Published as Hegarty, P., Lemieux, A., & McQueen, G. (2010). Graphing the order of the sexes: Constructing, recalling, interpreting, and putting the self in gender difference graphs. *Journal of Personality and Social Psychology, 98,* 375-391.

Abstract
Graphs seem to connote *facts* more than words or tables do. Consequently, they seem unlikely places to spot implicit sexism at work. Yet, in 6 studies (*N* _ 741), women and men constructed (Study 1) and recalled (Study 2) gender difference graphs with men's data first, and graphed powerful groups (Study 3) and individuals (Study 4) ahead of weaker ones. Participants who interpreted graph order as evidence of author "bias" inferred that the author graphed his or her own gender group first (Study 5). Women's, but not men's, preferences to graph men first were mitigated when participants graphed a difference between themselves and an opposite-sex friend prior to graphing gender differences (Study 6). Graph production and comprehension are affected by beliefs and suppositions about the groups represented in graphs to a greater degree than cognitive models of graph comprehension or realist models of scientific thinking have yet acknowledged.

Keywords:
gender differences, gender stereotypes, graphs, power, social construction of knowledge

Author Note:
Peter Hegarty and Grant McQueen, Department of Psychology, University of Surrey, Guildford, England; Anthony F. Lemieux, Department of Psychology, Purchase College, State University of New York. We thank Sarah Adda, Rebecca Friedmutter, Colin Howard, Patrick Lehman, Diana McWilliams, and Megan Strang for assistance and Adrian Banks, Linda Bastone, Chris Fife-Schaw, Anna Franklin, Rob Foels, Mary Hegarty, Afrodita Marcu, and Anne Maass for comments on earlier versions of the manuscript.
Correspondence concerning this article should be addressed to Peter Hegarty, Department of Psychology, University of Surrey, Guildford, GU2 7XH, UK, or to Anthony F. Lemieux, Department of Psychology, Purchase College, State University of New York, 735 Anderson Hill Road, Purchase, NY 10577.
E-mail: p.hegarty@surrey.ac.uk or anthony.lemieux@purchase.edu

Social psychologists have often examined the *biasing* effects of prior beliefs on scientific thinking; effects that give the illusion that one's beliefs are empirically grounded to a greater extent than is reasonable (e.g., Chapman & Chapman, 1969; Kunda, 1989; Lord, Lepper, & Ross, 1979; Rosnow & Rosenthal, 1997). In addition, people must also choose between interpretations of scientific data that have *equal* truth value. For example, gender differences are usually attributed to the less prototypical gender group, which is most often women (Miller, Taylor, & Buck, 1991). Similarly, psychologists voice more caveats when generalizing from women to men than the reverse (Ader & Johnson, 1994). Scientists chose between metaphors to represent the things that they study (Leary, 1990), and sometimes value generative metaphors more than accurate ones (Dunbar & Blanchette, 2003). But new metaphors can encode social beliefs, as when human gender roles are used to analogize biological interactions between eggs and sperms (Bangerter, 2000; Martin, 1991). As such, metaphors shape perceptions of reality, particularly when metaphorical and literal meanings are processed in parallel (Glucksberg, 2003), and when analogy gets confused with reality when remembering complex arguments (Blanchette & Dunbar, 2002; Perrott, Gentner, & Bodenhausen, 2005). Thus, metaphorical thinking is an important social psychological process of meaning construction whether it is regarded as “biased” or not.

Graphs as Social Cognition

The present research concerns one form of visual metaphor common to scientific communication: simple bar graphs. Graphs are culturally particular metaphors that became increasingly common within scientific and popular scientific communications in the West during the 19th century (Beninger & Robyn, 1978; Best, 2005; Tversky, 2005), and whose popularity continues to increase (Zachs, Levy, Tversky, & Schiano, 2002). However, it may appear odd to describe bar graphs as “metaphors” at all. Indeed, Latour (1990) has argued that although individual scientists’ can draw very different graphs of the same natural events (see also Roth, 2003), graphs tend to connote that those representations are *literally* true and beyond matters of human interpretation. Consistent with this view, graphs appear more frequently in natural sciences than social sciences publications (Cleveland, 1984), and more often in psychology journals that psychologists themselves consider to be reporting “harder” science (Smith, Best, Stubbs, Archibald, & Roberson-Nay, 2002). Health advice is sometimes more readily accepted (Fagerlin, Wang, & Ubel, 2005), and cognitive neuroscience arguments sometimes seem stronger (McCabe & Castel, 2008), if accompanied by appropriate graphic representations of data. Thus, the notion that graphs are *metaphorical* appears counter to the ways that graphs are routinely interpreted by many scientists and many laypeople.

Nevertheless, cognitive psychologists describe graphs as metaphors because graphs use the properties of two-dimensional space to analogize more abstract properties (Shah, Freedman, & Verini, 2005; Shah & Hoeffner, 2002; Tversky, 2005). Pinker’s (1990) influential model of graph processing describes how the implicit knowledge that is needed to interpret a graph is organized into a *graph schema*, which exploits the perceptual properties of two-dimensional space, Gestalt principles, and conventional knowledge about graph formats. Scientifically literate people in Western cultures use implicit knowledge to make inferences about graphs; they assume that line graphs represent continuous variables, whereas bar graphs represent discrete variables (Zachs & Tversky, 1999), and that the variable of interest in graphs depicted regression data varies along the *y*-axis (Gattis & Holyoak, 1996). People who use graphs may understand themselves to be engaged in quite literal forms of communication (Latour, 1990), but graph use requires active interpretation all the same.

Cognitive research on graph schemas has reached different conclusions about the extent to which graph comprehension is a “natural” process. Zachs and Tversky (1999) argued that graph comprehension is a cognitively “natural” activity and that Western graphing conventions followed naturally from properties of the visual information-processing system that is shared by all humans. In contrast, Tversky and Schiano (1989) argued that a bidirectional causal relationship exists between the graph schemas in individual minds and the graph formats conventionally used in publications. Consistent with this latter view, Roth (2003) found that graphing conventions varied so much among experts that graphs were often misinterpreted when taken out of context. We also argue against the cognitive naturalist view here; graphical cognition is much more *social* than either classic (Pinker, 1990) or more recent (Shah et al., 2005; Shah & Hoeffner, 2002; Tversky, 2005) models allow. In support of this argument, we present evidence that graphing conventions routinely draw on semantic beliefs about the groups and individuals that graphs represent, that such conventions sometimes draw on graph authors' own group identities, and that graph formats can also affect readers' inferences about a graph author's beliefs and identity.

Graphing the Order of the Sexes

Our research questions about the social nature of graphing were prompted by content analytic findings that cognitive models appeared to us to be unable to explain. Hegarty and Buechel (2006) found that about 75% of tables and graphs in published psychological research articles positioned data representing boys and men to the left of, or above, data representing girls and women. Rudin, Jones, Lemieux, and Hegarty (2009) recently found evidence of similar preferences in medical research articles. A *graph order preference* to position one social group so consistently ahead of another appears difficult to explain solely by reference to either the properties of the human perceptual system or to Gestalt principles of good form. Rather, Hegarty and Buechel's (2006) findings suggest that widely shared beliefs about groups, such as gender stereotypes, might affect the construction of graphs in Western scientific culture. Consequently, the present research had three general goals: to evidence the behavioral preference to graph men first among novice psychologists using a production task (Study 1) [note1] and a memory task (Study 2); to examine which gender stereotype affects graph order preferences (Studies 3 and 4); and to examine how graph order might be interpreted (Study 5) and changed (Study 6).

The Prototypicality Hypothesis

Hegarty and Buechel's (2006) results suggested one possible explanation of the graph order preference. In their study, verbal descriptions and explanations of gender differences referred to specific attributes of girls and women more often than to specific attributes of boys and men. Such asymmetries in explanation are typically attributed to the effects of implicit *category norms* (Kahneman & Miller, 1986), which conflate the attributes of prototypical groups with the general case, leading intergroup explanations to focus on less typical groups (Hegarty & Pratto, 2001; Miller et al., 1991; Pratto, Korchmaros, & Hegarty, 2007). Contrary to the overall trend to graph data representing males first, graphs and tables in developmental psychology studies positioned mothers first and fathers second, consistent with the possibility that psychologists assume that men and boys are prototypical in many contexts but that mothers are prototypical parents. Hegarty and Buechel (2006) concluded that widespread *androcentric* beliefs affect both verbal explanations of gender differences and graph order preferences. *Androcentrism* refers to the tendency to conflate maleness more than femaleness with prototypical human, animal, and divine being, typically to men's advantage (Bem, 1993; deBeauvoir, 1949; Eagly & Kite, 1987; Foster & Keating, 1992; Hyde, 1984; Lambdin, Greer, Jibotian, Wood, & Hamilton, 2003). Put differently, Hegarty and Buechel (2006) extended norm theory's *prototypicality hypothesis*, which explains asymmetries in verbal explanations as a possible explanation of asymmetries in graphs of group differences. When extended to graphing in this form, the prototypicality hypothesis implies that prototypical groups should be graphed first and that explanations of group differences should focus on the group who are graphed second, the less typical group. In several studies below, we tested the hypothesis that explanations of group differences would focus on second-graphed groups (Studies 1, 2, and 6). Only one published experiment has tested the prototypicality hypothesis directly (Hegarty, Buechel, & Ungar, 2006). In that research, participants drew graphs of gender differences in math and verbal abilities, differences between national ingroups and outgroups in public opinion, differences between prototypical and atypical animals in physical abilities, and differences between prototypical and atypical fruits in vitamin content. Although most graphs positioned typical entities first, and most graphs of gender differences positioned men first, the prototypicality hypothesis received only mixed support overall. Participants overwhelmingly graphed typical fruits first but showed no preference to graph typical animals ahead of atypical ones. No gender differences were observed in this experiment, and the preference to graph men first was not due to the ordering of verbal information in the stimuli.

Alternative Explanations of Graph Order Preferences

These results suggest that the prototypicality hypothesis may not be the most accurate explanation of graph order preferences. A different belief may cause men to be habitually graphed first. We extrapolated from cognitive research on order preferences to three other possible causes of graph order preferences. Consider first that androcentric belief systems are also sexist because they imply that men, by virtue of their prototypicality, are more important kinds of people than are women (Bem, 1993) and that graphs are sometimes described as more coherent when more important data are positioned first (Kosslyn, 1993). Thus, people may graph men before women because of a robust preference to graph first the groups that they implicitly consider to be more important. Second, androcentrism privileges masculinity over femininity as well as privileging men over women (Bem, 1993). Men may be positioned first in graphs because of a preference to graph stereotypically masculine groups before stereotypically feminine groups. Indeed, gender stereotypes have been shown to affect order preferences in other domains; Hegarty, Watson, Fletcher, and McQueen (in press) found that unfamiliar same-sex and opposite-sex couples were consistently named with stereotypically masculine partners first and stereotypically feminine partners second. Beliefs about the masculinity of men and femininity of women may similarly affect graph order leading to the preference to graph men first.

Finally, we considered *power* as an explanation of graph order preferences. The attributes of powerful groups are often taken to be prototypical in many societies (Dahrendorf, 1959), and gender stereotypes consistently attribute greater agency to men than to women (Eagly & Steffan, 1984; Kite, Deaux, & Haines, 2008). Three lines of research on order further motivated this hypothesis. First, people tend to position more agentic words first in *binomial phrases* (Cooper & Ross, 1975) such as “people and things” or “life and death” (McDonald, Bock, & Kelly, 1993; Pinker & Birdsong, 1979). Second, people are quicker to identify the names of powerful groups in the upper part of the visual field and powerless groups in the lower part of the visual field (Schubert, 2005). Third, people imagine action in the left-right axis more readily when it proceeds in the direction of their written language; from left-to-right for English and Italian speakers and from right-to-left for Arabic speakers, for example (Chatterjee, Southwood, & Basilico, 1999; Maass, Pagani, & Berta, 2007; Maass & Russo, 2003; see also Chokron & De Agostini, 1996, 2000; Spalek & Hammad, 2005). Recently, Maass, Suitner, Favaretto, and Cignacchi (2009) have shown that imagery along the left-right axis is further affected by stereotypes about groups’ agency. In their studies, Arabic and Italian people spontaneously positioned members of stereotypically agentic groups, such as men, before members of stereotypically less agentic groups, such as women, consistent with the direction of their particular language. Thus, men may be graphed ahead of women because of a more general tendency to position groups who are attributed more power first both in words and in pictures.

Interpreting and Changing Graph Order

Such effects of social stereotypes on graph order may communicate stereotypes in ways that scientific authors neither intend nor desire (cf. Kashima, Fiedler, & Freytag, 2007). Consequently, we also examined how graph order is interpreted. Readers of graphs might revise their beliefs about social groups on the basis of bar graph order, but we did not hypothesize such effects here. Rather, we examined how graph order might inform reader's stereotypes about a more unfamiliar target, the graph's author (Study 5).

As the preference to graph men and boys first might lead graph readers to erroneous conclusions about the authors of scientific graphs, we also explored one way to change the habit of graphing men first (Study 6). We hypothesized that people's personal knowledge of their own gender category membership, if properly activated, would lead them to graph themselves first, and so affect the way that they subsequently graph group differences. Any effect of such activation would have different meanings for women and men. For men, a preference to graph themselves first is *consistent* with a preference to graph men first. For women, it is not. We hypothesized that women who are prompted to draw graphs that include themselves *as members of gender categories* would be less likely to graph gender differences with men positioned first (Study 6).

Overview of the Present Research

In summary, in the present research we aimed to replicate previous findings of a preference to graph men first (Study 1) and to test whether this preference affects memory for graph content (Study 2). We examined several gender-related beliefs as causes of general graph order preferences (Study 3) and investigated the most promising belief to find a limiting condition on the preference to graph men first (Study 4). We asked people to scrutinize
graphs for "bias," to determine how graph order affects beliefs about a graph's author (Study 5), and examined whether leading women and men to think about their own and their friends'
membership in gender categories affected their graph order preferences (Study 6).

Study 1: Order Preferences in GenderDifference Graphs

In our first study, we aimed to replicate Hegarty et al.'s (2006) findings that people habitually graph men first and women second and to investigate Hegarty and Buechel's (2006) conclusion that this preference is due to implicit representations of men as more prototypical than women.

Method

Participants. Ninety-three psychology undergraduates participated in class in a British university. Data on age and gender were not recorded, but most participants were young adult women.

Materials and procedure. As a course assignment, students had been required to hypothesize a gender difference in social behavior and to conduct an observational study to test their hypothesis. For the present study, the male instructor asked students to write down their hypothesis and to draw a bar graph representing its prediction. The instructor mentioned "the two genders" but avoided ordered conjunctions of gender terms such as *male and female* or *women and men*. Participants were probed 1 week later in class about the purpose of the demonstration. None voiced suspicion of the study's goals. Results and a debriefing were then presented.

Results

The participants' graphs were categorized according to the gender group positioned first (i.e., to the left or on top of the other group's data), and the graph's substantive content (i.e., the gender group predicted to display more of the relevant behavior). For example, the graph in Figure 1 positioned men first and depicted women performing more behavior. Two unlabeled graphs could not be coded for position. Confirming our hypothesis, a binomial test revealed that more of the remaining 91 graphs positioned men first than women first (68.1% vs. 31.9%, *n*s = 62 and 29, respectively; $Z = 3.35$, $p < .001$).[Note 2].

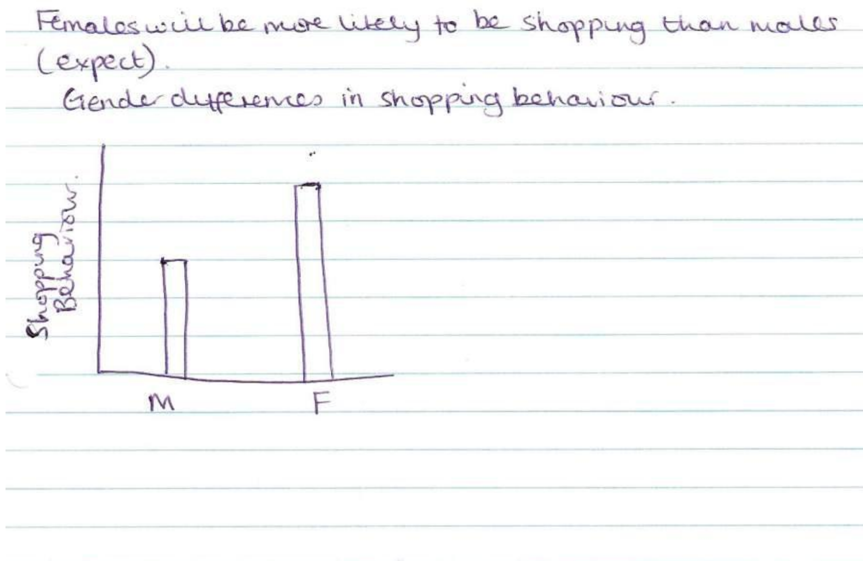

Figure 1. **Sample response in Study 1.**

We analyzed graph content next. Among the 91 graphs with a clear direction, eight depicted gender similarities and interaction effects. Of the remaining 83 graphs, a majority depicted women rather than men performing more behavior, (63.9% vs. 36.1%, *n*s = 53 and 30, respectively; $Z = 2.41$, $p < .05$). There was no relationship between graph order and graph content. Equivalent proportions of these 83 graphs positioned first the gender group who performed more ($n = 43$, 51.8%) or less ($n = 40$, 48.2%) of the behavior ($Z < 1$).

To analyze the verbal hypotheses, two coders identified the gender group that was the focal subject in each of the 93 participants' hypotheses. The coders disagreed about only two cases and quickly reached agreement through discussion. Of the 93 hypotheses, 53 focused on women (57%), 22 focused on men (23.7%), 13 had no clear focus (14.0%), and five focused on both groups equally (5.4%). Consistent with the prototypicality hypotheses, more of the 75 hypotheses that focused on one gender group focused on women than on men ($Z = 3.46$, $p = .001$). Two of the 75 hypotheses that focused on one gender group were accompanied by ambiguous graphs. The remaining 73 hypotheses focused almost exclusively on the gender group hypothesized to display more behavior rather than less behavior (94.5% vs. 5.5%, *n*s = 69 and 4, respectively).

Finally, we tested the prototypicality hypothesis by examining the graphs and verbal hypotheses together. This hypothesis predicts that more prototypical groups will be graphed first and that less prototypical groups will be the focus of hypotheses. We calculated a log linear model using data from the 73 participants whose hypotheses had a clear focus. Two variables were included in the model; graph order (women vs. men first) and hypothesis focus (women vs. men). [Note 3] The two-way contingency between these two variables was not significant ($Z = 1$, $p = .80$), and a custom model that excluded this contingency did not reduce the fit of the model to the data, $\Delta\chi^2(1, N = 73) = 0.02$, $p = .88$. For reasons of parsimony, we interpreted the model that excluded the two-way contingency. In this custom model, we observed significant contingencies that reflected participants' preferences to graph men first and to focus hypotheses on women (*Z*s = 3.26, 3.47, respectively; $p < .001$ for both). However, these preferences were independent of each other, disconfirming the prototypicality hypothesis.

Discussion

Here, novice psychologists preferred to verbally hypothesize gender differences by focusing on women and to draw graphs with men rather than with women first. In these regards, they resembled expert psychologists (Hegarty & Buechel, 2006) and participants in earlier experiments (Hegarty et al., 2006; Miller et al., 1991). However, prototypicality does not appear to be the basis of graph order preferences, as Hegarty and Beuchel (2006) suggested; men were equally likely to have been positioned first in graphs whether hypotheses focused on women or men. The causes of graph order and hypothesis focus preferences appear to be distinct. Alternative causes of graph order preferences are examined later. First we report more direct evidence that the preference to graph men first forms a part of widespread graph schemas.

Study 2: Memory for Gender Difference Graphs

Akin to classic accounts of the effects of semantic knowledge on memory (Allport & Postman, 1945; Bartlett, 1932; Carmichael, Hogan, & Walter, 1932), graph schemas distort memory of actual graphs toward preferred canonical forms or 'comparison points' (Tversky & Schiano, 1989). Graphs share some, but not all, of these comparison points with other forms of visuospatial representation. For example, asymmetric curves are systematically misremembered as symmetrical curves whether they represent rivers on maps or normal distributions on graphs. However, the tendency to mutate lines towards a 45 degree angle occurs when people remember lines close to the identity line $x = y$, but not in other contexts.

Tversky and Schiano (1989) argued that these errors follow from the perceptual organization of graphic information to conform to Gestalt principles of 'good form.' However, these principles cannot explain why people would graph men first. Consequently, we sought to examine if the preference to graph men first was also a 'comparison point' within graph schemas, and toward which memory for graphs is mutated. In Study 2 we tested the prediction that people would be more likely to 'switch' the order of the genders when remembering a graph that had positioned women first than one which had positioned men first. Study 2 provided a further test of the prototypicality hypothesis.

Method

Participants. Seventy-eight women and 35 men enrolled in a large psychology class at a public liberal arts college in the northeastern United States participated (age range = 17 to 30 years, Mean = 19.44 years). They described their ethnicities as White (n = 69), Latina/o (n = 18), African-American or Black (n = 12), Asian (n = 3), or did not identify their ethnicity (n = 11). All participated as part of a regular class session.

Materials. Both *prompt materials* and *recall materials* were used in this study. The prompt materials briefed participants as follows:

> This study is about the way that people make sense of the information that is displayed in bar graphs. A recent examination of math and verbal competence produced the following test scores. Please look at the bar graph below and answer the questions that follow.

The bar graph which followed showed an interaction effect with women always scoring higher on verbal competence and men always scoring higher on mathematical competence (see Figure 2). The stimuli were varied in terms of the gender positioned first (women vs. men) and the competency positioned first (verbal vs. mathematical) creating a 2x2 experimental design. This graph was followed by two prompts to describe, and to explain, the difference.

> Using only words (and not numbers) *describe* the gender differences depicted. Please *explain*, in your own words, why you think these gender differences in test scores were observed.

Each prompt was followed by eight blank lines. Finally, participants were asked to report their gender, age, and ethnicity.

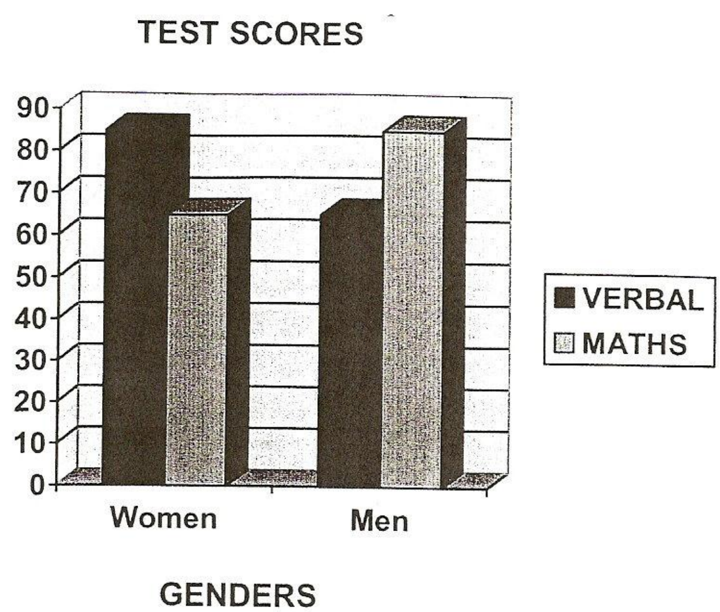

***Figure 2*: Sample Stimulus (Study 2).**

The recall materials were also titled “Making Sense of Bar Graphs.” This title was followed by a request to *recall* the graph.

> During the first session of the study, you viewed a bar graph, interpreted its data and explained why you think these findings occurred. Please sketch the bar graph as you remember it in the space provided.

A large blank space followed. Once again, participants were prompted ‘Please explain the findings of the graph’ and presented with eight blank lines.

Procedure. The prompt materials were distributed in class, completed under supervision, and collected. Three days later, the same students were presented with the recall materials as an unexpected recall task. Once again, students worked individually. After materials were collected, students were debriefed as to the falsity of the graphs’ data and the study’s purpose.

Coding. Two independent raters coded both sets of explanations for references to women and to men with regard to each of the two competencies. The raters agreed on the number of references to women’s mathematical and verbal performance (r = .75, .84 respectively) and the men’s mathematical and verbal performances (r = .81, .89 respectively). The two raters quickly resolved disagreements.

Results

Graph recall. One hundred and one participants attended the second class and recalled the graphs they had seen. Each graph was inspected for correct or incorrect recall of the direction of the effects, the order of the gender groups, and the order of the academic competencies. All graphs correctly presented women displaying higher verbal competency and men displaying higher mathematical competency. Four graphs varied the order of presenting the two genders, 11 varied the order of presentation of the two academic abilities, and 86 presented both orders consistently. As in Study 1, we observed no preferences to recall graphs with the higher scoring group first or second. Equal numbers of these 86 participants who recalled both graph orders consistently saw graphs with the group on the extreme left of the graph scoring high or low (both n = 43), and equivalent numbers recalled the graph a higher scoring group or lower scoring group in this position (57.0% vs. 43.0%, n = 49, 37 respectively), Z<1.2, p >.23.

We conducted an initial log linear model was conducted using these 86 cases including five variables; participant gender (women vs. men), order of gender groups presented (women vs. men), order of academic competencies presented (verbal vs. math), order of gender groups recalled (correct vs switched) and order of academic competencies recalled (correct vs. switched). No contingencies involving participant gender, order of presentation of academic competencies, or recall of academic competencies reached conventional significance levels, all Z < 1.5, p >.14, and a series of successive models removing all interactions and main effects involving these variables did not reduce the fit of the model to the data. [Note 4]. Consequently, we tested the study’s main hypotheses by calculating a second model that included only two variables; order of gender groups presented and order of gender groups recalled. As the recall of academic competency did not vary across conditions and was unrelated to the recall of gender group order, we included the eleven graphs that consistently ordered gender groups, but not academic competencies, in calculating this model.

A majority of these 97 participants recalled the gender order correctly rather than switched it (76.3% vs. 23.7%, n= 74, 23 respectively), Z = 5.08, p <.001. The contingency between the order of gender groups presented and recall accuracy was also significant, Z = 2.65, p <.01. A custom model that excluded this contingency significantly reduced the fit between data and model, $\Delta \chi^2$ (1) = 8.41, p <.01. Among the 23 participants who switched the order of gender groups, a majority switched a graph that had initially positioned women first rather than men first (78.3% vs. 21.7%, n = 18, 5 respectively), Z = 2.27, p <.01. {note 5] This pattern of recall data supports our hypothesis that preferences for gender group order, but not for academic competency order, are part of people's graph schemas.

Descriptions and Explanations. Participants' descriptions of the graphs were investigated to check that the direction of the effects in the graph had been correctly interpreted. No participants were excluded on this basis. Next, the explanations of the gender differences produced during each wave of the study were analyzed separately. A 2x2x2 ANOVA was conducted on the number of references to women and men in the explanations produced in response to the prompt materials. Gender referenced (women vs men) and task referenced (verbal vs. mathematical) were treated as repeated measures and participant gender as a between-subjects factor. A significant interaction between the gender group referenced and the task referenced was observed, F (1, 95) = 37.58, p <.001, η_p^2= .28. The references to women and men that the coders detected in these explanations tended to refer to groups who achieved higher scores; women's verbal competency was referenced more than men's (*M*s = .76, .03 respectively), but men's mathematical competency was referenced more than women's (*M*s = .70, .06 respectively).

The explanations produced during the recall phase of the study were analyzed using an ANOVA model with the identical design. These explanations contained fewer references to men than to women overall (*M*s =1.20, 1.32 respectively) F (1, 95) = 4.35, p <.05, η_p^2 = .04. Once again, participants focused their explanations overwhelmingly on high scoring groups, referencing men's mathematical competency more than women's (*M*s = 1.05, .11 respectively), and women's verbal competency more than men's (*M*s = 1.14, .06 respectively), with the relevant interaction being significant, F (1, 95) = 222.15, p <.001, η_p^2 = .70.

These verbal explanations cast further doubt on the hypothesis that prototypicality is the cause of graph order preferences. Graphs were selectively recalled with men to the left and women to the right, but explanations focused overwhelmingly on high performing groups of both genders, and only a small preference to focus explanations on women was observed in the recall phase of the study. To specifically assess whether participants' explanations of the gender differences were related to their recall of graph order, we ran a 2x2x2 mixed model ANOVA with gender referenced (women vs. men) and task referenced (verbal vs. mathematical) as within subjects factors and accuracy of recall of gender group order as a between subjects factor. As before, a large interaction between gender referenced and task referenced emerged, F (1, 90) =188.65, p <.001, η_p^2 = .68, but no other main effects or interactions were significant, all F < 2.1. Participants' explanations were independent of the way they recalled the graphs.

Discussion

This study provides the first evidence that *comparison points* (Tversky & Schiano, 1989) in modern graph schemas draw on semantic knowledge about the social groups being graphed. Graph schemas are permeable to semantic information about the social groups that they represent in ways that neither classic (Pinker, 1990), nor recent (Shah et al., 2005; Shah & Hoeffner, 2002; Tversky, 2005), statements on graph comprehension processes have considered. Graph formats may be habitual, but they are not simply natural consequences of the human visual system (Zachs & Tversky, 1999). Robust graph format preferences may also follow from robust stereotypes about social groups.

In Study 2, as in Study 1, effects of prototypicality on explanations were far weaker than in previous norm theory studies (see Pratto et al., 2007), and unrelated to the accuracy of participants' recall of the gender difference graphs. The results of these first two studies cast sufficient doubt on the prototypicality hypothesis that we investigated a broader range of gender-related semantic beliefs as possible causes of these preferences in the next study.

Study 3: The Semantics of Graph Order

As described in the introduction, power, importance, masculinity-femininity, and prototypicality could all plausibly affect graph order preferences. In Study 3, participants graphed differences between groups that differed on each of these four dimensions. We defined 'higher scoring groups' as those who possessed *more*, rather than *less,* of the dimension being represented. We interpreted a preference to graph high scoring groups first as evidence that graph order was affected by beliefs about group differences on that dimension.

We anticipated that our prompt to graph groups who differed with respect to a belief dimension might lead higher scoring groups to be positioned first more often than chance, regardless of the effect of that belief dimension on graph order. This preference would emerge when participants both graph first the groups who first come to mind, and call to mind groups that are 'positive tests' of the attribute more quickly than groups who lack the attribute (Klayman & Ha, 1987). To control for such an effect, participants were randomly assigned to graph opposing attributes that are stereotypically associated with men or women in regard to the dimensions of power, importance, masculinity-femininity, and prototypicality.

Method

Participants. Two hundred and thirty participants (187 women and 43 men) were recruited from a psychology classroom (n= 121) or approached on a British University campus (n = 109) and asked to volunteer (Mean age = 19.9, range = 17-45 years). Each condition included 27-31 participants.

Materials. The one-page materials instructed participants to draw two social groups that differed in one of eight ways. Participants assigned to graph group differences in *powerfulness,* which is stereotypically held by men, read the following materials:

> This is a study about the ways that people use graphs to represent social groups. Take a moment to call to mind two groups in our society that differ in how *powerful* they are in our society. You may call to mind *any* social groups that you wish, and define 'powerful' *any* way that you like. Now complete the two vertical bars of the graph below to show the difference in powerfulness between these two groups.

An empty graph frame followed (see Figure 3). Participants assigned to graph group differences in *weakness,* which is stereotypically held by women, read identical instructions except for the attribute named. In the importance conditions, participants were prompted to graph differences in *importance* and *marginality*, which are stereotypically associated with men and women respectively. In the masculinity-femininity condition, participants were prompted to graph differences in *masculinity* and *femininity*. In these conditions, participants were additionally instructed to 'call to mind two groups in our society *of the same gender*' (emphasis added). Finally, in the prototypicality conditions, participants were prompted to graph differences in the stereotypically male and female attributes of *typicality* and *unusualness*.

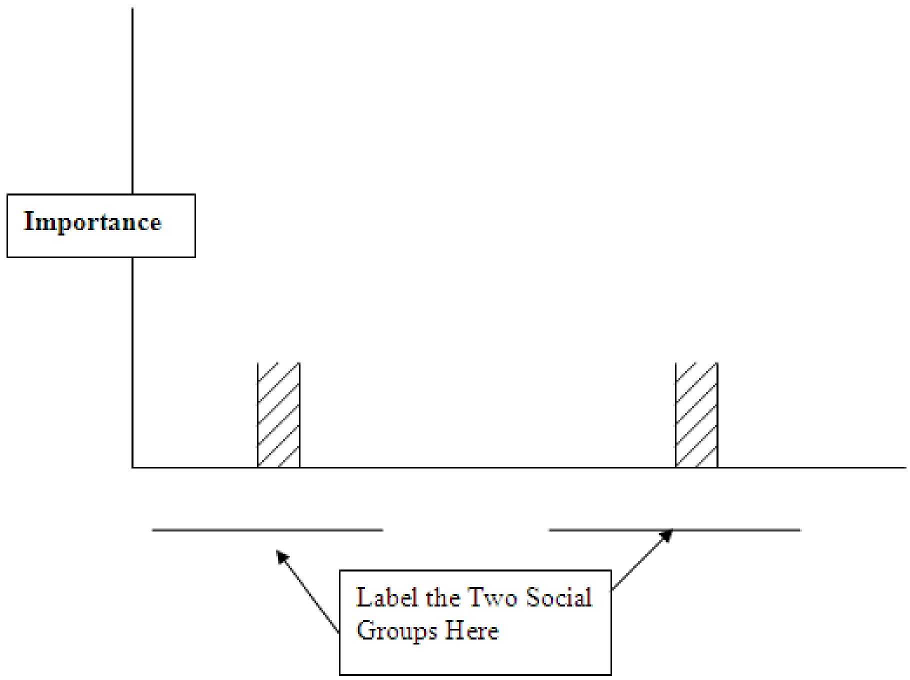

***Figure 3*: Sample Stimuli (Study 3).**

Procedure: During a regular class meeting and at several on-campus locations, participants were invited to participate in a study of how people draw graphs. After participating, participants were thanked and given an email address to contact for a full debriefing.

Results

As in earlier experiments, these data were analyzed using log linear models. We first calculated a model that included four variables; participant gender (female vs. male), the stereotype dimension (power, importance, masculinity-femininity, or typicality, coded from 1-4 respectively), the group stereotypically assumed to possess the attribute (men vs. women), and graph order (high scores vs. low scorers first). As participant gender interacted with no other factors, all Z <1.5, all p >.15, we calculated a second model with the three remaining variables. This model included a significant effect of graph order. As anticipated, more high scoring groups than low scoring groups were positioned first

(63.5% vs. 36.5%, n = 146, 84 respectively), $Z = 4.02$, $p <.001$. A three way contingency was also observed, and a custom model that excluded that contingency fit the data less well, $\Delta \chi^2 (1) = 13.49$, $p <.01$. Hence the saturated model was retained and interpreted.

The three-way contingency informed the question as to which beliefs about group differences affect graph order. This contingency was due to a relationship between graph order and the gender group assumed to possess the attribute in the power condition, Z = 3.07, $p <.01$. The equivalent contingencies pertaining to the importance, masculinity-femininity, and prototypicality conditions all failed to reach significance, all $Z <1$, all $p >.60$. Specifically, participants almost exclusively graphed high scorers first when graphing the stereotypically male attribute of power (93.1%, n = 27 of 29), $Z = 4.46$, $p <.001$, but graphed high scorers first non-significantly below chance predictions when graphing the stereotypically female attribute of weakness (41.9%, n = 13 of 31), $Z = -.72$, $p >.45$.

In other conditions, participants graphed high scorers first with equal frequency whether graphing attributes associated with men or women; importance and marginality (62.1% vs. 60.0%, n = 18 of 29 and 18 of 30 respectively), masculinity and femininity (63.3% vs. 59.3%, n = 19 of 30, 16 of 27 respectively), and typicality and unusualness (63.0% vs. 66.7%, n = 17 of 27, 18 of 27 respectively). In none of these six conditions did participants graph a disproportionate number of higher scoring groups first, all $Z <1.6$, all $p >.12$. These results demonstrate that graph order is affected by beliefs about power in ways that it is not affected by beliefs about importance, masculinity-femininity, or prototypicality.

Two other findings from this experiment suggest that beliefs about power might be the specific reason why men are habitually graphed first. First, recall that the 57 participants in the masculinity-femininity condition were not permitted to graph gender differences. Among the remaining 173 participants, 13.3% (22 women and 1 man) spontaneously used gender groups to represent group differences. Thirteen of those 23 participants (56.5%) had been asked to graph group differences in power, a greater than chance proportion given the distribution of participants across conditions, $Z = 1.99$, $p <.05$. [Note 6] Second, among these 23 participants, most graphed gender differences with men positioned on the left (73.9%, n = 17), $Z = 2.09$, $p <.05$.

Discussion

The prompt to illustrate group differences with bar graphs lead participants to graph groups that possessed those attributes first and those that lacked the attributes second. This preference was not observed in the first two studies. However, in Study 1 participants chose the attribute to graph but not the groups to represent. In contrast, in Study 3 instructions to graph group differences to represent an attribute may have lead participants to call to mind groups that possessed the attribute before those that lacked it (Klayman & Ha, 1987).

However, such recall processes cannot explain why powerful groups were graphed ahead of weaker groups so consistently. As such, Study 3 suggests that a preference to graph powerful groups first is the reason that men are graphed before women. If this explanation is correct, then people should graph women first in contexts where women possess power that men lack. Study 4 examined this novel hypothesis.

Study 4: Graphing the British Royal Family

The British Royal Family is an explicitly patriarchal system of power; successsion to the throne typically passes to the monarch's oldest male child. Yet currently, the reigning monarch is a queen, while those who are next in the line of succession are largely men. Thus, the British Royal Family allows for a strong test of the hypothesis that powerful women will be graphed ahead of less powerful men.

Method

Participants: Thirty-two women and 28 men (Mean age = 27.62, range = 17 – 56 years) were recruited as participants in cafes and restaurants at a large British University. Participants were British (n = 55), Danish (n = 1), German (n = 1), Italian (n = 1), Swiss (n = 1), and Turkish (n = 1).

Materials*.* Materials included instructions to draw a graph 'to represent a psychological difference between two members of the British Royal Family' and an empty bar graph frame. This frame resembled the one in Figure 3, but the Y-axis was not labeled, and the axis was accompanied by an empty line where participants could label it themselves. In other words, participants were demanded to both select the individuals within the Royal Family that they graphed, and the dimension along which those two individuals differed.

Procedure. A male experimenter approached participants on campus and invited their participation in a study of 'how people think about the British Royal family.' Participants completed the materials alone, were thanked and verbally debriefed, and given an email address to write to to learn about the study's results.

Results

Each of the sixty graphs represented two individuals. In order of succession to the throne, these individuals were Queen Elizabeth (n = 34), Prince Charles (n = 23), Prince William (n = 26), Prince Harry (n = 25), Prince Andrew (n = 3), and Prince Edward (n= 1). Four individuals who cannot inherit the throne were also graphed; Prince Philip, the Queen's husband (n = 5), Camilla Parker-Bowles (n = 1), the late Princess Diana (n = 1) and the late Queen Victoria (n = 1). As in Study 1, participants showed no preference to position individuals with a higher score on the attribute that they graphed on the left or right of the graph (n = 32, 27 respectively), Z <1. [Note 7]

Each graph was coded for the presence or absence of the Queen (as 1 and 0 respectively), and whether the person closer to the throne was graphed on the left or the right (as 1 and 0 respectively). A log linear model was calculated including participant gender and these two dependent variables. The fully saturated model showed an effect of graph order, Z = 2.35, p <.05, a two-way contingency between graph order and presence of the Queen, Z = 2.75, p <.01, and a three-way contingency, Z = 2.17, p <.05. The custom model which excluded this three-way contingency significantly reduced the fit of the model to the data, $\Delta\ \chi^2$ (1) = 4.61, p <.05, and the fully saturated model was retained.

The effect of graph order emerged because the person closer to the throne tended to be graphed first rather than second (70% vs. 30%, n = 42, 18 respectively). The two-way contingency emerged because the Queen was graphed first more often than second (84.4%, 15.6%, n = 27, 5 respectively), Z = 3.71, p <.001, but graphs that did not include the Queen positioned the person closer to the throne first and second with equal frequency (46.4%, 53.6%, n = 13, 15 respectively), $Z < 1$. The three-way contingency showed that this pattern was further moderated by participant gender. The Queen was graphed first more often than second by both women (80%, 20%, n = 16, 4 respectively), $Z = 2.46$, $p < .05$, and men (91.7% vs. 8.3%, n = 11, 1 respectively), $Z = 2.60$, $p < .01$. However, among the graphs that did not include the Queen, only women graphed the person closer to the throne first rather than second (83.3% vs. 16.7%, n = 10, 2 respectively), $Z = 2.02$, $p < .05$. Men were non-significantly more likely to place the person closer to the throne *second* rather than first (68.8%, 31.3%, n = 11, 5 respectively), $Z = -1.25$, $p > .20$.

Discussion.

Consistent with Study 3, these results suggest a general preference to graph powerful people ahead of less powerful people. Members of the Royal Family were graphed with those closer to the throne on the left, and this effect was most robust when the reigning monarch, a Queen, was included in the graph. Unexpectedly, the 12 men who did not graph the Queen did not conform to this pattern. While we are cautious about over-interpreting this last unexpected finding, we note that a high proportion of graphs produced by these men included a person who could not inherit the throne (41.7%, n = 5), compared to the other 48 graphs (6.3%, n = 3). In some cases, people who could not inherit the throne possessed kinds of power over those who could. For example, Prince Phillip was always graphed first ahead of his sons or grandsons even though they can inherit the throne and he cannot (n = 3).

Finally, as in Studies 1 and 2, there was no preference to graph Royals in a particular order because they scored higher or lower on the attributes that participants chose to graph. This finding is consistent with our interpretation of Study 3; only when asked to select groups to represent specific attributes have we found that people prefer to graph high scoring groups and individuals first.

Study 5: Interpretations of Order in Gender Difference Graphs

Thus far our research has shown evidence of a robust preference to graph men before women (Studies 1 and 2), and has indicated that stereotypes about power as the most plausible explanation of this preference (Studies 3 and 4). Latour's (1990) claim that graphs only connote literality suggests that such effects of stereotypes on graph order would typically go unnoticed. However, people sometimes scrutinize graphs for 'bias,' consistent with Twain's (1907) idea that there are 'lies, damned lies, and statistics.' In Study 5 we examined how graph readers make inferences about graph authors' biases and identities from the order in their graphs. Readers' inferences about authors might contribute to stereotypes about bias in science. For example, if readers assume that authors' have a bias that privileges the social group that they graph first, then the tendency to graph men and boys first in psychology and medicine may contribute to a stereotype that psychologists and medical researchers hold sexist beliefs that are biased in favor of males.

Method

Participants*:* Fifty one women and 32 men in a public liberal arts college in the northeastern United States were recruited during a regular class meeting (n = 56) and at public campus locations (n = 27). Participants' mean age was 21.3 (range = 18 – 44 years). Participants reported their ethnicities as White (n = 53), Black (n =8), Latina/o (n =8), ‘Other/mixed’ (n = 7) or Asian (n = 5). Two participants reported no ethnicity.

Materials. The materials were presented under the title ‘Making Sense of Bar Graphs’ and instructions were as follows:

> This is a study about the way that people make sense of the information that is displayed in bar graphs. A recent examination of math and verbal competence produced the following test scores. However, there are some people who think that you can ‘lie with statistics’, or draw graphs to give readers a particular impression of things. Thus, it may not be the case that the data itself is biased at all, just that the *way* it is presented may be biased. Please examine the bar graph below and answer the questions that follow.

A graph was presented next. As in Study 2, all graphs were vertical bar graphs that presented women scoring higher on verbal tests and men scoring higher on mathematical tests. The order of genders (women-first vs. men-first) and test subjects (math-first vs. verbal-first) were manipulated across conditions.

Participants were asked to report perceived bias on a scale from 1 (no bias) to 4 (significant bias):

> Do you think that there is anything biased about the presentation of information in this graph?

An open-ended item asked participants to explain the bias they perceived:

> How might this graph be biased? Please list as many ways as you can think of:

Next, three open-ended items asked the participants to report three beliefs about the author of the graph’s beliefs:

> Which gender does the author of the graph think is more [important/powerful/prototypical]?

Participants were then asked to guess the author’s gender:

> Which gender do you think the author of the graph is?

Finally, participants reported demographic information.

Procedure*.* During a regular class meeting and at several on-campus locations, participants were asked to participate in a study about ‘making sense of bar graphs.’ Participants completed the materials, and were offered a printed debriefing including an email address to contact for additional information.

Results

Two coders categorized the participants’ verbal explanations of their answers as blank (n = 27), mentioning the order of the genders or tests (n = 15), or explicitly mentioning only other aspects of the graph’s format and content (n = 41). Coders initially agreed on 95% of cases and resolved the remainder easily through discussion. A log linear analysis with participant gender (women vs. men), graph gender order (women vs. men first), graph subject order (verbal vs. math first), and the attribution of bias to graph order (present vs. absent) estimated no parameters that suggested that these variables were contingent upon each other, all $|Z| < 1.7$, all $p > .09$.

We examined perceptions of bias next. One participant left this item blank, and ratings of bias otherwise fell below the midpoint of 2.5 on the 4-point scale ($M = 2.18$), $t(81) = -3.18$, $p < .01$. A 2x2 ANOVA showed that the participants perceived equal amounts of bias in all conditions, $F < 1$ for both main effects and their interaction. However, perceptions of bias differed among the three groups of participants who mentioned order, mentioned other aspects of the graph, or mentioned nothing at all; $F(2, 79) = 74.37$, $p < .001$, $\eta_p^2 = .65$. Participants who explicitly mentioned order and those who explicitly mentioned only other factors perceived similar levels of bias (*M*s = 2.79, 2.66 respectively). Unsurprisingly, participants who left this item blank perceived less bias than these two groups ($M = 1.15$), Tukey's HSD, $\alpha = .05$. Most participants could construct a reason that the graph was biased, but only a minority attributed bias on the basis of graph order.

We examined the attributions that the participants made about the graph's author next. The 15 participants who attributed bias to graph order were considered first. These participants largely guessed that the author thought the first graphed group was more important (92.8%, n = 13 of 14), powerful (85.7%, n = 12 of 14), and was the author's own gender (80%, n = 12 of 15), all $Z > 2.07$, all $p < .05$. However, a non-significant majority thought that the *second* graphed group was believed to be more prototypical (66.7%, n = 8 of 12). [Note 8]. These participants' responses show that when order is perceived as a source of bias, that that bias consistently privileges the first graphed group. However, the remaining participants, who showed no awareness that graph order was a result of bias, guessed that the author positioned the more important, powerful, and typical gender and their own gender first or second no more often than chance would predict, all $Z < 1.6$, all $p > .10$.

Discussion

Even when prompted to look for bias, only a minority of participants de-code graph order as a consequence of graph authors' bias. However, this minority consistently presumed that the first graphed group was privileged by the author of the graph. This experiment suggests that many readers may not interpret the graphs in psychology and medical research articles with men positioned first as 'biased' (Hegarty & Buechel, 2006; Rudin et al., 2009). However, the more skeptical minority that do are likely to infer that such articles were authored by sexist men.

In other words, a majority of participants made *weaker* attributions than our earlier studies would warrant, while a minority made much stronger attributions. Specifically, this minority inferred that beliefs about importance were reflected in order. However, an earlier test for effects of such beliefs found none (Study 3). This minority also inferred that graph authors put their own genders first, but, thus far, we have found that women graph men first as much as men do (Studies 1 & 3, Hegarty & Buechel, 2006; Hegarty et al., 2006; Rudin et al., 2009). In toto, Study 5 suggests that graph order may communicate ideas to readers that authors do not intend. Consequently, our final study examined how people might be lead to graph gender differences differently.

Study 6: Shifting Preferences for Graph Order

Contrary to the conclusions drawn by some participants in Study 5, people do not draw their own gender group first; women and men both habitually graph men first. This finding is easily interpreted as a gender similarity, but it could also be interpreted as a *gender difference*; men graph their own gender group first, and women graph their own gender group second. In other words, the question of whether women's and men's graph order preferences are similar or different depends on whether individuals' memberships in gender categories are kept in mind or not.

Few topics have inspired more social psychological research than the question of when people do, and when people do not, behave in ways that are affected by their group memberships (see Brown, 2000; Tajfel & Turner, 1979; Turner, Hogg, Oakes, Reicher, & Wetherell, 1987). While theories of social identity have rarely made specific predictions about graphing, effects of both personal identities and collective identities on the perception of space have been demonstrated. For example, people's perception of distance in maps is exaggerated around the point where they imagine themselves to be (Holyoak & Mah, 1982), and across national boundaries that include their own nation state (Burris & Branscombe, 2005). Moreover, graphing methods are sometimes used to operationalize participants' sense of the overlap between self and romantic partners (Aron, Aron, & Smollan, 1992) and self and group identities (Tropp & Wright, 2001). Indeed, Geissner and Schubert (2007) showed that participants drew longer vertical lines on organizational diagrams to represent greater power differences between leaders and their subordinates. Ethnographers have also observed scientists use of personal pronouns when referring to points in graphs with phrases such as 'when I come down, I am in the domain state' (Ochs, Gonzalez, & Jaccoby, 1996). These different lines of cognitive, social, and cultural research all suggest that graphing group differences might be affected by membership in one of the social groups represented in the graph to varying degrees in situation-specific ways.

In this final study we tested the hypothesis that making people's own membership in gender categories salient would lead them to graph gender differences differently. The results of Study 3 suggest that Western people might have a preference to graph themselves first ahead of others; the Western self-concept is sometimes perceived as unreasonably powerful (Greenwald, 1980). For example, Western people quickly learn to make themselves the agents of narratives (Qi, 2004), have unrealistic positive views about themselves (Heine & Hamamura, 2007), and perceive high levels of personal control over their futures (Heine & Lehman, 1995). As described in the introduction, a preference to graph the self first might have little effect on the ways that men graph gender differences, but might lead women to change their graph order preferences and to graph their own gender first.

Our overall research program, and this final experiment in particular, were pursued with feminist theories in mind. While we hypothesized *individual* change in graph order preferences among women in Study 6, historical research suggests that women can affect larger *cultural* transformations in the way that gender stereotypes are mapped onto spatial and scientific representations. For example, Western male portrait artists have tended to draw women facing leftward and men facing rightward (Chatterjee, 2002), but women artists began to break this convention as ideas about gender equality become prominent in the mid-19th century (Suitner & Maass, 2007). Feminist theories of empiricism argue for further cultural changes in scientific conventions that are understood to be universal and value neutral, but which remain more consistent with men's subjective worldviews than with women's (Bem, 1993; deBeauvoir, 1949; Fausto-Sterling, 2000; Haraway, 1991; Harding, 1986; Jordanova, 1993). Harding (1986) argued that resisting conformity to such conventions and representing reality in ways that are more consistent with women's standpoints would lead to a 'stronger' form of objectivity in science (see also Harding, 1991).

The convention to graph males first may be just such a case in point. Study 6 examined whether graph order preferences would change when participants' membership in gender categories were made explicit to them through a graphing task. Participants graphed both differences between themselves and a friend of another gender, and drew graphs of gender differences. We manipulated the order of these two tasks, allowing a test of the claims that people graph individuals by putting the self first, and that order in graphs of familiar people affects the order of graphs representing larger gender categories.

Method

Participants*.* One hundred and four women who were psychology students at a large British University and 58 men who were engineering students at a second British University participated in class (age range = 17-36 years, *M* = 19.56).

Materials. The materials consisted of the *gender differences task* and the *individual differences task.* The tasks were presented in different orders to create *gender differences first* and *self-other differences first* conditions. The gender difference task was introduced as follows;

> Think about a psychological dimension that makes the two genders different from each other. This dimension may be a personality trait (e.g., extroversion), an ability (e.g., musical ability), or anything else that seems *to you* to make the two genders different from each other. Please complete the graph below to indicate how the two genders differ on this dimension in general.

A graph stem followed with instructions to label the two groups (as in Study 3) and the dimension being graphed (as in Study 4). Next, participants were prompted to explain the gender difference:

> In your own words, *why* do you think the two genders are similar or different on this dimension?

This was followed by five blank lines. On the following page, the self-other task was introduced:

> Next, take a moment to think about that dimension again. Now, take a moment to think about a person who you know well, and who is of the opposite gender to you. This person may be a friend, a romantic partner, or a sibling.
> Write the person's initials here ________ .
> This time draw a graph that represents how you think the two of you in particular compare on this dimension.

A graph stem similar to the one used for the gender differences task was presented. A prompt to explain the self-other difference followed:

> In your own words, explain *why* you think the two of you are similar or different on this dimension?

In the *self-other first* condition, parallel instructions informed the participants to first graph and explain differences between self and other, and then differences between gender categories.

Procedure. Participants completed the tasks during a regular class session, were debriefed about the purpose of the study immediately afterwards, and informed about its results one month later.

Coding. Two coders reliably examined the gender difference explanations for references to women and men, r (161) = .89, .95 respectively, and the self-other explanations for references to self and other, both r (161) = .95. Disagreements were easily resolved.

Results

Graph Content. Table 1 shows the counts of participants who drew graphs of each form, for each task, in each condition. We conducted log linear analyses to analyze these data as in previous studies. First we calculated a fully saturated model with the four variables shown in Table 1; participant gender (women vs. men), experimental condition (gender graphs first vs. self-other graphs first), graph type (gender graphs vs. self-other graphs) and order within the graph (female groups or individuals first vs. male groups or individuals first). The four-way contingency was not significant, $Z < 1$, $p > .70$, and we constructed a custom model that excluded this contingency. The exclusion did not reduce the model's fit to the data, $\Delta\ \chi^2$ (1) = .64, $p > .42$. The second model estimated three parameters to be significant; order of the genders within the graphs, $Z = 1.97$, $p < .05$, a two-way contingency involving graph order and experimental condition, $Z = 2.51$, $p < .05$, and a three-way contingency involving those graph order, experimental condition, and participant gender, $Z = 2.22$, $p < .05$. As there were no significant effects of graph type, all $|Z| < 1.55$, all $p > .13$, we ran a third fully saturated model with only participant gender, experimental condition, and order within the graph as variables. A custom model of the data without the three-way interaction significantly worsened the fit of the data, $\Delta\ \chi^2$ (1) = 4.83, $p < .05$. Thus, we retained the fully saturated model involving these three variables.

Table 1: Order of Gender Difference and Self-Friend Graphs (Study 6).

Participant Gender	Women			Men		
First Graphed Gender[1]	Women	Men	n	Women	Men	n
Graph Type						
Gender Differences						
First Task	16	34	50**	0	26	26***
Second Task	28	26	54	7	25	32**
Self-Other Differences						
First Task	24	30	54	10	22	32*
Second Task	20	30	50	2	24	26***

[1] The terms 'women' and 'men' refer to both gender groups and to individuals.
Significance tests next to sample sizes for each cell represent binomial tests of the null hypothesis that equal numbers of graphs were drawn with women and men first, *p <.05, **p<.01, ***p<.001.

Most likely, no effects of graph type were observed in this study because participants consistently transferred order across the two graph formats by positioning individuals and groups of the same gender in the same position across graphs. Most participants transferred order rather than switched it (85.8% vs. 14.2%, n = 139, 23 respectively), Z = 8.73, p <.001. Order was preserved among women and among men who graphed self-other differences first (81.5%, 90.6%, n = 44 of 54, 29 of 32 respectively), Z = 4.49, 4.42 respectively, both p <.001, and among women and men who graphed gender differences first (84% vs. 92.3%, n = 42 of 50, 24 of 26 respectively), Z = 4.67, 4.12 respectively, both p <.001. This pattern is consistent with our assumption that graphing self and other would be perceived as a gender-related task.

The three parameters that were significant in the original log linear model remained significant in the model selected for interpretation. A significant two-way contingency between participant gender and graph order was also observed. Overall more graphs positioned male groups and individuals first than female groups and individuals first (67% vs. 33%, n = 217, 107 respectively), Z = 3.57, p <.001. In contrast to earlier studies this preference was moderated by participant gender; men's graphs positioned male groups and individuals first more often than did women's graphs (83.6% vs. 55.6%, n = 97 of 116, 110 of 198 respectively), Z = 2.73, p <.01. The preference to graph men first was also moderated by experimental condition, Z = 2.84, p <.01. More graphs positioned male individuals and groups first in the condition where gender difference graphs were drawn first than in the condition where self-other differences were drawn first (75.0% vs. 59.9%, n = 114 of 152, 103 of 172 respectively).

The principal hypothesis of Study 6 was that order in gender difference graphs would change among women who first graphed a difference between themselves and a friend. Figure 4 displays the three-way interaction involving graph order, experimental condition, and participant gender which informs this hypothesis, Z = 1.99, p <.05. In the condition where gender differences were graphed first, most women drew graphs that positioned male groups and individuals first (64%, n = 64 of 100), Z = 2.70, p <.01. So too did most men (96.2%, 50 of 52 respectively), Z = 6.52, p<.001 respectively. In the condition where self-other differences were drawn first, a majority of men similarly positioned male groups and individuals first (73.4%, n = 47 of 64), Z = 3.36, p<.001. However, in contrast to these three groups, women in this condition positioned male groups and individuals first at a rate that did not differ from chance (48.1%, n = 52 of 108), |Z| < 1.

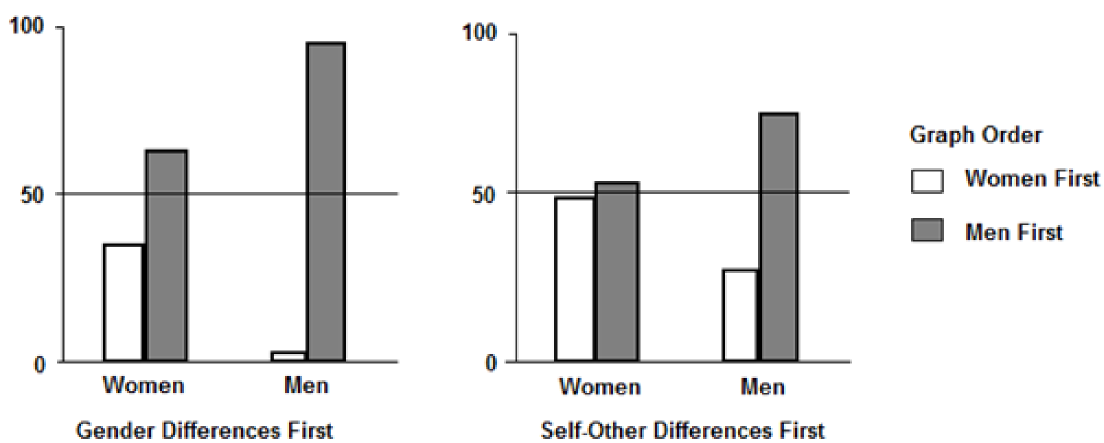

***Figure 4*: Effects of Task Order and Participant Gender on Graph Order (Study 6).**

Two factors account for the results among women who graphed self-other differences first. These women showed no preference to graph themselves first in their initial self-other graphs, unlike their male counterparts in this condition (see Table 1). Also, like all participants in this experiment, women who drew self-other graphs first transferred order across graphing tasks. Therefore, unlike the women who drew gender difference graphs first, the women who drew self-other graphs first and gender difference graphs *second* showed no preference to graph men before women (see Table 1). Rather, those who drew the self-other graph first with a male friend first, disproportionately graphed men first in the gender difference graph (76.7%, n = 23 of 30), $Z = 2.74$, $p < .01$, while those who positioned themselves first in the self-other graph, disproportionately positioned women first in their gender difference graph, (87.5%, n = 21 of 24), $Z = 3.47$, $p < .001$.

Verbal Explanation Content*.*

We also examined explanations to assess if there were correspondences between graph format and explanation content. We conducted separate analyses on the number of references to women and men and to self and other. Explanations of gender differences were examined using a 2x2x2x2 ANOVA with task order (first vs. second), graph order (women vs. men first), and participant gender (women vs. men) as between-subjects variables, and the gender referenced (women vs. men) as a within-subjects variable. Women's explanations included more references to attributes of gender groups than did men's explanations (Ms = 3.67, 1.53), F (1, 155) = 19.56, $p < .001$, $\eta_p^2 = .11$, and more references to gender categories were produced when the gender differences task came first rather than second (Ms = 3.58, 2.32 respectively), F (1, 155) = 8.63, $p < .01$, $\eta_p^2 = .05$. This effect was moderated by an interaction with the referenced gender, F (1, 155) = 4.78, $p<.05$, $\eta_p^2 = .03$. There were more references to men when the gender differences task came first rather than second (Ms = 2.12, 1.05 respectively), but an equal number of references to women in both conditions (Ms = 1.27, 1.46 respectively). However, women's and men's attributes were referenced with equal frequency (M =1.39, 1.55 respectively), $F < 1$, and none of these effects were significantly moderated by graph order. As with Study 1, these findings do not support the prototypicality hypothesis.

An ANOVA using the same factorial design was used to analyze the references to self and other. Again, women's explanations contained more references than men's overall (Ms = 3.81, 1.41), F (1, 155) = 35.98, $p<.001$, $\eta_p^2 = .19$, and participants also made more reference to their friends than to themselves (Ms = 1.82, 1.13), F (1, 155) = 14.50, $p<.001$, $\eta_p^2 = .09$. These two factors interacted, F (1, 155) = 5.25, $p<.05$, $\eta^2 = .03$. Tukey's HSD test revealed that women referenced their male friends significantly more often than they referenced themselves (Ms = 2.50, 1.32 respectively), but men referenced their women friends and themselves about equally (Ms = .60, .81 respectively). Again, none of these effects were significantly moderated by graph order.

Discussion

Once again, women and men graphed group gender differences with men positioned first. Men's self-other graphs also showed a significant preference to graph the self first, and overall men consistently graphed male individuals and groups first. However, women's self-other graphs positioned themselves and their male friends first with equal frequency, and women who drew self-other graphs first, subsequently drew gender difference graphs in which women and men were positioned first with equal frequency. Thus accessing women's knowledge of their own gender category membership mitigated the preference to graph gender differences with men first.

These findings extend our argument that graphing is a social activity by showing that the effects of group stereotypes on graph order are situation specific. Graphing familiar people may be affected less by gender stereotypes than graphs of more abstract gender categories (Fiske & Neuberg, 1990). The moderating effects of personal knowledge on graph order demonstrated here are not predicted by cognitive models of graph comprehension (Pinker, 1990), and cannot be explained by invariant properties of the human visual system. Rather, such effects are consistent with feminist empiricist claims that women's personal knowledge affords the generation of more diverse forms of scientific representation (Harding, 1986, 1991), and show that graphs can evidence the relationship between personal and group identities (Tropp & Wright, 2001).

In Study 6, in contrast to earlier studies, men graphed men first more than women did, both when graphing gender differences and when graphing self-other differences. Previous research at the campus from which the male engineering students were drawn found that engineering students scored higher than psychology students on a range of prejudice measures, including social dominance orientation, even after gender differences were controlled (Tee & Hegarty, 2006). As a result we can speculate that these men may have held stronger stereotypes about power differences between women and men. It is possible that these men also positioned themselves first more often than women did because they considered their selves to be more agentic (e.g., Cross & Madsen, 1997). Indeed, dominant individuals are quicker to map dominance onto the vertical axis of space (Moeller, Robinson, & Zabelina, 2008) and may be quicker to map power onto graph order also. To the extent that these gender differences in graphing self-other differences can be generalized, they imply that women will be less likely to draw the kinds of self-other graphs that shift the order of their gender difference graphs.

Study 6 was not designed to test the more ambitious claim that changes in graph order preferences lead to changes in participants' beliefs about the powerfulness of women and men. However, future studies ought to examine within-gender variation in beliefs about power, their effects on graph order preferences, and the degrees to which changing the ways that people graph differences affects the way they think about the powerfulness of groups.

General Discussion

These experiments show why graphing group differences can be a much more social activity than cognitive models of graph comprehension would suggest. Gender differences are graphed (Study 1) and misremembered (Study 2) with men first, and people draw upon beliefs about power when they order data in graphs (Studies 3 & 4). People rarely conclude that graph order is a consequence of an author's bias. When they do, they consistently conclude that the bias favors the group graphed first (Study 5). While women and men both spontaneously graph men first, accessing personal knowledge of participants' own gender category membership leads women, but not men, to graph women and men first with equal frequency (Study 6).

The implicit knowledge that scientifically literate people bring to graph production and interpretation is not simply 'cognitively natural' or a consequence of the ways that humans process visual information (Zachs & Tversky, 1999). Thinking with graphs is *social* cognition for at least three reasons. First, space in graphs in particular can represent obviously social concepts, such as power, in addition to more asocial properties, such as time (Boroditsky & Ramscar, 2002; Tversky, Kugelmass, & Winter, 1991). Second, graphs are read, by some skeptical readers, as evidence of their authors' beliefs (Study 5). As such, graph formats not only communicate mathematical information with varying levels of faithfulness (Shah & Hoeffner, 2002), they also allow readers to form impressions of an author's beliefs and identity that may surprise the author themselves. Third, personal knowledge of social group membership, when made salient, can affect graph order preferences (Study 6). The implicit knowledge that people draw upon to graph difference varies situationally (c.f., Pinker, 1990).

Graphs, Space, and Power

Our conclusion that graph order reflects implicit beliefs about power differences between groups suggests both a reinterpretation of previous findings, and possible avenues for future research. Hegarty and Buechel's (2006) prototypicality hypothesis received little support here; participants did not focus verbal explanations or hypotheses on second graphed groups (Studies 1, 2, & 6), or consistently graph typical groups first and atypical groups second (Study 3). It is possible that developmental psychologists graph mothers first because they consider that mothers have more power than fathers in influencing child development, and not because they consider mothers to be prototypical parents (see Hegarty & Buechel, 2006).

Our studies have not exhausted the relationship between graph order and power, and consideration of the relationship between graph order and related work on the spatial mapping of social thought suggests several fruitful avenues for future research (see e.g., Maass et al., 2009; Schubert, 2005). First, recall that we used the term 'first' and 'second' rather than 'left' and 'right' throughout this paper, because we were informed by cognitive psychologists' descriptions of graphs as *metaphors.* The metaphorical meanings of graph space might well be affected by such features as left-positioned axes in our graph stimuli (e.g., Figures 2 & 3) and in participants' own graphs (see Figure 1) which index where graph order begins. For these reasons, we cannot directly attribute the effects observed here to spatial agency biases, such as the tendency of English-language readers to position more agentic groups on the left side of visual images (Maass et al., 2009).

Nor can we conclude that spatial agency biases have nothing to do with the metaphorical meanings of graph order. Research findings could be integrated, and the basis of the 'order' metaphor in graphs could be further explored by further experiments examining a wider range of graph formats and orientations than we used here. Specifically, researchers should tease apart whether 'first' and 'second' order in graphs can be mapped onto both vertical and horizontal axes and both directions in each axis with equal ease. Moreover, while we concluded that power affects graph order here, power has many forms (e.g., French & Raven, 1959; Pratto, Pearson, Lee, & Saguy, in press). Furthermore, we did not distinguish participants' beliefs about power differences between groups from more dispositional stereotypes about the agentic traits of individuals within those groups or from beliefs about the extent to which power would be used to enact intergroup dominance. These aspects of power might lead to different effects on positional order in the left-right axis (c.f., Maass et al., 2009), and vertical axis (Moeller et al., 2008; Schubert, 2005) respectively.

Research on readers of languages written from right-to-left would also inform understanding of the conventional meanings of graph order. English is both read from left-to-right, and read by people who have long been advised to read graphs from left-to-right (e.g., American Statistical Association Joint Committee on Standards of Graphic Presentation, 1915). The results of research on the graph order preferences of people who read from right-to-left are difficult to predict. Consequently, such research would inform questions about the contribution of the spatial agency bias and graph order conventions to graph order preferences in the left-right axis. People integrate verbal and spatial information in a piecemeal fashion during graphic comprehension (Shah & Carpenter, 1998). Consequently, readers of languages read right-to-left might graph men to the right and women to the left. However, Western graphing conventions with global influence may also have affected the graph schemas of people who read languages from right-to-left, leading them to position men on the left as English-speaking participants did here.

The use of the English language as the medium of these experiments suggests a further contributor to visuospatial order. English speakers conventionally say ‘men and women’ rather than ‘women and men’ (Bodine, 1975; Cooper & Ross, 1975). For example, an internet search using www.google.co.uk on November 1st, 2008 ‘hit’ more sites on the internet that contain the phrase ‘men and women’ than ‘women and men’ (56, 100,000 vs. 7, 950, 000). While we avoided giving verbal cues to order in these experiments, previous experiments have found effects of word order on the ordering of women and men in pictures (Maass et al., 2009).

Word order conventions may influence graph order conventions, but we caution against the conclusion that such effects imply that graph order is ‘natural’ rather than social. The convention to name men before women was proscribed by English grammarians for explicitly sexist reasons (Bodine, 1975). The behavioral preferences to name men before women is stronger among men than among women, and stronger when the couple being named are considered to conform to gender stereotypes (Hegarty et al., 2009; Wright, Hay, & Bent, 2005). Rather than assume that word order is the ‘natural’ basis of graph order, the meaning of each kind of order convention and the situation-specific effects of each on the other ought to be investigated empirically.

Graph Order and Social Constructionism

Finally, we consider the implications of our research for debates about the social construction of scientific knowledge, as we aimed to conduct research that informs both experimental and social constructionist social psychologies (c.f., Jost & Kruglanski, 2002). First, we have exemplified how experimentation can compliment content analysis; we would not have conducted these experiments without Hegarty and Buechel’s (2006) findings, but our experiments gave a reason to reject the prototypicality hypothesis proposed by that research. Second, these experiments demonstrate that the social construction of meaning occurs through non-verbal media that can only be understood as ‘discourse’ only in the metaphorical sense of the term (c.f., Potter & Wetherell, 1987). Third, the results show that graphs carry implicit social meanings beyond the implication that the findings they represent are ‘hard science’ (Latour, 1990; Smith et al., 2002).

In particular, these results support the feminist view that scientific conventions lead people to reiterate particular views of reality that favor men (c.f., Harding, 1986; Keller, 1985; Merchant, 1980). Empiricism rejected the authority of written texts in favor of direct observation of nature during the 17th Century (Shapin, 1998) and alighted on the journal article as a medium that would avoid ‘meddling with Divinity, metaphysics, morals, Politics, grammar, Rhetorick, or Logicks’ (Hooke, 1663, cited in Bernal, 1971, p.

455). Graphs have long been part of this genre of writing (Best, 2005). However, 17th Century norms of empirical conduct which required the individual scientist to transcend individual subjectivity and self-interest (Shapin & Schaffer, 1985), conflated objective scientific conduct with elite male codes of conduct (Shapin, 1995), and relied on metaphors that associated scientific thinking with heterosexual dominance (Keller, 1985). Feminist researchers have used the visual metaphor of the *lens* to describe male-centered conventions in science (Bem, 1993). Visuospatial representations of gender in science may indeed focus our vision of the reality of group differences on some representations of those realities and blur the possibilities for visualizing others.

Feminist empiricists have argued that Western science is in need of greater reflexivity about scientists' own locations with gendered systems of power (Harding, 1991; Morawski, 1994, 2006). Greater attention to the semantics of graphing appears to be a domain where such reflexivity would have merit. A strong preference for order in graphs of gender differences has been hiding in plain sight in psychologists' own publications for decades (Hegarty & Buechel, 2006), but we psychologists have not consciously chosen this format, nor explicated the basis for this choice in our models of graph comprehension (e.g., Pinker, 1990), nor discussed this choice in our debates about whether and how gender differences ought to be communicated (e.g., Eagly, 1995; Hyde, 2007). Until we do, graph orders that are subtle cues to power will remain part of the 'positive unconscious' of our science (Foucault, 1973), something akin to James's (1890/1983) 'psychologist's error' which conflates the scientific representation with the thing represented and that "elude[s] the consciousness of the scientist and yet is part of the scientific discourse" (Foucault, 1973, p. xi).

Indeed, as several historians and anthropologists have observed, scientists spend less time looking at natural phenomena, and more time looking at visual representations of nature in diagrams, maps, and graphs (Latour & Woolgar, 1979; Lynch, 1985; Roth, 2003; Star, 1983; Shapin, 1984). In the spirit of engendering such 'reflexivity' (e.g., Morawski, 1994, 2006), we conclude by agreeing with Latour (1990) that our own empiricism relies more on the observation of human-made inscriptions and less on the literal act of looking at nature than this empiricist article has hitherto suggested. We never observed a 'graph schema' directly, but we spent quite some time puzzling over participants' graphs, and still longer looking at the graphs of our results that emerged from SPSS and our own hand-drawn sketches. A more critically reflexive science about the choices people make among equally 'unbiased' representations of group differences might lead psychology to a 'stronger' objectivity than our studies of bias alone can do.

Footnotes

1. Throughout this paper we use the terms 'first' and 'second' to refer to the left and right sides of graphs. We use these terms figuratively rather than literally; there are long-standing conventions to read Western graphs from left to right (American Statistical Association Joint Committee on Standards of Graphic Presentation, 1915). We did not observe the temporal order in which participants drew the components of their graphs.

2. In Studies 1, 2, 3, 4, and 6 we coded graphs that positioned women first as 0 and those that positioned men first as 1. As a result this dependent variable was non-normally distributed in all studies and was analyzed using non-parametric statistics.

3. This log linear analysis was replicated excluding also the four participants whose hypotheses focused on the gender group who performed less of the behavior. Identical statistical conclusions were reached.

4. Excluding the non-significant 5-way interaction from the model did not reduce the fit of the data to the model. As no significant contingencies in the resulting custom model involving order of presentation of academic competency, we calculated a fully saturated model with the remaining four variables. Excluding the non-significant 4-way interaction from this saturated model did not reduce the fit between data and model. No significant contingencies involving participant gender appeared in the custom model; we calculated a fully saturated model with the remaining three variables. Excluding the non-significant 3-way interaction from the model did not reduce the fit of the data to the model. As there were no significant contingencies involving recall order of academic competency, we calculated a fully saturated model with the remaining three variables. For all excluded effects, $Z < 1.5$, and $p > .15$, and all custom models fit the data as well as saturated models, all $\Delta\ \chi^2\ (1) < 1$, all $p > .38$.

5. For this binomial test we set an expected value of .525 for graphs presented with women first and .475 for graphs presented with men first to reflect the distribution of participants across condition.

6. For this binomial test we set an expected value of .346 for the power conditions and .654 for the importance and prototypicality conditions combined to reflect the distribution of participants across condition.

7. One graph depicted a similarity between two individuals.

8. Some analyses included less than 15 participants because some participants left some items blank.

References

Ader, D. N., & Johnson, S. B. (1994). Sample description, reporting and analysis of sex in psychological research: A look at APA and APA division journals in 1990. *American Psychologist, 49,* 216-218.

Allport, G. W., & Postman, L. J. (1945). The basic psychology of rumor. *Transactions of the New York Academy of Sciences, 8,* 61-81.

American Statistical Association Joint Committee on Standards of Graphic Presentation, (1915). Prelimenary report published for the purpose of inviting suggestions for the benefit of the committee. *Publications of the American Statistical Association, 14,* 790-797.

Aron, A., Aron, E.N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology, 63,* 596-612.

Bangerter, A. (2000). Transformation between scientific and social representations of conception: The method of serial reproduction. *British Journal of Social Psychology, 39,* 521-535.

Bartlett, F. C. (1932). *Remembering*. Oxford: Oxford University Press.

Bem, S. L. (1993). *The lenses of gender: Transforming the debate on sexual inequality*. New Haven, CT: Yale University Press.

Beninger, J. R., & Robyn, D. L. (1978). Quantitative graphics in statistics: A brief history. *American Statistician, 32,* 1-11.

Bernal, J. D. (1971). *Science in history: The scientific and industrial revolutions.* Cambridge, MA: MIT Press.

Best, L.A. (2005). An examination of drawings in philosophical transactions (1665 to present). *The International Journal of the Book, 3,* 45-54.

Blanchette, I., & Dunbar, K. (2002). Representational change and analogy: How analogical inferences alter target representations. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 672-685.

Bodine, A. (1975). Androcentrism in prescriptive grammar: Singular 'they,' sex-indefinite 'he,' and 'he or she.' *Language in Society, 4,* 129-146.

Boroditsky, L, & Ramscar, M. (2002). The roles of body and mind in abstract thought. *Psychological Science, 13,* 185-189.

Brown, R. (2000). Social identity theory: Past achievements, current problems, and future challenges. *European Journal of Social Psychology, 30,* 745-778.

Burris, C.T., & Branscombe, N.R. (2005). Distorted distance estimation induced by a self-relevant national boundary. *Journal of Experimental Social Psychology, 41,* 305-312.

Carmichael, L., Hogan, H. P., & Walter, A. A. (1932). An experimental study of the effect of language on the reproduction of visually perceived form. *Journal of Experimental Psychology, 15,* 73-86.

Chapman, L., & Chapman, J. (1969). Illusory correlation as an obstacle to the use of valid psychodiagnostic signs. *Journal of Abnormal Psychology, 74,* 271-280.

Chatterjee, A. (2002). Portrait profiles and the notion of agency. *Empirical Studies of the Arts, 20,* 33-41.

Chatterjee, A., Southwood, M.H., & Basilico, D. (1999). Verbs, events, and spatial representations. *Neuropsychologia, 37,* 395-402.

Chokron, S., & De Agostini, M. (1996). Reading habits and line bisection: A developmental approach. *Cognitive Brain Research, 3,* 51-58.

Chokron, S., & De Agostini, M. (2000). Reading habits influence aesthetic preference. *Cognitive Brain Research, 10,* 45-49.

Cleveland, W. S. (1984). Graphs in scientific publications. *American Statistician, 38*, 261-269.

Cooper, W.E., & Ross, J.R. (1975). World order. In R.E. Grossman, L.J. San, & T. J. Vance (Eds.), *Papers from the parasession on functionalism* (pp. 63-111). Chicago: Chicago Linguistics Society.

Cross, S.E., & Madson, L. (1997). Models of the self: Self-construals and gender. *Psychological Bulletin, 122,* 5-37.

Dahrendorf, R. (1959). *Class and class conflict in industrial society.* Stanford, CA: Stanford University Press.

deBeauvoir, S. (1949). *The second sex*. New York: Random House.

Dunbar , K., & Blanchette, I. (2003). The in vivo/in vitro approach to cognition: The case of analogy. *Trends in Cognitive Sciences, 5,* 334-339.

Eagly, A.H. (1995). The science and politics of comparing women and men. *American Psychologist, 50,* 145-158.

Eagly, A. H., & Kite, M. E. (1987). Are stereotypes of nationalities applied to both women and men? *Journal of Personality and Social Psychology, 53,* 451-462.

Eagly, A. H., & Steffan, V. J. (1984). Gender stereotypes stem from the distribution of women and men into social roles. *Journal of Personality and Social Psychology, 46*, 735-754.

Fagerlin, A., Wang, C., & Ubel, P.A. (2005). Reducing the influence of anecdotal reasoning on people's health care decisions: Is a picture worth a thousand statistics? *Medical Decision Making, 25,* 398-405.

Fausto-Sterling, A. (2000). *Sexing the body: Gender politics and the construction of sexuality*. New York: Basic Books.

Fiske, S. T., & Neuberg, S. L. (1990). A continuum of impression formation from category-based to individuating processes: Influences of information and motivation on attention and interpretation. In M. P. Zanna (Ed.), *Advances in experimental social psychology* (pp. 1-74). San Diego, CA: Academic Press.

Foster, R. A., & Keating, J. P. (1992). Measuring androcentrism in the Western God-concept. *Journal for the Scientific Study of Religion, 31,* 366-375.

Foucault, M. (1973). *The order of things: An archaeology of the human sciences*. New York: Vintage.

French, J.R.P., & Raven, B. (1959) The bases of social power. In D. Cartwright (Ed.), *Studies in Social Power* (pp. 150-167). Oxford: University of Michigan.

Gattis, M., & Holyoak, K.J., (1996). Mapping conceptual to spatial relations in visual reasoning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* 231-239.

Geissner, S.R., & Schubert, T.W. (2007). High in the hierarchy: How vertical location and judgments' of leaders' power are interrelated. *Organizational Behavior and Human Decision Processes, 104,* 30-44.

Glucksberg, S. (2003). The psycholinguistics of metaphor. *Trends in Cognitive Sciences, 7,* 92-96.

Greenwald, A.G. (1980). The totalitarian ego: Fabrication and revision of personal history. *American Psychologist, 35,* 603-618.

Haraway, D. J. (1991). *Simians, cyborgs, and women*. New York: Routledge.

Harding, S. (1986). *The science question in feminism*. Ithaca, NY: Cornell University press.

Harding, S. (1991). *Whose science? Whose knowledge? Thinking from women's lives.* Ithica, NY: Cornell University Press.

Hegarty, P., & Buechel, C. (2006). Androcentric reporting of gender differences in APA journals: 1965-2004. *Review of General Psychology, 10,* 377-389.

Hegarty, P., Buechel, C., & Ungar, S. (2006). Androcentric preferences for visuospatial representations of gender differences. In D. Barker-Plummer, R. Cox & N. Swoboda (Eds.), *Diagrammatic Representation and Inference: 4th International Conference, Diagrams 2006* (pp. 263-266). Berlin: Springer-Verlag.

Hegarty, P. & Pratto, F. (2001). The effects of social category norms and stereotypes on explanations for intergroup differences. *Journal of Personality and Social Psychology, 80,* 723-735.

Hegarty, P., Watson, N., Fletcher, L., & McQueen, G. (in press). When gentlemen are first and ladies are last: Effects of gender stereotypes on the order of romantic partners' names. *British Journal of Social Psychology*.

Heine, S.J., & Lehman, D. R. (1995). Cultural variation in unrealistic optimism: Does the West feel more invulnerable than the East? *Journal of Personality and Social Psychology, 68,* 595-607.

Heine, S.J., & Hamamura, T. (2007). In search of East Asian self-enhancement. *Personality and Social Psychology Review, 11,* 1-24.

Holyoak, K. J., & Mah, W.A. (1982). Cognitive reference points in judgments of symbolic magnitude. *Cognitive Psychology, 14,* 328-352.

Hyde, J. S. (1984). Children's understanding of sexist language. *Developmental Psychology, 20*, 697-706.

Hyde, J.S. (2007). The gender similarities hypothesis. *American Psychologist, 60,* 581-592.
James, W. (1890/1983). *The principles of psychology: Volume 1*. Cambridge, MA: Harvard University Press.
Jordanova, L. (1993). *Sexual visions: Images of gender in science and medicine between the eighteenth and twentieth centuries*. Madison, WI: University of Wisconsin Press.
Jost, J.T., & Kruglanski, A.W. (2002). The estrangement of social constructionism and experimental social psychology: History of the rift and prospects for reconciliation. *Personality and Social Psychology Review, 6,* 168-187.
Kahneman, D., & Miller, D.T. (1986). Norm theory: Comparing reality to its alternatives. *Psychological Review, 93,* 136-153.
Kashima, Y., Fiedler, K., & Freytag, P. (Ed.). (2007). *Stereotype dynamics: Language based approaches to the formation, maintenance and transformation of stereotypes.* New York: Erlbaum.
Keller, E. F. (1985). *Reflections on gender and science*. New Haven, CT: Yale University Press.
Kite, M.E., Deaux, K., & Haines, E.L. (2008). Gender stereotypes. In F.L. Denmark, & M.A. Paludi (Eds.), *Psychology of women: A handbook of issues and theories* (2nd ed., pp. 205-236). Westport, CT: Praeger.
Klayman, J., & Ha, Y.-W. (1987). Confirmation, disconfirmation, and information in hypothesis testing. *Psychological Review, 94*, 211-228.
Kosslyn, S.M. (1993). *Elements of graph design*. New York: W. H. Freeman & Co.
Kunda, Z. (1989). The case for motivated reasoning. *Psychological Bulletin, 108,* 480-498.
Lambdin, J., Greer, K. M., Jibotian, K. S., Wood, K. R., & Hamilton, M. C. (2003). The animal = male hypothesis: Children's and adults' beliefs about the sex of non sex-specific stuffed animals. *Sex Roles, 48,* 471-482.
Latour, B. (1990). Drawing things together. In M. Lynch & S. Woolgar (Eds.), *Representation in scientific practice* (pp. 19-68). Cambridge, MA: MIT Press.
Latour, B., & Woolgar, S. (1979). *Laboratory life: The construction of scientific facts*. London: Sage.
Leary, D. E. (1990). Psyche's muse: The role of metaphor in the history of psychology. In D.E. Leary (Ed.), *Metaphors in the history of psychology* (pp. 1-78). New York: Cambridge University Press.
Lord, C.G., Lepper, M., & Ross, L. (1979). Biased assimilation and attitude polarization: The effects of prior theories on subsequently considered evidence. *Journal of Personality and Social Psychology, 37,* 2098-2109.
Lynch, M. (1985). Discipline and the material form of images: An analysis of scientific visibility. *Social Studies of Science, 15,* 37-66.
Maass, A., & Russo, A. (2003). Directional bias in the mental representation of spatial events: Nature or culture? *Psychological Science, 14,* 296-301.
Maass, A., Pagani, E., & Berta, E., (2007). How beautiful is the goal and how violent is the fistfight? Spatial bias in the interpretation of human behavior. *Social Cognition, 25,* 833-852.
Maass, A., Suitner, C., Favaretto, X., & Cignacchi, M. (2009). Groups in space: Stereotypes and the spatial agency bias. *Journal of Experimental Social Psychology, 45,* 496-504.
Martin, E. (1991). The egg and the sperm: How science has constructed a romance based
on stereotypical male-female roles. *Signs, 16,* 485-501.

McCabe, D.P., & Castel, A.D. (2008). Seeing is believing: The effects of brain images on judgments of scientific reasoning. *Cognition, 107,* 343-352.

McDonald, J.L., Bock, K., & Kelly, M.H. (1993). Word and world order: Semantic, phonological and metrical determinants of serial order. *Cognitive Psychology, 25,* 188-230.

Merchant, C. (1980). *The death of nature.* New York: Harper Collins.

Miller, D. T., Taylor, B., & Buck, M. (1991). Gender gaps: Who needs to be explained? *Journal of Personality and Social Psychology, 61*, 5-12.

Moeller, S.K., Robinson, M.D., & Zabelina, D.L. (2008). Personality dominance and the preferential use of the vertical dimension of space: Evidence from spatial attention paradigms. *Psychological Science, 19,* 355-361.

Morawski, J. G. (1994). *Practicing feminisms, reconstructing psychology: Notes on a liminal science.* Ann Arbor, MI: University of Michigan Press.

Morawski, J. G. (2006). Reflexivity and the psychologist. *History of the Human Sciences, 18,* 77-105.

Ochs, E., Gonzales, P., & Jacoby, S. (1996). "When I come down I'm in the domain state": Talk, gesture, and graphic representation in the interpretive activity of physicists. In E. Ochs, E. Schegloff, & S. Thompson (Eds.), *Interaction and grammar* (pp. 328-369). Cambridge, UK: Cambridge University Press.

Perrott, D.A., Gentner, D., & Bodenhausen, G.V. (2005). Resistance is futile: The unwitting insertion of analogical inferences in memory. *Psychonomic Bulletin & Review, 12,* 696-702.

Pinker, S. (1990). A theory of graph comprehension. In R. Freedle (Ed.), *Artificial intelligence and the future of testing*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Pinker, S., & Birdsong, D. (1979). Speakers' sensitivity to rules of frozen word order. *Journal of Verbal Learning and Verbal Behavior, 18,* 497–508.

Potter, J. & Wetherell, M. (1987). *Discourse and social psychology: Beyond attitudes and behaviour.* London: Sage.

Pratto, F., Korchmaros, J., & Hegarty, P.J. (2007). How communication practices and category norms lead people to stereotype particular people and groups. In Y. Kashima, K. Fiedler, & P. Frietag (Eds.), *Language-based approaches to the formation, maintenance and transformation of stereotypes.* Mahwah, NJ: LEA.

Pratto, F., Pearson, A. R., Lee, I., & Saguy, T. (in press). Power dynamics in an experimental game. *Social Justice Research*.

Qi, W. (2004). The emergence of cultural self-constructs: Autobiographical memory and self-description in European American and Chinese children. *Developmental Psychology, 40,* 3-15.

Rosnow, R. L., & Rosenthal, R. (1997). *People studying people: Artifacts and ethics in behavioral research.* New York: Freeman.

Roth, W.M. (2003). *Toward an anthropology of graphing: Semiotic and activity-theoretic perspectives.* Berlin: Springer.

Rudin, S.I., Jones, M., O., Lemieux, A.F., & Hegarty, P. (2009). Androcentrism in medical journals: The communication of bias through visual displays. Poster presented at the Annual Purchase College Science Symposium.

Schubert, T.W. (2005). Your highness: Vertical positions as perceptual symbols of power. *Journal of Personality and Social Psychology, 89,* 1-21.

Shah, P., & Carpenter, P.A. (1998). A model of the perceptual and conceptual processes in graph comprehension. *Journal of Experimental Psychology: Applied, 4,* 75-100.

Shah, P., Freedman, E. G., & Verini, I. (2005). The comprehension of quantitative information in graphical displays. In A. Miyake & P. Shah (Eds.), *The Cambridge handbook of visuospatial thinking* (pp. 426-476). New York: Cambridge University Press.

Shah, P., & Hoeffner, J. (2002). Review of graph comprehension research: Implications for instruction. *Educational Psychology Review, 14*, 47-69.

Shapin, S. (1984). Pump and circumstance: Robert Boyle's literary technology *Social Studies of Science, 14,* 481-521.

Shapin, S. (1995). *A social history of truth: Civility and science in seventeenth century England.* Chicago: University of Chicago Press.

Shapin, S. (1998). *The scientific revolution*. Chicago: University of Chicago Press.

Shapin, S., & Schaffer, S. (1985). *Leviathan and the air-pump: Hobbes, Boyle, and the experimental life.* Princeton, NJ: Princeton University Press.

Smith, L. D., Best, L. A., Stubbs, A. D., Archibald, A. B., & Roberson-Nay, R. (2002). Constructing knowledge: The role of graphs and tables in hard and soft psychology. *American Psychologist, 57,* 749-761.

Spalek, T.M. & Hammad, S. (2005). The left-to-right bias in inhibition of return is due to the direction of reading. *Psychological Science, 16,* 15-18.

Star, S. L. (1983). Simplification in scientific work: An example from neuroscience research. *Social Studies of Science, 12,* 205-228.

Suitner, C., & Maass, A. (2007). Positioning bias in portraits and self-portraits: Do female artists make different choices? *Empirical Studies of the Arts, 25,* 71-95.

Tajfel, H., & Turner, J. C. (1979). An integrative theory of intergroup conflict. In W. G. Austin & S. Worchel (Eds.), *The social psychology of intergroup relations* (pp. 33–47). Monterey, CA: Brooks-Cole.

Tee, N., & Hegarty, P. (2006). Predicting opposition to the civil rights of trans persons in the United Kingdom. *Journal of Community and Applied Social Psychology, 16,* 70-80.

Tropp, L.R., & Wright, S.C. (2001). Ingroup identification as the inclusion of ingroup in the self. *Personality and Social Psychology Bulletin, 27,* 585-600.

Turner, J. C., Hogg, M. A., Oakes, P. J., Reicher, S. D., & Wetherell, M. S. (1987). *Rediscovering the social group: A self-categorization theory.* Oxford, England: Blackwell.

Tversky, B. (2005). Functional significance of visuospatial representations. In A. Miyake & P. Shah (Eds.), *The Cambridge handbook of visuospatial thinking* (pp. 1-34). New York: Cambridge University Press.

Tversky, B., Kugelmass, S., & Winter, A. (1991). Cross-cultural and developmental trends in graphic productions. *Cognitive Psychology, 23,* 515-557.

Tversky, B., & Schiano, D. J. (1989). Perceptual and conceptual factors in distortions in memory for graphs and maps. *Journal of Experimental Psychology: General, 118,* 387-398.

Twain, M. (July 5th 1907). Chapters from my autobiography. *North American Review, 186.*

Wright, S.K., Hay, J., & Bent, T. (2005). Ladies first? Phonology, frequency, and the naming conspiracy. *Linguistics, 43,* 531-561.

Zachs, J., Levy, E., Tversky, B., & Schiano, D. (2002). Graphs in print. In M. Anderson, B. Meyer, and B. Olivier (Eds.) *Diagrammatic representation and reasoning* (pp. 187-206). Berlin: Springer.

Zachs, J., & Tversky, B. (1999). Bars and lines: A study of graphic communication. *Memory & Cognition, 27,* 1073-1079.