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Sex and network recall accuracy

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ABSTRACT

How does an individual's sex influence their recall of social relations? Extensive research has shown that social networks differ by sex and has attempted to explain these differences either through structural availability or individual preferences. Addressing the limitations of these explanations, we build on an increasing body of research emphasizing the role of cognition in the formation and maintenance of networks to argue that males and females may exhibit different strategies for encoding and recalling social information in memory. Further, because activating sex roles can alter cognitive performance, we propose that differences in recall may only or primarily appear when respondents are made aware of their sex. We explore differences in male and female network memory using a laboratory experiment asking respondents to memorize and recall a novel social network after receiving either a sex prime or a control prime. We find that sex significantly impacts social network recall, however being made aware of one's sex does not. Our results provide evidence that differences in male and female networks may be partly due to sex-based differences in network cognition.

1. Introduction

How does sex influence the ability to encode and recall social relations? Males and females have long been known to differ in their network structures (Brashears, 2008a; Ibarra, 1992; Marsden, 1987; Moore, 1990; Smith-Lovin and McPherson, 1993), with these differences usually ascribed to structural constraints (e.g., McPherson and Smith-Lovin, 1987; Moore, 1990), dispositions/preferences (e.g., Eder and Hallinan, 1978; Feshbach and Sones, 1971; Ibarra, 1992, 1997), or combinations thereof (e.g., Brashears, 2008b; McGuire, 2002; Munch et al., 1997). However, there is growing evidence that social networks depend on the structure of the brain (e.g., Bickart et al., 2011; Dunbar, 1992, 1993, 1995; Goncalves et al., 2011; Meyer et al., 2012; Sallet et al., 2011; Stiller and Dunbar, 2007; Zahn et al., 2007), on cognitive development (e.g., Leinhardt, 1973; Schaefer et al., 2010) and on the use of schemata (e.g., Brashears, 2013; Brewer and Garrett, 2001; De Soto, 1960; Freeman, 1992; Killworth and Bernard, 1982). Thus, do male and female networks vary because men and women encode and recall those networks differently?

If males and females encode and recall networks differently, then variations in network structure, net of constraints, may not reflect differences in preferences, but instead simply result from differences in cognition. Moreover existing research on situational cognition (e.g., LaFrance et al., 2003; Lightdale and Prentice, 1994; Spencer et al., 1999) demonstrates that some sex differences in cognitive performance and behavior are only evident when context makes one's sex salient. Sex is a master status and therefore relevant to a wide variety of circumstances (Ridgeway and Correll, 2004; Ridgeway and Smith-Lovin, 1999), suggesting that it is often activated in the interactions that give rise to social networks. Yet existing research has not primed or activated sex and is thus unable to detect such effects if they do exist.

We use a randomized laboratory experiment to explore how sex and sex role activation, impact the encoding and recall of a novel social network. We find that females exhibit noticeably superior network recall relative to males, and that this advantage does not appear to depend on differential skill with "compression heuristics," which are useful for simplifying social networks, on personality differences, or on variation in cognitive flexibility, and exhibits no interaction with sex role salience.

2. Background

2.1. Networks and gender differences

The social networks of men are different from those of women. Female networks are often larger than male networks (e.g., Moore, 1990) and include a higher proportion of kin (Marsden, 1987),

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although this tendency may be weakening over time (McPherson et al., 2006, 2008; But see also Fischer, 2009; McPherson et al., 2009). While males and females predominantly associate with similar others (Marsden, 1988; McPherson et al., 2001), males make fewer distinctions between alters on the basis of religion, and more on the basis of age, than females (Brashears, 2008a). Sex also helps determine whether individuals name their spouses as discussion partners (Liao and Stevens, 1994) and influences the topics of discussion that arise with alters (Bearman and Parigi, 2004; Brashears, 2014; Small, 2013). Finally, females often provide more interpersonal support than males (Wellman and Wortley, 1990). In short, it is clear that networks differ in a number of ways by sex.

Two broad classes of explanation have been advanced for sex-based differences in networks: structuralist perspectives and preference-based perspectives. Structuralist perspectives argue that network structure and composition are primarily determined by the availability of others for association (e.g., Blau, 1977; Feld, 1981; McPherson and Smith-Lovin, 1982, 1987; Moore, 1990; Munch et al., 1997). Preference-based perspectives argue that males and females have different networks because they prefer, or select for, different types of alters and structures (e.g., Brashears, 2008b; Eder and Hallinan, 1978; Feshbach and Sones, 1971; Ibarra, 1992; Lewis et al., 2008). Research also suggests that individuals prefer to exhibit different behavior toward alters depending on the alter's sex (McDonald et al., 2009; McGuire, 2002).

Controlling for structural factors often reduces, but does not eliminate, the differences between male and female networks (e.g., Moore, 1990). Moreover, cross-national research reveals patterns of male and female network difference similar to the U.S. (Bastani, 2007). As such, structural accounts are insufficient. Preference based explanations help to compensate for the limitations of structural explanations, but typically assume that opportunities for contact are roughly similar, which is rarely the case (e.g., McPherson and Smith-Lovin, 1982, 1987). Moreover, few studies directly assess preferences and instead infer them from realized relationships. However, both structural and preference based accounts run afoul of a problematic assumption: that males and females understand networks and their features in the same way. Individuals respond to perceptions of the network rather than its reality (e.g., Kilduff and Krackhardt, 2008, Ch. 3) and if males and females perceive networks differently, then they could develop very different networks even while preferring the same outcomes and enjoying the same opportunities. This represents a serious oversight given the growing literature showing that cognition is essential to social networks.

2.2. Cognition, memory and social networks

There is growing evidence that cognition plays a key role in social networks. Research using both human and animal models has shown that brain structure is associated with network size and structure (Barton, 1996; Bickart et al., 2011; Dunbar, 1992, 1993, 1995; Goncalves et al., 2011; Kudo and Dunbar, 2001; Meyer et al., 2012; Sallet et al., 2011; Stiller and Dunbar, 2007; Zahn et al., 2007). Likewise, human social networks have been shown to resemble those of many non-human species, further confirming the roots of human sociability in our biological endowments (Faust and Skvoretz, 2002; Skvoretz and Faust, 2002). Social abilities increase during early childhood as individuals learn to model the intentions of others (Karniol and Ross, 1979), and to manage triadic relations (Hallinan and Kubitschek, 1988; Leinhardt, 1973; Schaefer et al., 2010, But see also Daniel et al., 2013), suggesting that social networks depend on the maturation of critical brain regions. Moreover, recent studies (Janicik and Larrick, 2005; Simpson et al., 2011a) have shown that memory for social structure taps a fundamentally different set of skills than does memory for non-social stimuli.

Research also indicates that the manner in which social information is processed influences learning speed and overall recall success (For a review see Brashears and Quintane, 2015). De Soto (1960) found that networks were learned more rapidly when they were built from the expected type of relation and concluded that his subjects possessed schemata (1960: 420), or pre-existing frameworks for understanding information, that allowed them to organize the learning experience and complete it more rapidly (Bartlett, 1932; Neisser, 1967). Schemata are integral to memory for many types of information (e.g., Brewer and Treyens, 1981; Martin, 1993), and so their relevance to social domains is logical. Schemata pertaining to affective balance (Cartright and Harary, 1956) and triadic closure appear to play an especially significant role in aiding recall (Fischer, 1968; Freeman, 1992; Janicik and Larrick, 2005; Picek et al., 1975; Sentis and Burnstein, 1979; Walker, 1976). Recent research by Brashears (2013) finds that schemata not only accelerate the learning of social networks but also function as "compression heuristics," allowing larger numbers of relations to be recalled more accurately. The types of mistakes made also depended on the compression heuristics that were activated.

The preceding studies indicate that encoding (i.e., inserting information into memory) and recalling (i.e., accessing information from memory) networks relies on stable cognitive attributes and strategies, but the quality of network recall also depends on transient qualities of cognition. For example, recognition of alters from a list is compromised by negative moods (Hlebec and Ferligoj, 2001). More central persons in a network tend to have more accurate perceptions of its structure (Krackhardt, 1987, 1990), as do actors with low structural power (e.g., Simpson and Borch, 2005), but network perception can also be improved merely by priming respondents with a sense of low power (Simpson et al., 2011a). These final results are important because sex roles can prime respondents in ways that alter their cognitive performance and therefore, may also influence the cognitive processing of social networks.

2.3. Sex and situational cognition

The notion that males and females think differently is so old that the original citation was likely published on a clay tablet. Yet, there is increasing evidence that sex-based differences in cognition and behavior are situational rather than durable. Neurological evidence shows that the density of dendritic spines in the hippocampus, which is implicated in learning, varies as a function of sex, blood estrogen level, and stress condition (Shors et al., 2001). In other words, the biological readiness of the brain to learn is shaped by its context (i.e., exposure to stress and, if female, phase of its menstrual cycle) as well as by an organism's sex. Behaviorally, Lightdale and Prentice (1994) showed that when sex roles were deactivated females were equal to males, if not greater, in their aggressive behavior. This indicates that rather than males being inherently more aggressive than females, it is likely that females limit their aggressiveness in order to conform to sex expectations (see also Eagly and Steffen, 1986). Similarly, Anderson and Leaper (1998) found that while males were more prone to intrusively interrupt in conversation, these differences were substantially reduced in dyads, relative to larger groups. This result is consistent with a greater reliance on sex expectations in interactions that are less tailored to specific individuals and their relationship. LaFrance et al. (2003) found an international tendency for females to smile more than males, but the extent of the difference nonetheless varies by nation. They also found a greater female advantage in smiling in situations characterized by social rather than task-related tension, and evidence that activation of sex norms directly increases the disparity in male/female smiling. These results show that cultural expectations impact the rates of male/female smiling, and that females may be more sensitive to social conflict than males.

The well-studied phenomenon of stereotype threat provides another example of situational cognition. Stereotypes are ideas about a category of individuals that are widely available, and accepted, in a given culture (Lippmann, 1922; Judd and Park, 1993; Operario and Fiske, 2001). For example, females are often viewed as less adept at mathematics than males (Shih et al., 1999; Spencer et al., 1999). Much like status characteristics, stereotypes can impact the performance of the groups that they are applied to (see Nguyen and Ryan, 2008), even if the group members do not agree with the stereotype themselves. However the individual must be explicitly or implicitly (Greenwald and Banaji, 1995) primed on, or otherwise made aware of, their stereotyped status or the stereotyped status of others (Aronson et al., 1999) while performing a salient task (Steele and Aronson, 1995; Shih et al., 1999). For example, a female who completes a math test in an environment that makes her sex salient will generally exhibit poorer performance relative to a female whose sex is not made salient (Steele, 1997). The phenomenon has also been observed outside the lab, indicating that it is generalizable (Rothgerber and Wolsiefer, 2013; Stricker and Ward, 2004). The mechanism linking activation of the stereotype to altered performance is somewhat unclear, but likely results either from unconscious conformation to expectations (Kray et al., 2001; Wheeler and Petty, 2001) or the depletion of cognitive resources produced by the awareness of the expectations, and the desire to defy them (Beilock et al., 2007; Schmader and Johns, 2003; Schmader et al., 2008). Moreover a parallel process of "stereotype boost" has been observed, wherein priming individuals on a favorable stereotype results in improved performance on stereotype relevant tasks (e.g., Shih et al., 2002, 2011). In either case, cognition and behavior are situationally shaped by the salience of one's sex.

Sex is one of the first characteristics individuals note during interaction and, due to the roughly equal proportions of males and females in the population, it is activated frequently (Ridgeway and Correll, 2004; Ridgeway and Smith-Lovin, 1999). It is therefore reasonable to expect that when forming and maintaining network ties males and females are often aware of their sex, and should be primed to behave in ways consistent with these expectations. As a result, differences in male and female network cognition may primarily, or only, appear when sex is made salient.

3. Hypotheses

In the previous sections, we reviewed the extant literature showing that: (1) males and females have different networks, (2) cognition, and especially the encoding and recall of network information, can explain differences in networks, but there is a dearth of work linking cognition to differences in social networks between males and females, and (3) cognitive differences between males and females can be invoked, or increased, through priming sex. Based on these premises, we propose that males and females differ in the accuracy of their recall of social networks, and that these differences rely on, or are accentuated by, sex priming. We further propose that the structure of the target network and the type of relationships to be recalled will partially or fully explain differences in male and female recall accuracy.

There is little existing research to argue for a greater (or lower) accuracy of recall (rather than just different) between males and females. Yet, what does exist inclines us toward greater accuracy among women as compared to men. Females have been found to have larger networks than males (e.g., Moore, 1990), which implies that they have the cognitive ability to manage these larger groups. Additionally, prior work indicates that network perception is impacted by power and that individuals who are in low power positions (Simpson and Borch, 2005), or perceive themselves as having low power (Simpson et al., 2011a), have more accurate network recall. Because female has the lower value for the sex diffuse status characteristic (Ridgeway, 2001), females are likely to often be in the low power position and thus may have better network recall than males, or may have improved recall when they are primed on their sex.

- **Female-Sex Hypothesis:** Females are more accurate at recalling networks than are males.
- **Female-Priming Hypothesis:** Females who are primed on their sex are more accurate at recalling networks than are females who are not so primed.

While previous research indicates that triads are often used as schemata for learning networks faster or more effectively (e.g., Brashears, 2013; Brashears and Quintane, 2015; Janicik and Larrick, 2005), females are less prone to complete triads than males (Eder and Hallinan, 1978; Feshbach and Sones, 1971; Lewis et al., 2008). This may stem from differences in the types of games played in childhood, with males forming large groups for team sports and females forming dyads for imagination play. Regardless, the finding suggests that females may be less practiced with schemata implying, or relying upon, triadic closure than males. This in turn suggests that females are more accurate at recalling networks that are significantly or primarily composed of open triads. Alternatively, for females, priming on sex may make non-triadic, gender-linked schemata more cognitively available, and improve recall of networks that contain many open triads.

- **Triad-Sex Hypothesis:** Females are more accurate at recalling networks exhibiting open triads than are males.
- **Triad-Priming Hypothesis:** Females primed on their sex are more accurate at recalling networks exhibiting open triads than are females who are not so primed.

Previous research shows that relationship type can be a powerful schema for network recall (Brashears, 2013; Brewer and Yang, 1994). Females exhibit networks more centered on kin than males (Marsden, 1987), and this tendency is often exacerbated by life events that make male/female differences more salient, like the birth of a child (Moore, 1990; Munch et al., 1997). Moreover, research shows that oxytocin enhances perception of kin relations among females, but not among males (Fischer-Shofty et al., 2013). We might therefore expect that females are more adept at utilizing kin schemas than males, and that females primed on their sex will be more adept at using these schemas than females not so primed.

- **Kin-Sex Hypothesis:** Females are more accurate at recalling networks composed of kin relations than males.
- **Kin-Priming Hypothesis:** Females primed on their sex are more accurate at recalling networks composed of kin relations than are females who are not so primed.

4. Methods

4.1. Basic experimental design

Participants (235 female, 134 male) were recruited from among the undergraduate population of a mid-sized northeastern university in the United States using flyers and other direct solicitations. These participants were randomized into one of four experimental conditions with a minimum of 89 and a maximum of 97 participants per condition. Drawing on the method described in Brashears

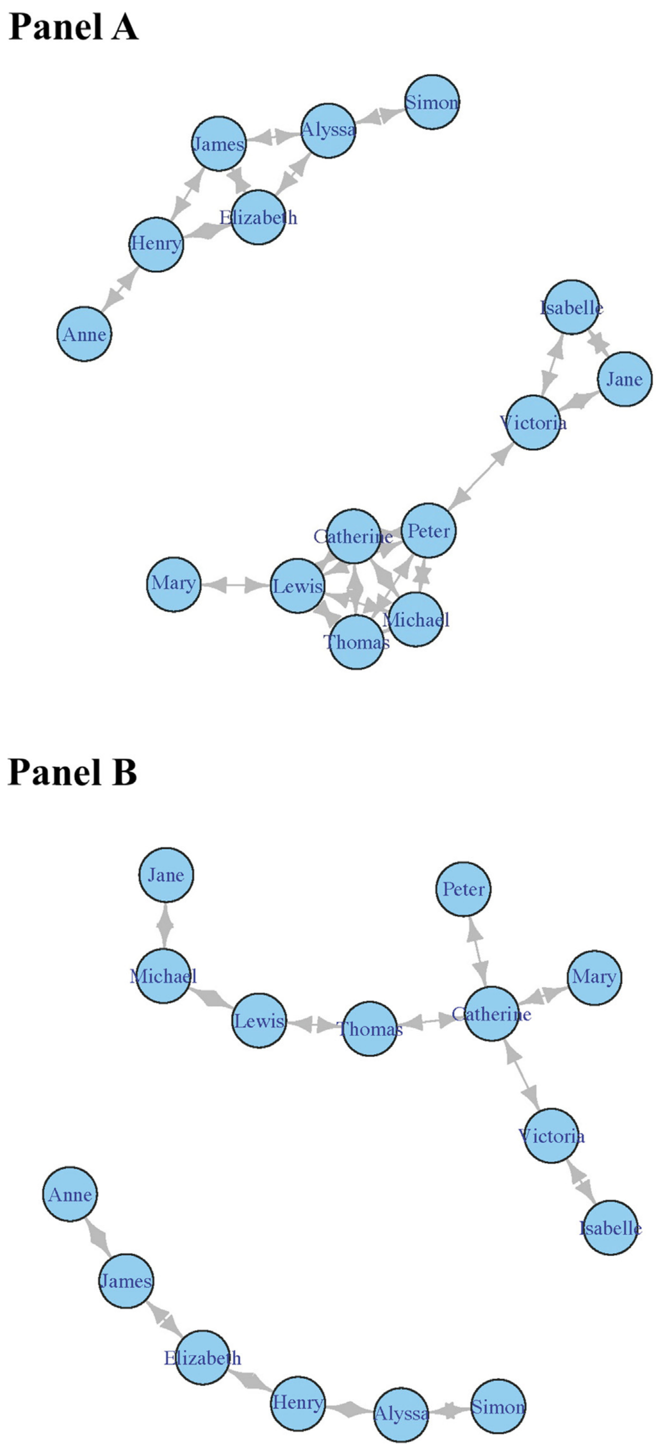

Fig. 1. Reducible (panel a) and irreducible (panel b) network structures.

(2013), all four conditions presented a vignette describing a network of relationships between fifteen individuals (e.g., "Henry is Alyssa's brother. Henry is also Elizabeth's son..."), and each vignette included a structural reducibility manipulation and a cultural schema strength manipulation. A network was reducible if it contained triadic closure[1] (Fig. 1a), while it was irreducible if it contained no closed triads (Fig. 1b). A network had a strong cultural schema if relations were described using kin labels (e.g., parent/child, brother/sister), and it had a weak cultural schema if the relations were described using non-kin recreational labels (e.g., friend, group member). Spouses were considered to be kin because they are fictive kin, because they often share genetic relationships to shared children, and because they represent a durable kin-like alliance. Females are hypothesized to be less sensitive to triads than males (Triad-Sex & Triad-Priming Hypotheses), and to be more sensitive to kin relations than males (Kin-Sex & Kin-Priming Hypotheses), making these manipulations appropriate. All vignettes contained two disconnected components (i.e., subgroups with no connections between them), and the strong and weak schema conditions used different relationship types (e.g., spouse, friend, etc.). The same number of relationship types were used in each vignette, the components did not vary in size by condition, and both characters and ties were presented in the same order in each vignette.

The vignettes in all conditions contained 15 nodes, but all reducible condition vignettes contained 46 reciprocated directed ties while all irreducible condition vignettes contained 26 reciprocated directed ties and no vignettes contained unreciprocated ties. Because the number of nodes was constant in all vignettes and the specified constraints were imposed (e.g., triadic closure), the vignettes in the reducible and irreducible conditions were forced to have unequal numbers of ties. The network size of 15 was chosen using research on working memory capacity (Reisberg, 1997) with the intention of stressing the participants; the number of individuals depicted exceeds the capacity of working memory by roughly a factor of two, and the potential number of relations (i.e., 210) is more than an order of magnitude greater.

Participants began the presentation phase by sitting at a prepared computer terminal and answering a series of simple demographic questions. A randomly chosen vignette was then presented as a paragraph of text and the participants were instructed to commit it to memory. Participants had unlimited time to study the vignette and were allowed to take notes, but knew that the notes would be confiscated before the recall phase. The amount of time spent studying the vignette was measured without the participants' knowledge. Once the participant finished studying the vignette, they completed a word span exercise (Daneman and Carpenter, 1980) with the experimenter. This both cleared the sensory and working memory stores, and provided a conventional measure of working memory acuity.

In the recall phase participants checked a series of boxes to indicate which characters had relations with each other and what types of relationships they had. The presentation order for the relationship presence items was randomized by respondent to prevent order effects. Finally, participants were compensated and debriefed. Participants were told that the amount of compensation (i.e., $6) was contingent on their success at recalling the vignette, but all participants who completed the experiment were compensated equally. The deception ensured that the participants were motivated to recall the information accurately.

The experiment typically required forty minutes to complete, and all participants completed it. Researchers were blind to respondent condition during data collection and all procedures were approved by the IRB.

4.2. Sex primes

The procedures described above are sufficient for most of our hypotheses, but cannot determine whether sex priming impacts the encoding and recall of social networks. After completing the demographic questions, but before presentation of one of the vignettes described above, our subjects were exposed either to a

[1] A closed triad occurs when three persons, A, B, and C, all have relationships with each other. An open triad results when one or more of the possible relationships between A, B, and C do not exist.

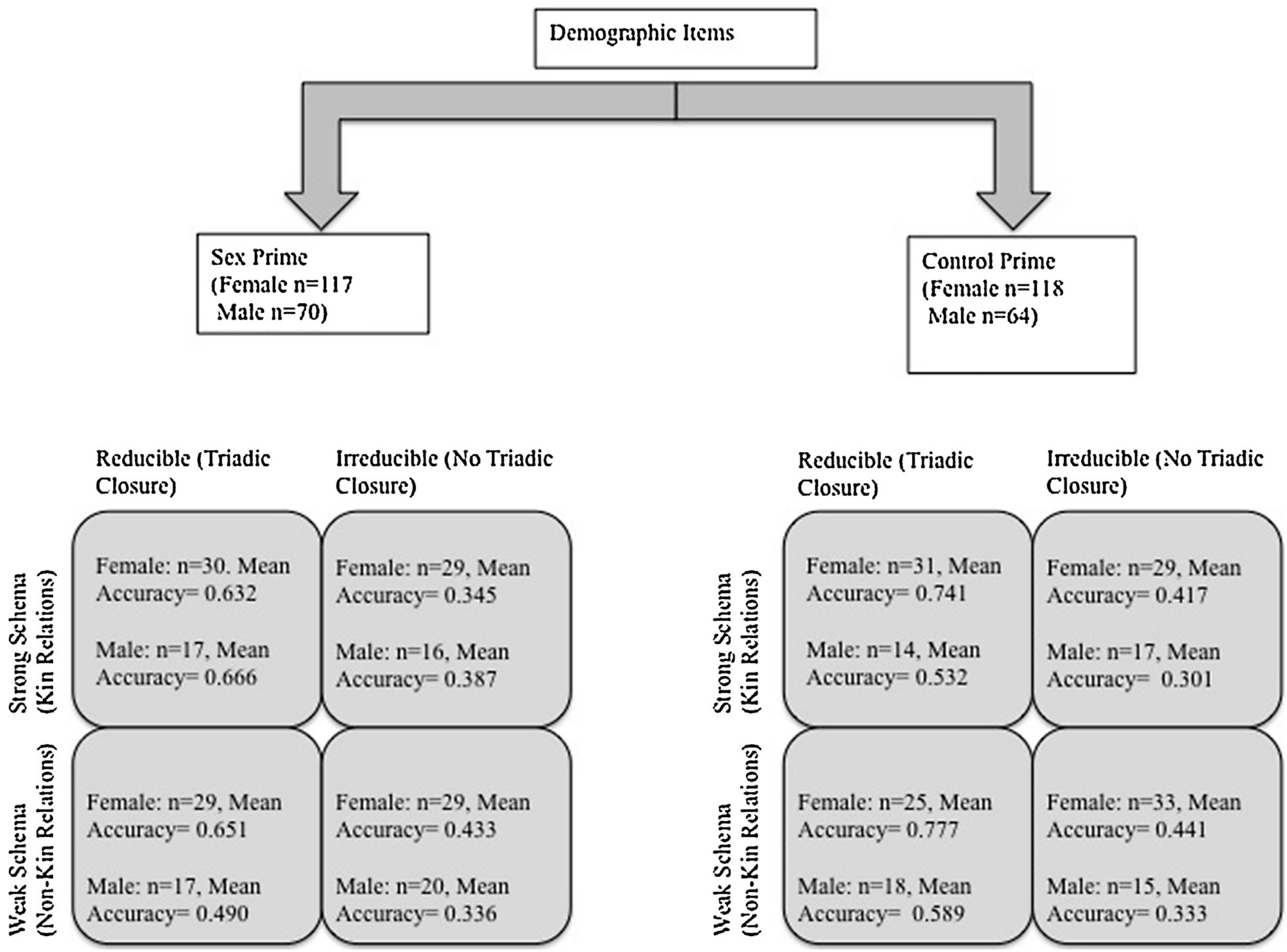

Fig. 2. Overall experimental design with per cell observations and mean accuracy levels.

sex prime, or a control prime, taken from past research (i.e., Shih et al., 1999). In the sex prime condition subjects were asked to give their opinions on living in same-sex versus mixed-sex housing. In the control prime condition subjects were asked for their opinions on the university phone and cable television services. The sex prime has triggered stereotype effects (i.e., situationally impacted cognition) in previous research (Shih et al., 1999), and is thus appropriate for our purposes. Subjects were randomized into either the sex prime ($n = 187$) or the control prime ($n = 195$) condition before being exposed to the vignette, and thus in total the experiment is a $2 \times 2 \times 2$ design. The final design is illustrated in Fig. 2.

We also included a manipulation check to confirm that the primes had worked as expected. Following recall of the network described in the vignette, the subject was asked to complete a series of ten math problems drawn from practice materials for the Graduate Record Examination (GRE). Subjects were informed that they had seven minutes to complete the problems and that their performance would be judged based on both the number of problems completed and on their accuracy. If the subject had not completed the problems by the end of seven minutes, the system automatically advanced to the next stage. Given past research (e.g., Shih et al., 1999; Steele, 1997), if sex primed females show a decline in mathematics performance then the manipulation was successful and its effects were felt throughout the network encoding, word span, and recall phases. We confirm the reducibility and schema strength manipulations by reproducing the effects in Brashears (2013); without distinguishing by sex or priming, a strong schema should exert a negative effect, reducibility a positive effect, and their interaction should be positive. The results of both checks are favorable (analyses omitted to save space), indicating that females primed on their sex exhibit significantly poorer math performance than non-primed females, and that there is no significant difference between primed and non-primed males. This confirms both that the sex prime was effective, and that its influence persisted throughout the study, word span, and recall phases. We can therefore reasonably expect to observe the effects of sex activation on network recall, if such effects exist. We also successfully reproduced the effects reported in Brashears, 2013, and therefore can be sure that the reducibility and schema strength manipulations are operating as expected.

4.3. Measures

To test our hypotheses it is necessary that we be able to quantify the quality of network recall. We use *accuracy*,[2] computed by multiplying participant precision[3] (i.e., correctly recalled ties divided by all recalled ties) by participant coverage (i.e., correctly recalled ties divided by all depicted ties), as our outcome variable. This measure equals one when the participant recalls all the ties depicted in the vignette, and only those ties, and is less than one when the respondent recalls less than the full number of ties, or recalls ties that were not depicted. This measure also compensates for the unequal number of ties by condition.

[2] This measure is identical to the measure called "performance" in Brashears (2013).
[3] This measure is identical to the measure called "accuracy" in Brashears (2013).

Several controls were also included. *Word span* is the participant's score on the working memory exercise and provides a conventional measure of general memory acuity, independent of the experimental task. *Time spent* is the number of seconds participants devoted to learning the vignettes. Because the respondents could spend as much time as desired, it is necessary to adjust for the effort they expended in learning the target networks. Respondents spent a mean of 538 s (i.e., roughly nine minutes) learning the network, with a standard deviation of 339 s (i.e., approximately six minutes).

5. Results

We begin by examining the differences between males and females. These models allow us to test our Triad-Sex, Kin-Sex, and Female-Sex hypotheses. We then estimate models contrasting sex-primed females with non-primed females, and sex-primed males with non-primed males. These models allow us to test our Triad-Priming, Kin-Priming, and Sex-Priming hypotheses. We then estimate an additional three models to examine whether the differences we detect can be attributed to variation in mean personality traits using the five-factor personality model. Finally, we discuss the results of exponential random-graph modeling to identify differences in male/female cognitive flexibility.

5.1. Males vs. females

We examine whether males and females differ in their skill at encoding and recalling social information and whether these differences are associated with either reducibility (i.e., triadic closure) or schema strength (i.e., kin vs. non-kin). All results comparing males directly to females are available in Table 1.

The results presented in Model 1 (Table 1) indicate that females appear to be significantly more accurate than males (0.077, $p < 0.007$), consistent with the Female-Sex Hypothesis. These results suggest that females are noticeably more accurate in recalling network information than males, even after controlling for the availability of compression heuristics, working memory capacity, and the amount of time spent studying the target network.

Model 2 includes interactions between female sex and each of the compression heuristic variables. Females continue to exhibit superior accuracy relative to males (0.111, $p < 0.040$), but none of the interactions are significant. Given the lack of significant interactions, we estimate a new model (Model 3) that eliminates the three-way interaction between female sex, reducibility, and schema strength, but retains all other effects. Female sex continues to exert a positive effect on recall accuracy (0.101, $p < 0.034$), but its interactions with both reducibility and schema strength remain non-significant. This indicates that the female advantage in network recall is not related to relative skill with either of these heuristics, and fails to support the Triad-Sex and Kin-Sex hypotheses.

Finally, we estimated a model identical to Model 1, but including an interaction effect between female sex and time spent. The results (Model 4) are consistent with earlier models, but roughly double the main effect of female sex (0.196, $p < 0.001$). Intriguingly, the model also indicates that females benefit *less* from additional time spent studying the vignette than do males (-0.0002, $p < 0.009$). In other words, these results indicate that females are not only more accurate than males at encoding and recalling social information, but that they do so while benefiting less from study time. This further supports a conclusion that females are more efficient than males at processing social information, and supports the Female-Sex hypothesis, while failing to support the Triad-Sex or Kin-Sex hypotheses.

5.2. Sex prime vs. Control prime

We next estimate a series of six models: the first three contrast sex primed females with control primed females, while the second three contrast sex primed males with control primed males. All priming results are available in Table 2.

Beginning with females, Model 5 shows that the main effect of sex priming is non-significant, suggesting that recall accuracy is not influenced by making one's sex salient. The time spent studying the vignette continues to improve recall accuracy (0.0005, $p < 0.001$) and respondent word span score has no significant effect. This implies that working memory capacity is not strongly related to female social network recall performance.

Model 6 adds interactions between the sex prime and the compression heuristics. The sex prime variable remains non-significant and none of its interactions with compression heuristics attain significance. We estimate a third model (i.e., Model 7) that drops the non-significant three-way interaction between sex priming, reducibility, and schema strength. However, the results are consistent with the previous two models: the main effect of sex priming, as well as its interactions with compression heuristics, are non-significant.

Moving on to males, in Model 8 the main effect of sex priming is non-significant, indicating that males who are made aware of their sex are no better at encoding and recalling social networks than males who are not so aware. However, both word span (0.036, $p < 0.049$) and time spent (0.0007, $p < 0.001$) exert a positive influence on recall accuracy.

Model 9 adds interactions between the sex prime and the compression heuristics. As before, the main effect of the sex prime is non-significant, as are its interactions with the compression heuristics. We estimate a final model (i.e., Model 10) that eliminates the non-significant three-way interaction between sex priming, reducibility, and schema strength. However, as with females, the results are consistent with previous models: sex priming, as well as its remaining interactions, have no significant impact on male recall accuracy.

In total, the results of these six models fail to support the Triad-Priming, Kin-Priming, or Female-Priming Hypotheses. Neither males nor females are impacted directly by making their sex salient, and salience does not appear to make triadic or kin-based compression heuristics more or less available for use. This strongly suggests that the female advantage in network recall identified previously is *not* situational in nature. Below we consider two alternate explanations for this effect: personality characteristics and differences in cognitive flexibility.

5.3. Sex, memory and personality

Females enjoy a recall advantage relative to males, but benefit less from study time than do males, and do not differ from males in the processing of triadic or kin-based schemata. So why is female network recall more accurate than male recall? Previous research (e.g., Casciaro, 1998; Emery, 2012; Kalish and Robins, 2006; Klein et al., 2004; Mehra et al., 2001) has identified associations between personality traits, network perception, and network structure. Moreover, males and females differ systematically in their typical personality traits (Costa et al., 2001; Weisberg et al., 2011). Therefore, differences in male and female recall success might disappear once personality is controlled.

To explore this issue we turn to data on the "Big Five" personality traits: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness (Digman, 1990; John et al., 2008). The Big Five have been shown to influence network structure and perception (Casciaro, 1998; Emery, 2012; Kalish and Robins, 2006; Klein et al., 2004), and are therefore appropriate for our purposes. Participants

Table 1
Regression models comparing male recall performance to female recall performance.

Model number: Group:	1 All	2 All	3 All	4 All
Reducible	0.186***	0.209**	0.195***	0.196***
	(0.038)	(0.061)	(0.051)	(0.037)
Strong Schema	−0.067~	−0.0298	−0.044	−0.068~
	(0.037)	(0.062)	(0.051)	(0.037)
Reducible * Strong	0.160**	0.132	0.161**	0.153**
	(0.054)	(0.089)	(0.054)	(0.053)
Female * Reducible		−0.036	−0.014	
		(0.078)	(0.055)	
Female * Strong		−0.058	−0.036	
		(0.077)	(0.056)	
Female * Reducible * Strong		0.046		
		(0.111)		
Word Span	0.029*	0.0298*	0.030*	0.029*
	(0.013)	(0.013)	(0.013)	(0.013)
Time Spent	0.0005***	0.0005***	0.0005***	0.0007***
	(0.00004)	(0.00004)	(0.00004)	(0.00007)
Female	0.077**	0.111*	0.101*	0.196***
	(0.028)	(0.054)	(0.047)	(0.053)
Sex Prime	−0.028	−0.027	−0.028	−0.038
	(0.026)	(0.027)	(0.027)	(0.027)
Female * Time Spent				−0.0002**
				(0.00009)
Constant	0.019	−0.005	0.002	−0.058
	(0.051)	(0.060)	(0.058)	(0.058)
R^2	0.46	0.461	0.461	0.471
N=	368	368	368	368

* $p < 0.05$, ~$p < 0.05$ one-tailed.
** $p < 0.01$.
*** $p < 0.001$.

in our study completed a brief Big Five personality trait inventory adopted from previous research (Goldberg, 1992). This inventory consisted of a series of twenty-five (five per trait) Likert scale items with item sequence randomized by participant to prevent order effects.

We estimated three models that duplicate Model 4 (Table 1), but with control variables added for the "Big Five" personality traits. The first model includes the controls for the Big Five traits for all respondents, the second does so for females only, and the third for males only. If the female recall advantage is due to differences in personality between males and females, then inclusion of these variables should render the female coefficient, the female interaction with time spent, or both, non-significant. The single sex models, in contrast, allow us to confirm that a sex priming effect is not being obscured by personality effects. All models are given in Table 3.

Table 2
Regression models estimating the effect of sex priming on male and female recall performance.

Model number: Group:	5 Females	6 Females	7 Females	8 Males	9 Males	10 Males
Reducible	0.187***	0.223**	0.229***	0.210***	0.247**	0.205**
	(0.050)	(0.072)	(0.061)	(0.055)	(0.081)	(0.0698)
Strong Schema	−0.082~	−0.065	−0.056	−0.041	−0.006	−0.049
	(0.049)	(0.068)	(0.059)	(0.056)	(0.082)	(0.070)
Reducible * Strong	0.158*	0.172~	0.159*	0.152~	0.063	0.152~
	(0.071)	(0.100)	(0.071)	(0.081)	(0.118)	(0.082)
Sex Prime * Reducible		−0.076	−0.089		−0.071	0.008
		(0.099)	(0.069)		(0.111)	(0.081)
Sex Prime * Strong		−0.04	−0.052		−0.068	0.015
		(0.097)	(0.069)		(0.113)	(0.082)
Sex Prime * Reducible * Strong	−0.025			0.169		
		(0.1395)			(0.161)	
Word Span	0.025	0.024	0.024	0.036*	0.036~	0.036~
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Time Spent	0.0005***	0.0005***	0.0005***	0.0007***	0.0007***	0.0007***
	(0.00005)	(0.00005)	(0.00005)	(0.00007)	(0.00007)	(0.00007)
Sex Prime	−0.034	0.031	0.036	−0.042	−0.013	−0.053
	(0.035)	(0.068)	(0.059)	(0.041)	(0.079)	(0.069)
Constant	0.157*	0.127	0.125	−0.095	−0.111	−0.087
	(0.064)	(0.069)	(0.067)	(0.072)	(0.084)	(0.082)
R^2	0.414	0.420	0.42	0.550	0.554	0.550
N=	235	235	235	133	133	133

* $p < 0.05$, ~$p < 0.05$ one-tailed.
** $p < 0.01$.
*** $p < 0.001$.

Table 3
Regression models evaluating the effect of the five-factor personality model on recall performance.

Model number: Group:	11 All	12 Females	13 Males
Reducible	0.206***	0.199***	0.228***
	(0.038)	(0.051)	(0.057)
Strong Schema	−0.073*	−0.093~	−0.038
	(0.037)	(0.049)	(0.056)
Reducible * Strong	0.157**	0.164*	0.153~
	(0.053)	(0.071)	(0.081)
Word Span	0.032*	0.027	0.042*
	(0.013)	(0.018)	(0.018)
Time Spent	0.0007***	0.0005***	0.0007***
	(0.00007)	(0.00005)	(0.00007)
Female	0.194***		
	(0.053)		
Sex Prime	−0.034	−0.029	−0.041
	(0.027)	(0.035)	(0.041)
Female * Time Spent	−0.0002*		
	(0.00009)		
Neuroticism	−0.020	−0.026	−0.013
	(0.012)	(0.016)	(0.0196)
Extraversion	−0.031*	−0.018	−0.057*
	(0.016)	(0.020)	(0.025)
Openness	−0.008	−0.014	0.0008
	(0.018)	(0.025)	(0.025)
Agreeableness	0.012	−0.0096	0.043
	(0.020)	(0.027)	(0.029)
Conscientiousness	−0.003	0.0004	−0.005
	(0.015)	(0.020)	(0.024)
Constant	0.127	0.429*	−0.007
	(0.129)	(0.173)	(0.195)
R^2	0.482	0.428	0.572
N=	367	234	133

* $p < 0.05$, ~$p < 0.05$ one-tailed.
** $p < 0.01$.
*** $p < 0.001$.

Examination of Model 11 reveals that of the Big Five traits, only extraversion exerts a significant effect, but this effect is negative (−0.031, $p < 0.048$), which runs counter to what we and previous research (e.g., Casciaro, 1998) might expect. Most critically, both the main effect of female sex (0.194, $p < 0.001$) and its interaction with time spent (−0.0002, $p < 0.016$) remain significant and of the same direction and magnitude as in Model 4 (Table 1), while the main effect of the sex prime manipulation remains non-significant. In other words, controlling for personality traits has no effect whatsoever on the apparent female advantage in network recall.

The female-only results (Model 12) are consistent with this overall conclusion; in this case, none of the Big Five traits are significant, but neither is the main effect of the sex prime manipulation. As such, it appears to be highly unlikely that any of the Big Five personality traits account for the lack of effect from the sex prime for females.

Lastly, the results for males-only (Model 13) are also consistent with previous findings; of the Big Five traits, only extraversion exhibits a significant effect (−0.057, $p < 0.023$), but this effect is negative. Finally, the main effect of the sex prime remains non-significant for males.

Given the above results, it appears to be highly unlikely that the female advantage in network recall relative to males, or the lack of effect exerted by the sex prime, can be attributed to differences in personality as captured by the Big Five.

5.4. Cognitive flexibility

Finally, we investigated whether males and females display different levels of cognitive flexibility. Recent research (Brashears and Quintane, 2015) has shown that when asked to remember a social network, respondents were able to use heuristics corresponding to different microstructural features (i.e., triads and groups) depending on the information contained in the network. The female recall advantage identified previously may therefore result from greater skill at identifying and employing the most appropriate heuristic for a given network.

We explored this possibility empirically using Exponential Random Graph Models (ERGMs – Lusher et al., 2013) to capture the micro-level structures that characterize the recalled networks. More specifically, our models enable us to detect consistent tendencies toward specific types of recall errors. These consistent errors allow us to infer whether there is a systematic tendency to use dyads, triads or groups as a primary heuristic to encode the network in memory and, in turn, to determine if this tendency varies by sex.

We carried out two different analyses of cognitive flexibility. First, we used the statnet package in R (Handcock et al., 2014) to model each respondent's network, using terms for dyad, triad and group encoding, and while controlling for the network to be recalled. We then counted the number of significant edges, triads or group parameters across the models, distinguishing by condition (i.e., Male/Female, Primed/Non Primed) to determine if males and females used different heuristics to recall the networks. Our results (omitted to save space) show no evidence for the use of different recall heuristics between males and females or between primed and non-primed respondents. As such, the female network recall advantage does not appear to derive from more flexible or appropriate use of heuristics.

Second, we created a series of consensus networks for each condition in the manner of Brashears (2013), Krackhardt (1987), and Brashears and Quintane (2015). In each network, ties are considered to exist if a specified percentage (i.e., consensus level) or more of the respondents agreed that it existed. For example, for a tie to exist in a 5% consensus network, at least 5% of respondents need to have mentioned it in their answers. Because recall accuracy is, in general, quite high these consensus networks provide a more effective way to capture consistent error types and allow us to examine the networks at different levels of sensitivity. Because consensus networks above 25% do not have ties that deviate from the network to be recalled (they have missing ties, but no additional ties), we generated five consensus networks (5%, 10%, 15%, 20% and 25%) for each combination of conditions (i.e., Reducible/Irreducible × Male/Female × Sex/Null Prime). We obtained a total of 40 networks and estimated an ERG model in PNet (Wang et al., 2006) for each network using terms that represent dyads, triads and group heuristics while controlling for the network to be remembered. As above, the pattern of significance of the ERGMs failed to reveal any specific difference between male and female, between primed female and non-primed females and between primed males and non-primed males regarding their use of specific heuristics to recall the target network. Thus, once again, we do not identify any evidence that the female recall advantage is derived from differences in cognitive flexibility.

6. Discussion

Males and females typically inhabit different networks, but the reasons for this are unclear. One possibility is that males and females experience different opportunities and constraints when building and maintaining networks, leading to their different end configurations. Alternatively, males and females may pursue different networks because they prefer different configurations. In this paper, we exposed a third line of explanation, and suggested that these outcomes result in part from different fundamental understandings of how the network is structured.

Our primary finding is that females exhibit superior recall of social networks relative to males, and this advantage is quite substantial. The results from Model 4 (Table 1) indicate that, if recall accuracy were rated from 0% to 100%, being female is sufficient to improve one's score by almost twenty percentage points. Moreover, while both males and females benefit from studying the network for longer periods of time, females benefit less than males. This suggests that females encode and recall social information more efficiently than do males. We have therefore uncovered an additional explanation for the observed differences in male and female networks: females typically have larger networks than males in part because they are able to cognitively manage these networks more reliably. While this certainly does not indicate that structural availability and preferences are irrelevant to network composition, it does strongly suggest that at least some of the differences between males and females derive from cognition. We have therefore provided evidence for a third, and previously unstudied, explanation for sex differences in social networks.

Previous research suggests that females should be more adept at managing networks with many open triads, and more skilled with networks composed of kin. However, our models failed to identify any differences between males and females in recall success based on these attributes. Therefore, while females do appear to recall networks more efficiently than males, this advantage does not stem from their skill (or lack thereof) with the tested compression heuristics.

Because sex is frequently activated in, and relevant to, interaction, it is reasonable to ask whether priming sex could impact network encoding and recall. Our results indicate unequivocally that while our sex prime was effective, it had no effect on the recall of social network information. This suggests that the female recall advantage does not stem from cultural expectations that females are superior at this task, or other forms of situational cognition directly determined by sex.

Personality traits are associated with network perception and network structure, and females and males systematically differ in their typical personality traits, so the female network recall advantage could simply be the result of different typical personalities. However, even when we controlled for the Big Five personality traits, we continued to observe a significant association between female sex and network recall. Moreover, the smaller benefit females reap from study time is unchanged.

Finally, previous research has demonstrated that humans are able to flexibly adopt the most appropriate encoding method for a given network. We therefore used ERG models to determine if the differences between males and females were rooted in preferences for different microstructures. However we identified no significant differences in the microstructures selected by males and females.

In summary, we find that females are markedly superior to males in recalling social network information and that this superiority cannot be accounted for using priming effects, differences in the use of compression heuristics, working memory capacity, personality traits, or cognitive flexibility. Somewhat reluctantly, we are forced to suggest that this may reflect an underlying neurological difference between the sexes. There is a growing awareness that social science must take biology into account (e.g., Freese et al., 2003; Hopcroft, 2005, 2006; Yamagishi et al., 2003) and we agree that biological and neurological explanations for social phenomena should receive more attention (e.g., Todorov et al., 2011). Nevertheless, it seems more likely to us that circumstances shape males and females such that females develop a relatively greater ability to encode and recall social networks. In general, psychological research on gender difference is more consistent with overall similarities than distinctiveness (see Hyde, 2005, 2014; Joel et al., 2014). Moreover, neurological research shows that mean differences in brain structure between the sexes are smaller than the variations within-sex (Joel, 2012). Previous research showing that low power actors have superior network knowledge (Simpson and Borch, 2005; Simpson et al., 2011a) is consistent with, and may explain, our results without the need to assume fundamental differences between males and females, and this possibility is worthy of further study.

The female advantage in network recall suggests that the differences in male and female networks may be partially determined by cognition. At a minimum, the female superiority in network recall could allow them to cognitively manage larger networks than males, and therefore in times of need they should often have deeper reserves of social capital to draw upon. Similarly, females may be better able to sustain the cognitive demands imposed by bridging positions in a network (e.g., Burt, 1992, 2002), and thus may be more effective brokers than males, though a lack of legitimacy in many organizations may make it difficult to capitalize on this advantage (Burt, 1998). However, while research shows that individual low power actors can benefit from their superior network knowledge, possession of equally good network knowledge by all low power actors tends to produce negative outcomes (Simpson et al., 2011b). The improved knowledge allows all low power actors to recognize and attempt to take advantage of opportunities, thereby increasing the competition between them. Additionally, more efficient encoding and recall of social networks does not automatically result in superior network knowledge or the ability to translate awareness into action. Future research will be necessary in order to fully understand the connections between the female recall advantage and realized network structure.

7. Conclusion

We began by asking how sex impacts network recall. Our results indicate that females are superior at recalling social networks relative to males, supporting our argument that sex differences in realized networks may derive from cognitive, rather than preference or structural, variability. Moreover, the female recall advantage does not derive from differences in compression heuristic use, working memory, sex priming, personality, or cognitive flexibility. To our knowledge, this paper is the first to demonstrate this effect and it is an important start to a new avenue of research.

Future efforts should cluster in two key areas. Researchers should endeavor to determine why females are superior to males in recalling social networks. One obvious possibility is that females are often in lower power positions, and lower power is associated with improved network awareness. Alternatively, because women often direct different types of ties to different types of alters so as to balance homophily with instrumental benefit (e.g., Burt, 1998; Ibarra, 1992, 1995), it may be that women are more practiced with understanding and encoding complex network structures than are men. More generally, it may well be that whenever individuals must divide their ties across multiple semi-overlapping groups they develop superior network recall. Additionally, future research should attempt to identify the specific consequences of superior network recall. Like the Cassandra of Greek mythology, who could see the future but not avert it, females may often be able to perceive their social environment more accurately, without necessarily being able to derive benefit. However, even if they cannot benefit, a greater ability to recall networks may help to explain network structure at a large scale.

Our initial results are clear and fascinating. Females are substantially better at encoding and recalling social networks, even when controlling, both experimentally and statistically, for a wide variety of other factors. Uncovering the reasons why can only add both to our knowledge of social networks and to our understanding of sex.

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