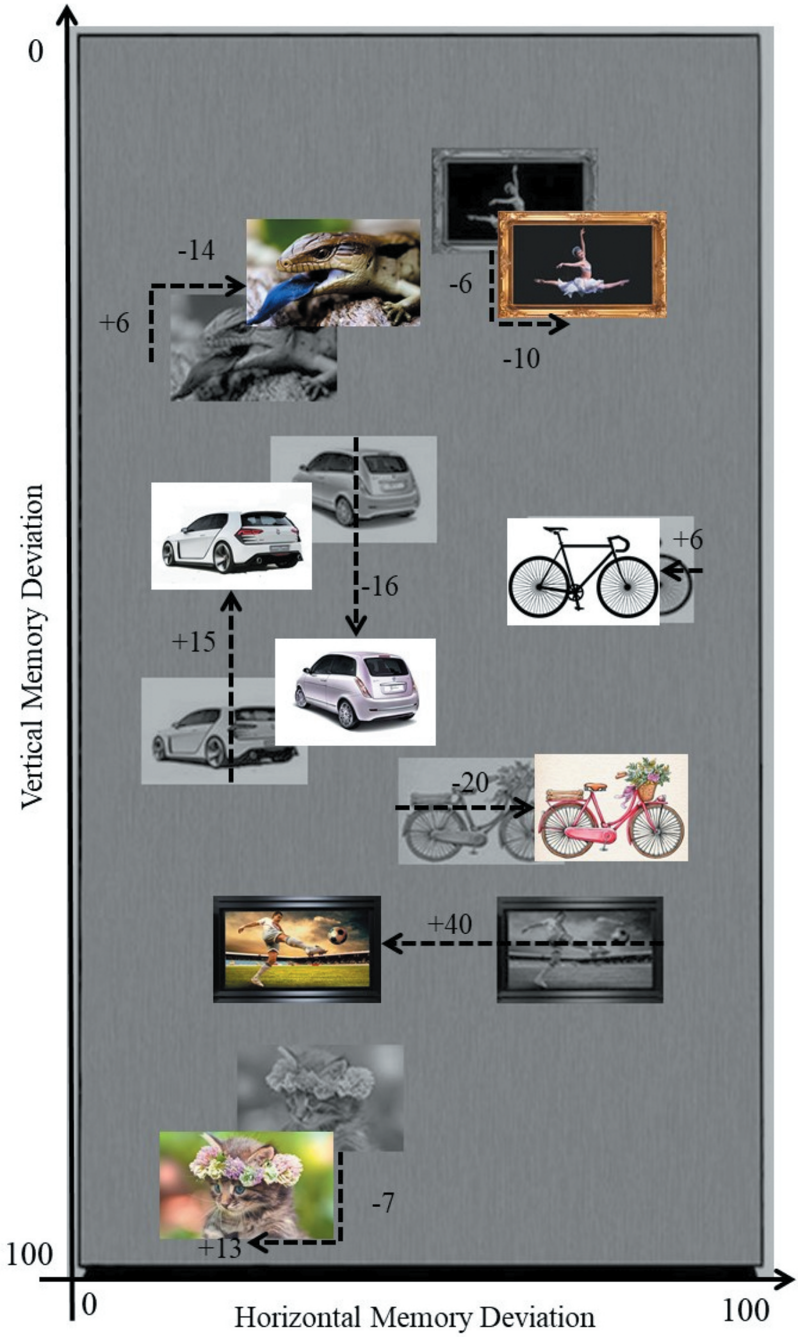

Figure 4. Example spatial memory task performance. Original magnet placements are shown in faded grayscale watermark with how a participant may have remembered the placement on top at full opacity. Deviation scores were calculated by measuring the distance that each magnet was moved from its original position. When a magnet was recalled as being in a more advantaged location (i.e., higher or more leftward), it was recorded as a positive number. Values are reported as a percent of refrigerator length and width.

that if gender identity contributed to men's spatial placement, that prototypicality threat should shift their behavior accordingly. Consistent with the effects observed in Study 1, participants in Study 2 exhibited a gender ingroup bias in how they placed feminine and masculine objects. Women placed feminine objects higher than masculine objects – and this was true regardless of their condition. However, men placed masculine objects higher than feminine objects, but only in the control and threat conditions. Only the affirmation condition mitigated ingroup placement bias.

The similarity in men's response between threat and control is consistent with past work. There are reasons to expect that men may typically respond as if they are under threat. The Precarious Manhood Theory posits that men's fit with their gender is evaluated more on the basis of social evidence than biological markers and therefore must be regularly proven (Vandello et al., 2008). Other work suggests that affirming one's prototypicality can generate a modesty effect wherein people exhibit an *outgroup* bias (Cadinu & Cerchioni, 2001). We found evidence consistent with this Modesty Effect (Cadinu & Cerchioni, 2001); men responded to affirmation by exhibiting an *outgroup bias* in vertical placement relative to the control condition.

Thus, Studies 1 and 2 provide self-report and experimental evidence consistent with our theory that gender identity contributes to men's (and women's) spatial placement. We also found further support for the importance of *vertical* (but not horizontal) space in transmitting ingroup bias. Ingroup bias was observed among women and men along the vertical, but not the horizontal axis.

Study 3: memory bias under social identity threat

In the previous two studies, we observed an effect of participant gender on magnet placement. In this task, participants were not limited by time and were allowed to rearrange objects until they are pleased with their final product. Despite the subtlety of expressing ingroup bias by placing an object in space, we reasoned that the observed effect on the placement task likely owed to more controlled processing given that the act of placing a magnet engages personal choice and deliberation. However, we were interested in whether spatial bias would also be observed in more automatic processing. Thus, in Study 3, we sought to test for ingroup bias and stereotypical bias in spatial memory.

Indeed, a large literature has examined the nature of location memory finding support for the automaticity of this process (Druker & Anderson, 2010; Richardson & Spivey, 2000; Shadoin & Ellis, 1992; Sridharan et al., 2013). People encode location information even when such information is irrelevant to the task at hand (Richardson & Spivey, 2000; Shadoin & Ellis, 1992). Furthermore, human and non-human animals learn associations between an object's location and its appearance in as little as a single experiment and stimulus location probabilities can facilitate item detection (Ciaramitaro et al., 2001; Druker & Anderson, 2010). Thus, we expected that to the extent ingroup spatial bias extends to automatic processing, it would be observed in a task employing spatial memory. Ingroup biases in spatial memory would suggest that cultural patterns of male spatial elevation wherein men are higher than women are amplified in memory for men.

Methods

Participants and setting

Students were recruited from the Departments of Engineering, Chemistry, Biology, Psychology, and Mathematics at the University of Padua. Participants were fluent either in Italian or English and were tested by an experimenter fluent in that language. Participants were paid for their participation in the 30-minute experiment. The study was approved by the institutional ethical committee of psychological departments at the University of Padua. The experiment was conducted using Qualtrics and Tobii Pro Studio with each student in their own room for the duration of the experiment. The final sample consisted of 138 participants (57% women), ranging in age from 19 to 28 with quartiles at 20, 21, and 23.[9] There were 121 participants who completed the study in Italian and 17 international participants who completed the study in English. We aimed for 20–40 participants per gender/condition cell based on sample sizes of previous studies assessing spatial memory (Bettinsoli et al., 2019; Crawford et al., 2016, 2006; Richardson & Spivey, 2000; Vestner et al., 2019). After exclusions, there were between 27 and 39 participants per cell of the 2 (Threat) by 2 (Gender) design.

Spatial memory task

The goal of this task was to test participants' memory for the vertical and horizontal location of feminine and masculine objects. Participants were shown a refrigerator with the same eight magnets as used in Studies 1 and 2 – four feminine/masculine pairs (e.g., ballerina/soccer player) for 30 seconds. The magnets were arranged such that feminine and masculine magnets were, on average, centered at the vertical and horizontal midpoint of the refrigerator. The positions of the specific magnets were also counterbalanced into 16 different arrangements so that each magnet appeared in each location in each mirrored version.

We calculated deviation scores by computing the difference between where each magnet originally appeared and where the participant recalled it having been. Higher values indicated that participants placed the magnet higher or further left than where it had originally appeared on the refrigerator. See Figure 4 for example.

Procedure

When participants first arrived at the lab, they were calibrated on the Tobii Pro X3-120 eye tracker.[10] They then completed informed consent and indicated their age and gender to allow for proper randomization into feedback condition. Participants completed the BSRI and were randomly assigned to receive threatening or affirming feedback. All participants then completed the spatial memory task and a brief demographics questionnaire before an experimenter fully debriefed them about the purpose of the study and nature of the personality feedback.

Results

We again estimated cross-classified mixed models but this time to examine whether the participant's gender, magnet rating, and gender identity threat condition influenced where the participant recalled each magnet's location. Vertical placement was analyzed as a function of participant gender (woman (1) vs. man (−1); contrast-coded), centered magnet ratings (higher values indicated more femininity), condition (threat (1) vs. affirmation (−1); contrast-coded), and all higher-order interactions. There were no main effects (*ps*>.384), no two-way interactions (*ps*>.456), and, critically, no three-way interaction, $b = .05$, $se = .48$, $t(1089.36) = .12$, $p = .909$. We also tested horizontal spatial memory using the same predictors in a cross-classified model. No effects emerged, *ps*>.456. Thus, we observed no effects on spatial memory.

Discussion

We found no evidence that people exhibit ingroup bias in their memory for the location of gendered objects. Nor did we find evidence of a stereotype-consistent bias in spatial memory. The absence of an effect here is in contrast to Study 1 and Study 2 wherein we found gender ingroup bias in vertical spatial placement. The null effect may be a result of the unique mechanisms guiding spatial memory (relative to spatial placement). Research suggests that spatial memory is automatically encoded and recalled during these free recall tasks (Logan, 1998; Shadoin & Ellis, 1992). Thus, the absence of an effect suggests that vertical spatial bias is bounded by task automaticity. We observed vertical placement bias, but not vertical memory bias suggesting that women and men only exhibit spatial bias in tasks enabling more controlled processes such as placement (Studies 1 and 2 here). Further research is needed to disentangle these two components within the same task (see Jacoby, 1991 & Payne, 2001).

It is worth noting that the sample and procedure in Study 3 were unique in a number of ways. Participants were calibrated to an eye tracker before completing the study. This may have made them anxious or more attentive to the study protocol. The sample was smaller in this study given time limitations of data collection with the eye-tracker (i.e., each experimental session was conducted one at a time with an experimenter fluent in that participants' preferred language) and a smaller estimated sample size based on the spatial memory task. Participants were also recruited from an Italian university; thus, the majority of participants were Italian and completed the study in Italian. We do not anticipate that this latter set of differences altered the experimental manipulation in meaningful ways. For example, the model is based on individualized ratings of each magnet so cultural differences in the perception of magnet gender-stereotypicality should be accounted for. Furthermore, past work has used gender identity threat manipulations with Italian samples successfully (Hunt et al., 2016; Maass et al., 2003) and we were thus assured that this manipulation would be suited to this population. Nonetheless, we wanted to replicate the null effects observed in Study 3 on the memory task in a larger sample where individuals were randomly assigned to complete the placement or memory version of the task.

Study 4: comparing placement and memory bias

We hypothesized that people would place objects in ways that vertically (but not horizontally) advantaged their ingroup. Women would place feminine objects higher than masculine objects, whereas men would place masculine objects higher than feminine objects. As in Study 2, we anticipated moderation by gender identity affirmation for men (but not women). Furthermore, we hypothesized that gender ingroup bias would not be observed in spatial *memory*, and exploratorily examined the hypothesis that stereotype-consistent bias would be observed on this more automatic outcome.

We also explored the role of gender stereotypes in spatial bias. In Study 1, gender identity (i.e., positive affect toward one's gender) predicted the strength of ingroup spatial placement bias and in Study 2, inducing gender identity affirmation mitigated the ingroup bias among men. Yet behavior is multiply determined and the influence of gender identity on spatial placement does not preclude the influence of gender stereotypes. This is especially true for men whose pattern of spatial placement would be identical regardless if they were guided by gender identity as if they were guided by gender stereotypes.

Methods

Participants and setting

A large sample of US participants were recruited from both introductory psychology classes at a southeastern public university for partial course credit and from Prolific Academic for pay. The study took participants about 15 minutes to complete and was approved by the Institutional Review Board. The experiment was conducted using Qualtrics with each participant completing the study online. The final sample consisted of 805 participants (53% women; 77% Prolific Academic; 74% white[11]), ranging in age from 18 to 73 with quartiles at 20, 26, and 34.[12] Using the simR package in R (Green & Macleod, 2016), we estimated the sample size needed to achieve .80 power. Specifically, we used the effect observed in Study 2 from the addition of the three-way interaction of gender, dummy-coded threat v. affirmation condition variable, and magnet gender. This analysis yielded a sample size of 400 participants. (See SOM for R script and materials.) Since we planned to add a factor in which participants were randomly assigned to the placement or memory task, we doubled this number to yield our target sample size. In our pre-registration for this study (https://osf.io/ez5vh/?view_only=82ccc390bcc54e5cb269a71b44b6a31a), we indicated that we sought to collect 880 participants (i.e., our target sample size plus 10%). We oversampled to account for the anticipated exclusions based on technical errors, attention checks, and non-binary gender identity. Following exclusions, we met our required *a priori* sample size goal.

Gender stereotype measure

Participants indicated their perceived gender stereotypes with 10 adjectives. They responded to items like, "People think that men, in general, are competent" and

"People think that women, in general, are independent" on a scale from 1 (not at all) to 7 (extremely). The scale included the following adjectives: competent, intelligent, independent, competitive, confident (α = .76). We took a difference score between ratings of women and ratings of men such that higher scores indicated stronger perceived gender stereotypes.

Procedure

When participants clicked on the study link, they were asked to complete the study in one sitting and turn off all distractions in their environment. Qualtrics and Prolific restricted participants from completing the task on a mobile device. They then completed informed consent and indicated their age and gender to allow for proper randomization into feedback condition. Participants completed the BSRI and were randomly assigned to receive threatening or affirming feedback. All participants then completed either the spatial memory task or spatial placement task before completing a gender stereotype measure and a brief demographics questionnaire. They were then fully debriefed about the purpose of the study and nature of the personality feedback before being given the opportunity to reconsent using their data in analyses.

Results

Vertical location

We anticipated that participants would preferentially place gender ingroup items high in space and that affirmation would mitigate this bias among men. We did not anticipate gender ingroup bias in spatial memory.

Vertical placement

Vertical placement was analyzed as a function of participant gender (woman (1) vs. man (−1); contrast-coded), centered magnet ratings (higher values indicated more femininity), condition (threat (1) vs. affirmation (−1); contrast-coded), and all higher-order interactions. Vertical placement values could vary from 0 to 100 (i.e., distance from the top of the fridge to the magnet as a percent of the fridge length). No significant main effects emerged. There was a marginal main effect of threat such that people in the threat condition placed objects lower than those in the affirmation condition, $b = -1.00$, $se = .55$, $\beta = -.20$, $t(465.34) = -1.82$, $p = .070$. However, the sample was large and thus we hesitate to over-interpret this marginal effect. A significant two-way interaction of participant gender and magnet rating indicated that participants placed ingroup objects higher than outgroup objects, $b = -1.17$, $se = .23$, $t(3415.99) = -5.15$, $p < .001$ (see Figure 5). Women placed feminine objects higher than masculine objects, $b = -1.48$, $se = .33$, $t(3322.50) = -4.43$, $p < .001$, whereas men placed masculine objects higher than feminine objects, $b = .87$, $se = .36$, $t(3436.13) = 2.42$, $p = .016$. However, this interaction was not *moderated* by gender identity threat, $b = .06$, $se = .23$, $t(3416.42) = .28$, $p = .782$. Thus, affirmation did not significantly mitigate men's ingroup bias as it had in Study 2. See discussion for more on this pattern of results.

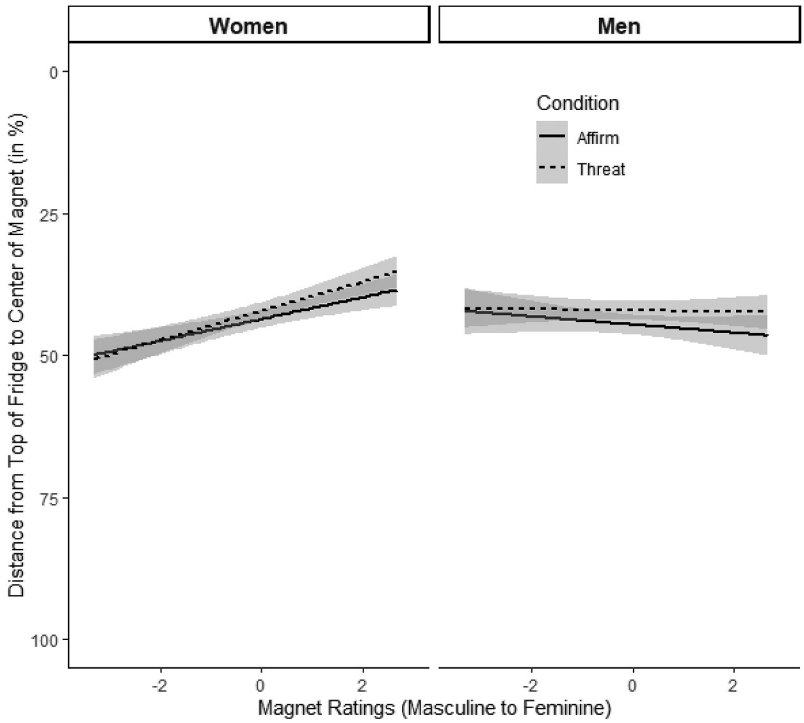

Figure 5. Magnet placement in Study 4 for women (left panel) and men (right panel) in each condition. Women place feminine magnets higher than masculine magnets while men place masculine magnets higher than feminine magnets regardless of condition.

We also exploratorily entered gender stereotypes into a model with magnet rating separately for men and for women. Endorsement of gender stereotypes moderated magnet placement for men, $b = .58$, $se = .29$, $t(1565.82) = 1.99$, $p = .047$, such that men who strongly endorsed gender stereotypes were especially likely to spatially advantage masculine (vs feminine) objects, $b = .92$, $se = .45$, $t(1246.09) = 2.06$, $p = .040$. In contrast, magnet gender ratings did not predict vertical placement for men *low* in gender stereotype endorsement, $b = -.26$, $se = .51$, $t(1414.63) = -.50$, $p = .614$. For women, the endorsement of gender stereotypes did not moderate magnet placement, $b = -.05$, $se = .22$, $t(1789.11) = -.24$, $p = .807$. Even when accounting for gender stereotype endorsement in this model, women still placed feminine objects significantly higher than masculine objects, $b = -1.06$, $se = .34$, $t(1784.17) = -3.09$, $p = .002$. Thus, men's spatial placement is guided by both perceived gender stereotypes and gender identity.

Vertical memory

Vertical memory was analyzed as a function of participant gender (woman (1) vs. man (−1); contrast-coded), centered magnet ratings (higher values indicated more femininity), condition (threat (1) vs. affirmation (−1); contrast-coded), and all higher-order interactions. Vertical memory values could vary from −100 to 100 (i.e., the difference between actual and remembered location of each magnet as a percent of fridge length). People

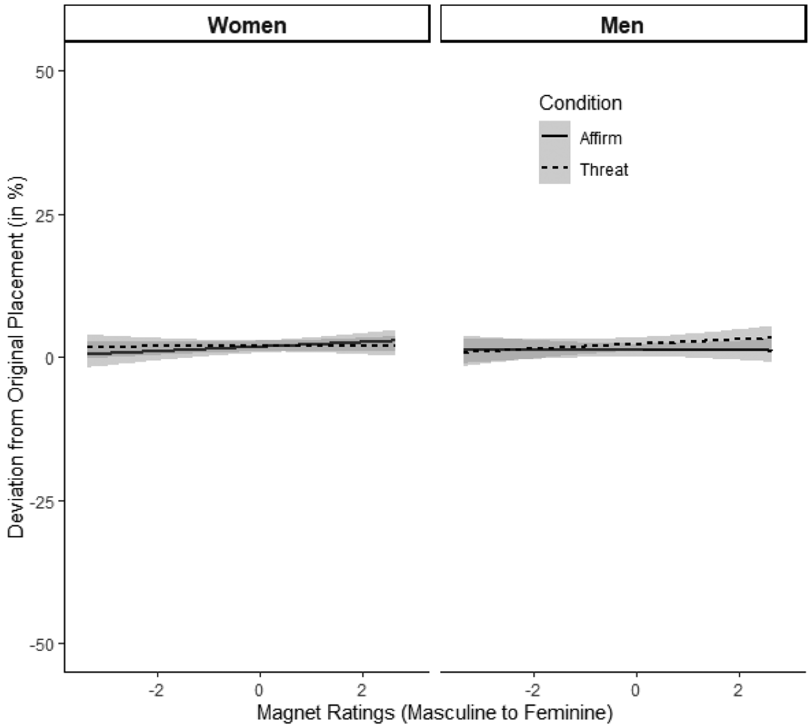

Figure 6. Vertical memory bias in Study 4 for women (left panel) and men (right panel) in each condition. Positive values on the y-axis mean that magnets were placed higher than they originally appeared. There were no significant effects of magnet rating, participant gender, or threat condition on memory for object location.

recalled objects as higher than they were, $b = .02$, $se = .007$, $t(7.06) = 2.55$, $p = .038$. No other main effects or two-way interactions emerged, $ps > .317$. Critically, the three-way interaction was not significant, $b = -.002$, $se = .002$, $t(2367) = -1.36$, $p = .175$ (see Figure 6), even when testing for moderation by gender stereotypes, $b = .002$, $se = .001$, $t(2374.00) = 1.59$, $p = .113$.

Horizontal location

Although we anticipated no effects in horizontal placement or memory, we tested outcomes on this dimension. As predicted, no effects emerged in a model predicting horizontal spatial placement, $ps > .384$, or horizontal spatial memory, $ps > .129$.

Discussion

We had hypothesized that we would observe gender bias in spatial placement but not spatial memory and that threat would moderate effects for men. These hypotheses were partially supported. As we had observed in Study 2, participants exhibited ingroup bias in vertical but not horizontal placement. Women placed feminine magnets higher than masculine magnets regardless of whether having been told they were typical or atypical of women in their age group. However, in contrast to Study 2, we observed no effect of gender identity affirmation on men's ingroup placement bias. Even when affirmed, men placed masculine objects higher than feminine objects. There are two possible explanations. First, it is possible that the true effect of identity affirmation on men's ingroup placement bias is weaker than Study 2 indicated. In this case, gender identity may be less critical in guiding men's placement of gendered objects. Nonetheless, we still find evidence of gender identity being related to vertical ingroup bias among men in Study 1. Thus, second, it is possible that the gender identity threat manipulation was less compelling to participants in this online format. Indeed, participants were not in physical proximity to the researcher, did not engage with the researcher during setup, and feedback may have thus felt less personalized. Comparing a suspicion question asked during the debrief (scale from 1 to 5), participants reported being more suspicious of personality feedback in this study (M = 2.94, SD = 1.18) than in Study 2 (M = 2.68, SD = 1.22), t (1042) = 2.94, p = .003, 95% CI [.08,.43]. Thus, we tentatively suggest that gender affirmation may indeed reduce ingroup placement bias among men when affirmation is provided in a more personalized way. Additional research would be valuable to test this hypothesis.

This study provided a robust and well-powered assessment of ingroup vertical placement bias. Both women and men placed objects according to their femininity and masculinity. However, we observed no such effect on spatial memory, replicating the null effect observed in Study 3. We discuss the implications for the automaticity versus controlled nature of spatial bias in the General Discussion.

General discussion

People tend to vertically advantage objects that symbolize their gender ingroup. In Study 1, women and men both expressed ingroup vertical placement bias. This was strongest among women with high ingroup affect and among men with high ingroup affect, ingroup ties, or centrality. This is consistent with past theorizing; people favor their ingroups to bolster their own self-esteem and this is especially true for those who identify with their group (Cadinu & Cerchioni, 2001; Haslam et al., 1995; Hohman et al., 2017; Tajfel & Turner, 1979). In Study 2, we observed that gender affirmation mitigated men's ingroup response, confirming support for a mechanism of gender identity. Women, on the other hand, were unaffected by threat. This is perhaps because being told they are not very feminine is not much of a threat in the current social hierarchy where women are a lower-power group (Browne & Misra, 2003; Halim et al., 2013; Moore & Shackman, 1996; Munsch & Willer, 2012). In Study 3, we focused on teasing apart automaticity versus control. We did not observe a pattern of group bias in spatial memory; gendered spatial bias thus occurs more so in tasks that allow for control than those that do not. In Study 4, we replicated this null finding on spatial memory alongside ingroup bias on spatial placement.

Underlying mechanisms of spatial bias

We had broadly theorized that spatial bias would be guided by two potential mechanisms: that people may (a) arrange their environments to bolster their ingroup gender identity or (b) arrange objects consistent with current gender stereotypes – with masculine objects higher or further left than feminine objects. Throughout this set of studies, we observed evidence consistent with the first mechanism: ingroup bias. However, men's spatial placement of objects may have owed to either mechanism: gender identity or gender stereotypes. Women's spatial placement of objects may instead owe to just gender identity – since gender identity and gender stereotypes would work against each other. In Studies 1 and 2, we observed evidence that gender identity predicted spatial placement. In Study 1, responses to the Social Identity Scale predicted spatially advantaging ingroup magnets relative to outgroup magnets for women and men. In Study 2, gender prototypicality threat altered men's ingroup spatial bias. Gender identity affirmation mitigated the ingroup bias such that men in this condition placed feminine objects higher than masculine objects. Yet in Study 4, we observed evidence that gender stereotypes guide men's (but not women's) object placement. The more than men endorsed the prevalence of traditional gender stereotypes, the more that they spatially advantaged masculine objects relative to feminine objects. Thus, it is possible that gender identity predicts spatial bias in some settings, whereas gender stereotypes predict spatial bias in others. More research is needed to test when each of these mechanisms is operating.

Whether or not participants expressed gender spatial bias depended on the type of task they completed. Specifically, we observed gender bias in vertical placement, but not vertical memory recall, suggesting that gender spatial bias is observed in tasks involving more controlled processes. A large body of research suggests that spatial location is automatically encoded. For example, people recalled where a photograph appeared regardless of whether they were instructed to do so and even elementary-aged children exhibit incidental memory for spatial location (Park & James, 1983; Shadoin & Ellis, 1992). Of course, other factors contribute to spatial memory, such as age, task load, and individual differences (Naveh-Benjamin, 1987). We anticipated that if spatial bias extended to automatic processes, that gender identity or stereotypes may contribute to encoding or recall of spatial memory. Yet, we instead found null effects suggesting that automaticity is a boundary condition for gendered spatial bias.

The importance of vertical vs. horizontal space

Gendered spatial bias was only observed on the vertical (not horizontal) spatial dimension. This is perhaps unsurprising given the limited horizontal width of the refrigerator (410 pixels) and the landscape layout of the magnets (100 pixels wide x 63 pixels high). The vertical axis of the fridge used in the studies was about 80% larger than the horizontal axis (i.e., 737 pixels). Thus, the spatial placement task and the spatial memory task had somewhat limited horizontal space in which to observe bias.

Preliminary evidence

To evaluate that limited space may have a limited observation of horizontal ingroup spatial bias, we designed a follow-up spatial placement task to examine whether ingroup spatial bias would also be observed on the horizontal dimension if the task had allowed. In this follow-up study, participants were asked to complete a similar aesthetic arrangement task of feminine and masculine objects, but this time instead of a refrigerator, participants arranged objects in an undecorated waiting room (813 pixels wide x 542 pixels high; see Supplement

Figure S1 for example). Participants (N = 211; 50% women) were recruited from Mturk and ranged in age from 20 to 76 with quartiles at 28, 36, and 47. Objects were digitally created so that they were matched in style and could be moved around a waiting room with a transparent background. These objects were pretested using a similar methodological structure and participant sample as when pretesting the refrigerator magnets (see Study 1). All objects (i.e., a backpack, a purse, a brown watch, a pink watch, a picture of a soccer player, a picture of a ballerina, a women's magazine, and a men's magazine; see supplement for examples) were significantly different in their stereotypicality. We tested for ingroup spatial bias along the horizontal axis. Using the same analytical approach to account for variation by subject and stimulus, we did not find evidence of horizontal placement bias. The interaction of participant gender and magnet gender on horizontal placement was not significant, $b = -.30$, $se = .20$, $t(1672) = -1.37$, $p = .172$. See Figure 7. Nor were there any main effects of participant gender or magnet gender ($ps > .473$) suggesting that gender spatial bias may not be expressed along the horizontal axis even when the task allows.

However, there was an unexpected main effect of magnet gender on vertical placement, $b = .37$, $se = .18$, $t(1612.90) = 2.07$, $p = .039$, such that women and men participants placed masculine objects higher than feminine objects. We explore the potential implications of this preliminary finding for our broader theory below. Thus, even when people could vary the horizontal placement of objects, group biases did not emerge.

The secondary nature of horizontal location

We can speculate a few reasons why verticality may have been more utilized in the expression of ingroup bias. First, this pattern may be due to the importance of vertical and horizontal cues relative to each other. Specifically, the meaning ascribed to verticality may be more universal than the meaning ascribed to horizontality. Humans and many non-human animals use size to communicate dominance. Humans stand taller and use

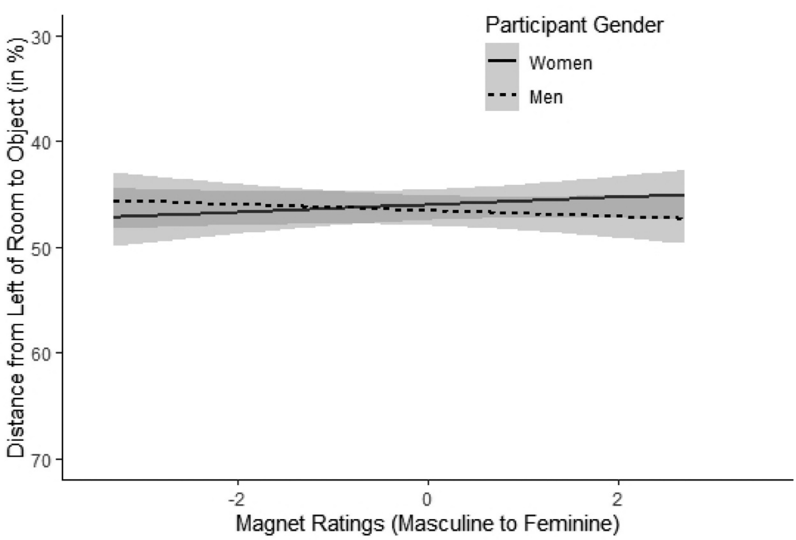

Figure 7. Average horizontal placement of magnets by women and men based on how masculine or feminine the magnets were rated in the follow-up.

expansive postures to communicate dominance while non-human animals like dogs and gorillas bristle their hair and stand on their hind legs to communicate dominance (Maslow, 1940; Weisfeld & Beresford, 1982). The vertical dimension is also sustained by a constant physical force (i.e., gravity), whereas this is not true for the horizontal dimension. Gravity is universally experienced on Earth and thus associations between verticality and power may be more constant (i.e., experienced since birth) and therefore stronger than associations between horizontality and agency. Conversely, the link between agency and horizontal location is culturally specific; it is related to written language and learned alongside reading and writing (Maass et al., 2014; Suitner, Maass, Bettinsoli et al., 2017). Thus, this association may be weaker because it is dependent on exposure to language and cultural environments in which L to R or R to L associations with agency are featured.

Associations between verticality and power are learned early; research suggests that both children and adults hold links between power and vertical location (L. Schubert et al., 2013). In fact, scientists argue that children are exposed to the association between vertical size and power from birth because their parents and other caretakers are larger than they are (Landau et al., 2010). Thus, when verticality and horizontality are pitted against each other, verticality may take precedence. It is possible that horizontal placement becomes more important when variability along the vertical dimension is removed or in situations when the relative positioning of just two objects (i.e., an agent and an object) is central.

Different dimensions for different meanings

Alternatively, both kinds of spatial associations may be held strongly but employed to communicate slightly different messages. Evidence from developmental samples suggests that children and adolescents exhibit both vertical *and* horizontal associations with power and agency (Lu et al., 2017; Suitner, Maass, Bettinsoli et al., 2017). Thus, we may have observed effects uniquely on vertical placement because verticality is more meaningful in the communication of group bias.

The vertical axis is related to valence (Meier & Robinson, 2004, 2006; Meier et al., 2007) and to power/status/dominance (Lamer & Weisbuch, 2019; Schubert, 2005; Zanolie et al., 2012). Especially the latter suggests that verticality is a marker of social hierarchies. Horizontal spatial bias is related to motor action and is considered a marker of agency (Maass et al., 2014; Suitner & Maass, 2016). Agency may have been less relevant than status and power in the arrangement of gendered objects. For example, the tasks required no movement of the objects once they had been set and the objects themselves (e.g., backpack, kitten) were mostly unrelated to agency. Future research should explore the question of when horizontal location is used to convey group bias.

Some research has looked at the combined influence of horizontal and vertical space. For example, Schoel et al. (2015) have developed an individual difference measure – the Spatial Power Motivation Scale – that tests perceivers' attention to power along both the horizontal and vertical dimensions. Participants see dots symbolizing self and other; their task is to select which orientations they prefer. Higher scores on this measure indicate that people prefer upper-left positioning relative to lower-right positioning. However, scores are reported cumulatively and not separately by horizontal and vertical dimensions. In other work, Paladino et al. (2017) compared how the four spatial quadrants (e.g., upper-left, lower-right) communicate leadership. Consistent with work on both horizontal and vertical space, participants inferred that people pictured in the upper-left hand corner of a layout were more likely to hold leader (vs. follower) roles in an organization. However, it is unclear what role vertical and horizontal space have relative to each other in communicating leadership in this paradigm. The work we have presented here provides some initial evidence for the *relative* importance of vertical and horizontal spatial cues and lays a foundation for future research questions comparing the influence of vertical and horizontal dimensions in communicating attributes like power, status, and agency.

Variation in vertical group bias

Conceptual Metaphor Theory argues that people employ concrete concepts, like vertical location, to understand and convey abstract concepts, like power, status, or agency (Landau et al., 2010). Indeed, higher vertical location is associated with higher perceived power (i.e., control over resources), greater dominance (i.e., personality trait), higher status (i.e., respect), and more positive affect (Giessner & Schubert, 2007; Hecker Von & Sankaran, 2013; Lamer & Weisbuch, 2019; Meier & Robinson, 2004; Tang et al., 2018; Weisfeld & Beresford, 1982). Group bias in the placement of feminine and masculine objects may reflect associations with any of these dimensions. For example, men may place masculine objects higher than feminine objects because they endorse gender stereotypes of dominance, because they are aware of status differences between women and men, because they are bolstering the power of their own gender group, or even because they feel more positively about their own gender group (though this would be inconsistent with the Women are Wonderful effect; Eagly & Mladinic, 1994). Vertical location may be a uniquely effective way of communicating group bias because location is associated with these different concepts that overlap with existing gender stereotypes (Hentschel et al., 2019).

Whether people place objects consistent with stereotypical or ingroup bias may also be impacted by the type of setting being manipulated. We suspect that the anticipated audience may contribute to whether people express ingroup bias or stereotypical bias. For example, we observed a *stereotypical* bias on vertical placement in the waiting room task reported above. Both women and men placed feminine objects lower than masculine objects. Finding an effect on verticality in this task where there was less vertical distance in which to move objects first bolsters the idea that verticality may be especially important in the expression of information about groups. Further, the stereotypical bias suggests that there may be important moderators to the kind of product people are designing. It is possible that stereotypical bias would be observed in arrangements created for public settings relative to private settings. That is, waiting rooms are encountered by many people, whereas refrigerators are primarily encountered by the individual(s) who live in that home. However, these hypotheses are purely speculative and require replication and further investigation.

Further research is needed to understand how people use vertical location to bolster groups and an important extension of this work will be the examination of spatial bias in other kinds of groups, such as race groups or minimal groups. For example, minimal group assignment would enable researchers to examine group placement in the absence of established group-based stereotypes. Conversely, testing spatial bias with race would enable researchers to examine group placement by participants who do not share an ingroup identity with targets to be placed. This sort of examination would also enable researchers to assess the role of specific stereotypes on placement. For example, stereotypes about people with Black racial identities include aspects of dominance and aggression (Bjornstrom et al., 2010; Dill et al., 2005) whereas those about people with Asian racial identities include aspects of passivity and submission (Zou & Cheryan, 2017). Thus, if group bias in vertical placement is primarily an expression of dominance, then placement of Black individuals should be higher than placement of Asian individuals. Conversely, if group bias in vertical placement is primarily an expression of status, then placement of Asian individuals should be higher than Black individuals (to the extent participants endorse model minority stereotypes; Kao, 1995). Future work should leverage the unique components of these alternative groups (e.g., minimal groups, race/ethnic groups) to isolate the meaning of vertical location in spatial placement bias and assess cultural patterns of spatial bias along other social dimensions.

Cultural patterns

There is a cultural pattern of vertical placement favoring men over women (i.e., in magazines; Lamer & Weisbuch, 2019). Given that men are more likely to be on magazine and journal editorial boards than women (Kulik & Metz, 2017; Pollitt, 2011), this may in part explain the pattern of spatial bias that favors men in magazines. Thus, patterns of men being placed higher than women should be observed more strongly in media where men hold a disproportionate amount of power relative to women. Consistent with other work on the importance of representation (Oyserman et al., 2006; Stout et al., 2011), this work highlights that lack of representation can have subtle consequences for patterns of social group bias. People may not even recognize the ways that they exhibit group-based biases, such as placing objects in space. Having women and men represented is one way to reduce bias selectively favoring one group. Although spatial bias is subtle, consistent exposure to patterns of men being higher than women may accumulate meaningfully to shape stereotypical beliefs (see Lamer & Weisbuch, 2019). Thus, these studies highlight the importance of gender representation, especially at high levels of leadership and decision-making.

Conclusion

The studies we report here are consistent with our theory that people express gender bias via vertical spatial placement. People may typically organize information in a way that favors their gender and our data suggest that this is guided by both gender identity and stereotypes for men and by gender identity for women. Not only is vertical location prioritized in the human visual system, but it may also be used to communicate and reify bias toward social groups.

Notes

1. We excluded participants who had incomplete data. Sixteen participants were excluded because they failed to complete the study. These participants did not follow the external link to complete the spatial placement task. We were therefore unable to run analyses including these participants' data.
2. Results are similar regardless of the analytic method.

3. Magnet ratings from participants in Study 1 confirmed pretesting; feminine magnets were rated as significantly more feminine than masculine magnets ($M_{difference}$ = 2.86, *SD* = 1.21), *t* (186) = 32.39, *p* <.001.
4. Significance testing with mixed effect models can be calculated several different ways. In this case, we estimated degrees of freedom using Satterthwaite's procedures which are based on the number of participants rather than groups (Satterthwaite, 1946). Degrees of freedom may vary substantially within the same model based on which effect is evaluated. The Satterthwaite method has demonstrated reliability in mixed effect models with sufficient sample sizes and low Type I error rates (Manor & Zucker, 2004). See Kuznetsova, Brockhoff, and Christensen (2017) for more information on the implementation of this estimation procedure in R.
5. Including random slopes exceeded what the data could reliably estimate in models we report throughout the manuscript. We, therefore, have run all models with only random intercepts.
6. Seven participants were excluded for one of these two reasons: because they did not complete the placement portion of the study (*n* = 6), or because they identified as gender non-binary (*n* = 1).
7. Although multi-level models draw statistical power from both the sample size of participants and stimuli, this study and Study 3 are likely underpowered given the small number of stimuli. We address this power issue in Study 4.
8. Participants also completed several other exploratory measures. See Appendix for a list of these additional measures.
9. One person declined to provide their age; their data were included in analyses. Ten participants were excluded because they did not complete the study due to technical issues with the eye tracker.
10. Exploratory analyses were conducted on visual attention as part of a student's thesis project. See Appendix for list of additional measures used in this thesis project.
11. The sample included 90 participants who identified as Asian/Pacific Islander, 45 who identified as Black/African American, 44 who identified as Hispanic/Latinx, 595 who identified as White/European American, 5 who identified as Native American, 3 who identified as Middle Eastern, and 21 who identified as Multiracial.
12. One person declined to provide their age and two people declined to provide their race; the rest of their data were still included in analyses. Twelve participants were excluded because they did not pass the attention checks. Specifically, they did not correctly plot their score on the graph during the identity threat manipulation (± 5 points) and failed to accurately recall their score (± 5 points). We reasoned that if people failed both of these checks that they were unlikely to have been paying attention to or have understood the experimental manipulation. See pre-registration for more information (https://osf.io/ez5vh/?view_only=82ccc390bcc54e5cb269a71b44b6a31a). We also excluded participants using the following pre-registered criteria: 20 identified as gender non-binary, 2 entered their gender incorrectly at the start of the study, 55 failed to complete a portion of the study (i.e., they did not follow the external link or started but did not complete the study), and 7 opted to exclude their data once they learned the purpose of the study.

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Appendix Additional Measures

Study 1
- Bem Sex Role Inventory (Bem, 1974; Vafaei et al., 2014)
- Experienced Threat Scale (Schmitt & Branscombe, 2001)

Study 2
- Collective Identity Scale (Luhtanen & Crocker, 1992)
- Spatial Power Motivation Scale (Schoel et al., 2015)

Study 3
- Contingencies of Self-Worth Scale (Crocker et al., 2003)
- Experienced Threat Scale (Schmitt & Branscombe, 2001)
- Spatial Power Motivation Scale (Schoel et al., 2015)
- Need to Belong Scale (Baumeister & Leary, 1995)
- Social Identity Scale (Cameron, 2004)