Article

When Majority Men Respect Minority Women, Groups Communicate Better: A Neurological Exploration

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Abstract

Groups must leverage their members' diverse knowledge to make optimal decisions. However, the gender composition of a group may affect this ability, particularly because solo status female members (one female grouped with males) are generally allocated lower status than their male counterparts, so their knowledge is more likely to be ignored. Whereas most previous work suggests ways solo status women can increase their status; instead, we propose that groups communicate better when men give their female teammate appropriate respect. We examine this in mixed-gender groups working on a hidden profile task while wearing wireless EEGs to measure live neural activity. We find that groups who solve the problem correctly are more likely to contain majority male members with more approach-oriented mindsets, operationalized as neural alpha asymmetry, as they respect their female teammate more. Thus, we provide evidence that neural activity is partially responsible for whether mixed-gender groups make optimal decisions.

Keywords

group decision making, gender, approach motivation, alpha asymmetry, hidden profile

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Groups are naturally composed of individuals with different backgrounds, abilities, and expertise (McGrath et al., 2000). This diversity is purported to be beneficial since it allows groups to draw from large information pools to solve the complex problems they face (Mathieu et al., 2019). Yet, groups often ignore the unique expertise of their members in favor of information all members have in common, resulting in suboptimal decision-making (Lu et al., 2012; Stasser & Titus, 1985, 2003).

Much of the work exploring this prevalent effect comes from the hidden profile paradigm (Lu et al., 2012; Mesmer-Magnus & DeChurch, 2009), which we adopt here. In it, task information is distributed such that there is a common set of information all group members can access and a secondary set of information that is unique to each group member. Importantly, in hidden profile tasks, the common information favors a suboptimal decision alternative. Thus, the group can only make an optimal decision when members share their unique information and apply it to the collective decision (Stasser & Titus, 1985, 2003). As such, the information needed to make an optimal choice is "hidden" from the group until they combine their unique information. Because of this, the hidden profile paradigm has become prominent in the group decision-making literature. It allows exploration of when groups are able to combine the unique expertise of their members to discern an optimal problem solution.

However, because in this paradigm unique information necessarily goes against the narrative established by the information all group members hold in common, sharing it may incur social costs (Stasser & Titus, 2003). Particularly, group members often attempt to persuade those with information not supporting opinions of the majority of group members to join the group narrative and may even show hostility toward those sharing such information or ostracize them from further group discussion (Marques et al., 2002; Mojzisch et al., 2014). In this case, group members must take extra effort to establish their unique information as credible and relevant. This effort acts as an additional cost of sharing unique information (Stasser & Titus, 2003).

One must also consider that sharing unique information eschews the benefits of sharing information supporting the common narrative. As one's teammates generally prefer to engage with information that is consistent with their own preferences (Bragaw & Misangyi, 2022; Faulmüller et al., 2012), they are more likely to validate such information and evaluate those sharing it more positively (Wittenbaum et al., 1999). Thus, sharing unique information forces the sharer to defend his or her credibility and give up the benefits of sharing information supporting the collective preference. Alternatively, sharing common information supporting the preferred narrative allows group members to feel valued and understood by their group (Faulmüller et al.,

2012). Because of these feedback mechanisms, group members share common information more often than critical unique information when making collective decisions (Lu et al., 2012; Stasser & Titus, 2003). As Stasser and Titus (2003) reflect, "social costs are often too risky for lower status members, who are likely to drop [sharing] unique information like a hot potato" (p. 308). This occurs because unique information is seen as inherently risky, as it cannot be validated by one's teammates (Stasser & Titus, 1985) and often stands counter to their established narrative (Mojzisch et al., 2014).

Here, we posit that certain individual characteristics may attenuate or exacerbate this information sharing bias. Particularly, we suggest that women with solo status, who are the only female members of their group (Viallon & Martinot, 2009), face a double-burden in sharing their unique expertise. First, because women are generally allocated less social status than men (McClean et al., 2018), defined as the extent to which one is respected or admired by others and held in high regard (Magee & Galinsky, 2008), and sharing unique information carries a social risk, we expect solo status women to be more hesitant to participate in group discussions and share their unique knowledge. Moreover, this tendency may be exacerbated by social identity threat, that is, a situational stressor that arises when stigmatized individuals are placed in contexts where their stigmatized identity is primed. Women often face social identity threat in task groups when they are outnumbered by men (Inzlicht & Ben-Zeev, 2000; Steele et al., 2002). The discomfort faced by individuals experiencing social identity threat can present a host of downstream consequences like inefficient cognitive processing (Liu et al., 2017; Steele & Aronson, 1995), decreased working memory capacity (Forbes & Schmader, 2010; Schmader & Beilock, 2012; Schmader et al., 2008), and heightened stress and anxiety (Steele et al., 2002).

Second, when women are able to overcome this social risk and social identity threat to offer their expertise to the group, it may not be accepted by their male teammates since the unique knowledge of low status group members is often seen as unlikely to help the group succeed. Although unique information cannot be validated by one's teammates (Stasser & Titus, 1985) and often stands counter to their established narrative (Mojzisch et al., 2014), when unique information is offered by high status group members, they are often given the benefit of the doubt, since they are generally seen as competent and benevolent (Anderson & Kilduff, 2009). However, when the same information is offered by low status group members who do not garner the same respect, the possibility that the information may be incorrect or selfish (as these attributions are associated with lower status, Anderson & Kilduff, 2009) and thus harm the group's decision, is seen as too high and the information is often discarded (Mojzisch et al., 2014). Importantly, this neglect

has significant implications for group information processing and decision making. When members' unique information is undervalued or ignored, it dilutes the information pool groups rely on to make effective decisions (Stasser & Titus, 2003). It also restricts group information processing by neglecting these information sharing and information elaboration attempts (Emich & Vincent, 2020; West et al., 2003). Finally, it makes it less likely group members will speak up with unique information in the future (Mojzisch et al., 2014).

We suggest that the key to overcoming this tendency, and the disadvantageous information restriction associated with it, is for majority male group members to allocate appropriate status (i.e., respect) to their minority female teammates. One clear way to achieve this is to more optimally manage the risk perceptions associated with the unique information she shares. It is paramount to recognize the potential benefits of incorporating her knowledge into the group discussion, instead of the potential drawbacks of hearing new, uniquely held, information.

The extent to which majority males are approach-oriented (as opposed to avoidance-oriented) may be one means to facilitate this end. Approach and avoidance motivation represents two predominant motivational states regulating whether people direct their behavior toward positive outcomes (approach) or away from negative outcomes (avoid; Elliot & Thrash, 2001). Those group members with an avoidance orientation are likely to avoid risky information, which has the potential to derail the decision-making process. Alternatively, group members with an approach focus concentrate on maximizing positive outcomes, even if they involve risk (Elliot & Thrash, 2001). As such, majority males with an avoidance orientation are likely to eschew the risky unique information of their low status female teammates. However, approach-oriented majority males are likely to instead concentrate on the potential benefit of incorporating novel information into the group decision-making process. As a result, we predict that when majority males are approach oriented, they will value their female teammate's unique information to a greater degree and subsequently allocate her more status, facilitating healthier group information sharing.

We test these propositions in an experimental study where we manipulate the gender composition of groups and measure members' approach and avoidance motivation on-line, while they interact during a group hidden profile decision-making task, via their brain alpha asymmetry patterns (using Electroencephalograms [EEGs]; Coan & Allen, 2003). In doing so, we aim to contribute to the group decision-making literature in three ways. First, by providing evidence that men and women are respected differently when experiencing solo status. Second, by providing evidence that this difference

in status allocation negatively affects the group's tendency to exchange task-relevant information. And third, by providing evidence that majority group members' approach versus avoidance motivation interacts with social perceptions of gender to affect group decision making. Particularly, when majority males are approach-oriented, we expect they are more likely to allocate status to female minority members, positively affecting the group's ability to exchange information and make effective decisions.

Status and Group Member Information Sharing

Status characteristics theory, a branch of broader expectation states theory, suggests that intragroup status perceptions develop quickly based on salient and socially significant individual characteristics (Berger et al., 1972; Magee & Galinsky, 2008). This status differentiation has important implications for group decision making, since the ubiquity of social status is often attributed to its functional value in distributing scarce resources among individuals and in facilitating the coordination of individual effort (Blau, 1972). High-status group members have room to take risks, to speak more, and to have greater influence over group decisions (Berger et al., 1980; Wittenbaum & Bowman, 2005). Low-status members participate less and focus on less risky information when they do participate (Bonito & Hollingshead, 1997). In hidden profile tasks, risky information includes the sharing of unique information (i.e., information that only one group member possesses) since this information goes against the majority group opinion. In these instances, teammate reactions to unique information are relatively unknown (Stasser & Titus, 2003). Low-status group members present less unique information to the group because, although unique information can be repeated by other group members, it cannot be corroborated (Stasser & Titus, 2003). Thus, it has little potential to allow low status group members to build credibility and increase their status. However, it has great potential to be challenged by higher status members (Stasser & Titus, 2003). Ultimately, these considerations result in a positive relationship between one's social status in a particular group and the amount of unique information they share.

Gender and Group Member Status

One of the most basic and culturally meaningful characteristics used to allocate group member status is gender (Ridgeway, 2001), especially when gender is linked to group task demands (Ayman & Korabik, 2010). Men are stereotypically thought of as more agentic and competent, whereas women are stereotypically considered more reactive and communal (Ellemers, 2018). In goal-directed

tasks, such as group decision making, groups prioritize perceptions of agency and competence. Members perceived to act independently and competently are allocated more status. Indeed, research has confirmed that men are generally conferred more status than women across a variety of contexts (Eagly & Wood, 1982; Fiske et al., 2002) and are more often put in group leadership positions because their behavior is seen as more legitimate (McClean et al., 2018).

In combination, this work from the status and gender literatures indicates that women may have a hard time speaking up in decision-making groups because of the status their teammates allocate to them. This tendency may be exacerbated when they are the only minority member in a group of men, that is, experiencing solo status. While experiencing solo status, minority members, especially female minority members (who may be negatively stereotyped in group decision-making contexts), are susceptible to identity threats when working in a domain where performance is measured explicitly. Such identity threats often have the ironic consequence of perpetuating and reinforcing the lower status allocated by their peers (Emerson & Murphy, 2015; Sekaquaptewa & Thompson, 2003; Shapiro & Williams, 2012). Alternatively, when men experience solo status, we predict that it does not necessarily reduce the status allocated to them by their female teammates since the stereotypes associated with the male gender role (agency and competence) match standards for ideal group decision-making behavior (Eagly & Wood, 1982; McClean et al., 2018). Based on this reasoning, we hypothesize that:

> H1: Male solo status group members will be allocated higher status by their teammates than female solo status group members.

The Effect of Information Sharing on Majority and Minority Member Status

In addition to being hesitant to share unique information, female solo status group members may face an additional burden: When they do speak up, sharing unique information may harm the status they have accumulated. The root of this phenomenon stems from the risky nature of unique information discussed. This risk indicates that unique information has a certain probability of benefitting the group and a certain probability of being irrelevant or even actively harming the group discussion. This could occur by derailing the prevailing narrative (Mojzisch et al., 2014). Because of the lower status associated with female solo status members, the unique information they share is more likely to be interpreted as irrelevant or harmful to the group. This occurs because, in groups, status signals competence and benevolence (Anderson & Kilduff, 2009). As such, members with high status are generally attributed

these characteristics during group interactions, while members with low status are denied these attributes (Hardy & Van Vugt, 2006; Swencionis & Fiske, 2016). For example, information volunteered by dominant group members is generally seen as more competent, even if those members do not have more knowledge or expertise than their teammates (Anderson & Kilduff, 2009). These status-based information attributions help to maintain social status and streamline information sharing in groups; however, they also create a double burden for low status members, such as female solo status group members. Not only are they less likely to speak up because they are aware of the associated social risks of doing so; when they do speak up, their unique expertise is less likely to be seen as competent and benevolent, further threatening their social status. As such, we predict that:

> H2: Unique information sharing and status will be negatively related for female solo status group members, such that their male majority teammates will allocate them less status the more they share unique information.

These potential information sharing biases present a conundrum: Solo status women are not likely to speak up in their group. However, to realize the benefits of group decision making—which rely on combining diverse knowledge, information, and perspectives (e.g., Van Knippenberg & Schippers, 2007), particularly in hidden profile tasks (Lu et al., 2012; Stasser & Titus, 1985)—all members must contribute to group decisions.

When one member is ignored, or afraid to speak up, their knowledge cannot be combined with their teammates' knowledge to produce novel solutions (West et al., 2003). Additionally, often, bringing up different perspectives during group decision making forces groups to integrate and elaborate on that knowledge (Emich & Vincent, 2020; Jehn & Mannix, 2001). Thus, when group members are excluded from collective decision making, group discussions involve less knowledge seeking, less knowledge sharing, and less information elaboration (Mell et al., 2014). Together, we term knowledge seeking, sharing, and information elaboration "group decision-making involvement" because, in line with other considerations of involvement, these behaviors signal that the focus of the group's attention is the decision-making process (Duda & Nicholls, 1992; Nicholls, 1984). Because teams with more ignored members have a less involved decision-making process, we expect teams in which solo status females garner little respect to have less involved problem-solving conversations than teams in which all members are respected:

> H3: Groups with female solo status female members have a less involved group decision-making process than groups with male solo status members.

Overcoming Information Sharing Bias—Respecting Female Minority Members

Traditionally, solutions for overcoming a lack of respect are pinned squarely on the women who are not receiving appropriate status for their group contributions (e.g., Sandberg, 2015). However, because it is majority males who are responsible for allocating appropriate status to their solo status female teammates, the onus for dealing with this issue may lie on the majority males, since high-status members are given the latitude to generate social change within their groups (McClean et al., 2018; Ridgeway & Diekema, 1992). First, majority members can ease the tension on solo minority members by allocating them status. Showing respect for female solo minority members should encourage them to participate more and allow them to feel comfortable sharing riskier unique information (Wittenbaum, 1998, 2000). Additionally, the positive and accepting social atmosphere generated by this allocation has been linked to the expression of dissident minority information (Hackman, 1987). When a minority member is granted status equal to the majority members, groups can perform better because demographic differences signal informational differences which can be drawn out to make more optimal collective decisions (Van Knippenberg & Schippers, 2007). This technique has been demonstrated successfully in multiple scenarios, specifically in the jigsaw classroom (Perkins & Saris, 2001). Here, performance is increased in groups by granting each group member a specific job to complete or topic to study, essentially making them an "expert" in their respective job or topic. Thus, all group members have equal status, must rely on one another, and thus must contribute in order for the group to succeed.

Still, group information processing is reciprocal. Sharing unique information does not necessarily mean that information will be acknowledged and drawn into a final group decision (Hinsz et al., 1997). Majority members' approach or avoidance motivation may play a vital role in whether minority information draws the attention of the group, is responded to, and is incorporated into the group decision. Because group members high in approach motivation are more likely to take risks to achieve a positive outcome (Elliot, 1999; Elliot & Thrash, 2002), we predict that they will be more likely to attempt to use their low-status minority teammate's information to further the group discussion, despite the risk inherent in accepting information from a low-status teammate (Bonito & Hollingshead, 1997). Alternatively, we predict that group members with higher avoidance motivation will be more likely to refuse to acknowledge their low-status teammate's contributions in favor of information provided by safer high-status members since they are motivated to avoid any risk that may be associated with new information. In

sum, we draw on status characteristics theory to predict that men and women will experience solo status differently. Solo status women's information will likely only be drawn into the group discussion if their male teammates are approach-oriented and thus able to overcome the social stigma associated with the female gender role. Conversely, solo status men's information is more likely to be integrated regardless of their female teammates' approach versus avoidance motivation. Formally, we hypothesize that:

> H4: Male members of male majority groups who make better decisions will exhibit a more approach-oriented mindset, as indicated by greater left-lateralized alpha asymmetry during group interaction, and thus allocate greater status to their solo minority female teammates.

The Neurological Basis of Approach and Avoidance Motivation

Measuring approach or avoidance motivation can be done in a variety of ways. Previous work has employed self-report measures using myriad Likert scales to assess approach or avoidance motivation (Elliot & Thrash, 2002). Yet, in group decision making, where approach or avoidance motivation may be critical for information sharing in the moment, self-report measures are not ideal as individuals are surveyed before or after information sharing takes place. Thus, they are intrusive to the natural group process and may prime motivation-oriented demand characteristics implicitly (Wang et al., 2021).

One way to align the measurement of information sharing and motivation is by using an in the moment measurement of approach and avoidance motivation. Previous research has employed the help of live neural recordings to do just that (Kelley et al., 2017; Lacey & Gable, 2021; Vecchio & De Pascalis, 2020). An abundance of literature in cognitive neuroscience has directly mapped the degree of large scale neural coordination at specific frequencies (termed power) in the prefrontal cortex—a hub for higher order cognitive processes including executive function, self-regulation, and motivation—to both state and trait-based approach and avoidance motivation.[1] Specifically, it is the power in the left prefrontal hemisphere in relation to the right prefrontal hemisphere, or asymmetry, that is the best correlate and predictor of approach versus avoidance motivation.[2] Frontal asymmetry, as it is most often referred, is frequently assessed using electroencephalography (EEG) to examine greater relative left or right frontal activity (Coan & Allen, 2004; Gartstein et al., 2020; Harmon-Jones, 2006; Schutter & Harmon-Jones, 2013). Meta-analysis has shown that greater relative left-frontal activity is associated with approach motivation, while greater relative right frontal

activity is associated with avoidance motivation (Harmon-Jones & Gable, 2018). Thus, employing EEG methodology to measure approach and avoidance motivation through frontal cortex activity asymmetry provides a solution for measuring these constructs in the moment.

Method

We tested our hypotheses in a single study of mixed-sex triads (three-person groups) solving a hidden profile murder mystery task (see Stasser et al., 1995). We manipulated the triads to be either majority male or female and tracked group member brain activity using independent wireless EEG systems, placed on each group member. EEG systems record live neural activity by measuring electrical charges that result from cellular activity in the brain, through sensors placed on the scalp. We can transform and analyze these signals to observe whether particular brain areas are active during a task. This design allows us to observe naturalistic group interactions. It also provides a means to unobtrusively record EEG signals from each group member throughout, as past research has demonstrated with similar wireless EEG systems (Dikker et al., 2017). We determined sample size before any data analysis occurred by requesting the maximum amount of students possible from our department subject pool. This allowed us the opportunity to ensure our design was as well powered as possible. We report all measures, manipulations, and exclusions.

Participants

One hundred forty-seven undergraduate business students (70 women, 77 men; 108 Caucasian, 8 African American, 15 Asian, 4 Latino/Latina, 2 Mixed Race)[3] participated in this study to complete their research requirement. These participants were divided into 49 triads, 28 of which were majority male (two men and one woman), and 21 of which were majority female (two women and one man). No group members knew each other previously. All triads interacted in person. All triads were also told that the group task would be diagnostic of their group intelligence. All instructions and tasks were identical across groups. Thus, the only difference between triads was gender composition.

Procedure

Researchers randomly assigned participants to either a majority male or majority female triad before entering the laboratory. After entering the laboratory,

participants were seated at individual computers where they were given task instructions. They were told that their task was to solve a murder mystery with their group. First, they independently read the task script, entitled "The Case of the Fallen Businessman" (see Stasser et al., 1995). Each script contained 21 pieces of information related to the fictional murder of a prominent businessman. This information was given in the form of newspaper articles and interviews surrounding the case. Of these 21 pieces of information, 18 were common, such that they were present in each group member's script. However, each script also contained three pieces of unique information. These nine pieces of unique information (three per member) were only known by one member of each group. (Participants were unaware that each script contained unique information.) Importantly, these unique pieces of information were crucial for deriving the correct answer. In this way the task was set up as a hidden profile (Stasser & Titus, 1985, 2003), where each triad member would have to share their unique information to logically discern the murderer.

Participants were given 20 min to individually read the script and take one page of notes. After reading the script, scripts were returned to the experimenter. Participants were able to bring their page of notes to the group discussion to discuss and show other participants (Emich 2012, 2014). After reading the script, participants were put in their triad and set up with a wireless EEG head cap. Before groups could discuss their information, they were told that this group task was diagnostic of the participant's problem solving and analytic skills, similar to that of the math portion of the GRE. In addition to informing participants that the group task would be diagnostic of their intelligence, they also marked their gender, thus making gender salient and presumably priming identity threat and the expectation of stereotypical differences between men and women in the supposed evaluative context of the present study (Ganley et al., 2013). Groups were given up to 25 min to come to a unanimous decision as to whom the murderer was (of three preselected suspects). The average length of discussion was 13.2 min. Once the group task was complete, but before the group knew if they selected the correct suspect, participants returned to their individual computers to complete a post-task questionnaire regarding group social status and peer ratings. The group's solution was also recorded. We chose this task because it requires groups to communicate effectively to come up with the correct answer and, as compared to other hidden profile tasks, there is an objectively correct answer (Lu et al., 2012).

Measures

Status. After the task, and before participants knew whether they chose the correct suspect, participants completed a status measure. Because status is

defined as the level of respect and admiration allocated to a given group member (Magee & Galinsky, 2008), we used a round-robin approach to measure status where each member rated the extent to which two items were characteristic of each other group member on a seven-point Likert scale (1 = *completely uncharacteristic*; 7 = *completely characteristic*). The two items are: (a) S/he had a high level of respect in our group's eyes; and (b) S/he is held in high regard by our group (McClean et al., 2018). These items were adapted from Anderson et al. (2012) and averaged to form a composite status measure ($r = .89$).

Group Information Coding. To determine who shared what information, all group interactions were recorded and transcribed. Three undergraduate research assistants were trained to identify the common and unique information in each group transcript. After being trained to a 100% consensus (because of the objective nature of the information shared being common or unique), coders read through the transcribed group conversations and marked down how many times a group member mentioned their unique or common information. Unique and common information mentioned was operationalized as the total mentions of unique information and the total mentions of common information throughout the task, respectively. Thus, the measures indicate the first instance of a piece of unique or common information being shared, as well as subsequent repetitions. This measure is in line with other work using hidden profile tasks (see Lu et al., 2012 for a review).

Group Decision-Making Involvement. We focus on three behaviors members of a decision-making group can engage to indicate involvement with the group decision-making task. First, members can share common or unique information with each other. In line with previous work, information sharing was coded as the sum of common and unique information shared, as described above (Stasser & Titus, 2003).

Second, group members can seek information, which we defined as asking for a specific piece of information from a teammate or the group as a whole, also in line with previous work (Emich, 2012, 2014). An example of information seeking is asking a group member where one of the suspects was at a particular time on the day of the murder or what they had been doing. For example, a member of Group 17 asked "Did the handyman see Bob [the victim] in the morning?" Another asked, "Was he [Eddie, a suspect] working in his shop?" Both were coded as information seeking.

Third, group members can elaborate on their teammates' information, which is defined as building on a teammate's knowledge by integrating it with the extant group discussion (Mell et al., 2014). For example, in Group

18, one group member combines a teammate's information that a suspect's car was loud with another teammate's information that the car that was at the scene was quiet: "Billy had the muffler that was loud, so he would've heard that, whoever threw it out. . .I feel like we've – I'm going to cross off Billy." This was coded as information elaboration.

To measure group decision-making involvement, we summed the total amount of these three behaviors each group member engaged in during the task. These behaviors were coded by two undergraduate research assistants. Specifically, research assistants were trained in tandem over three sessions until their coding was consistent. This occurred when they were able to code three of the same transcripts with greater than 90% consensus (Hayes & Krippendorff, 2007; Smith & McGannon, 2018). Then, they each coded half of the remaining groups.

Approach and Avoidance Motivation. Complicating matters specific to assessing motivation or perceptions in the face of identity threats or demand characteristics, group members may not be consciously aware of their underlying motivations for sharing information, or they may be unwilling to report these underlying motivations truthfully (Nisbett & Wilson, 1977; Wang et al., 2021). Because of this, we chose to operationalize unconscious approach and avoidance motivation using alpha asymmetry, as in previous work (Harmon-Jones, 2006; Nash et al., 2012; Rutherford & Lindell, 2011). We assessed alpha asymmetry using wireless EEG systems, which provides an unobtrusive way to assess how group member's unconscious motivation interacts with the gender of solo minority group members to affect group outcomes.

EEG activity was recorded during the group task from all triad members. Participants were briefed on the EEG system and were told to minimize head movement while the group task was being completed. A 14-electrode emotiv EPOC wireless EEG headset and its corresponding EmotivPRO recording software was used for each student in the triad (Figure 1).

EEG Data Cleaning. For our asymmetry analyses, we epoched the EEG signal from 0.5 to 1 s intervals every 10 s during the group task to capture spontaneous neural activity. EEG epoching is a procedure in which specific time-windows are extracted from the continuous EEG signal. EEG artifacts were removed via FASTER (Fully Automated Statistical Thresholding for EEG artifact Rejection; Amey et al., 2022; Forbes et al., 2018; Liu, Backer, Amey, & Forbes, 2021; Liu, Backer, Amey, Splan, et al., 2021; Nolan et al., 2010), an automated approach to cleaning EEG data that is based on multiple iterations of independent component and statistical thresholding analyses. Processing the data through iterations of thresholding analyses helps remove

Figure 1. Emotiv EPOC wireless EEG system.
Note. The EPOC has two electrode arms, each containing nine locations (seven sensors, two references). Two sensor locations (M1/M2) already have rubber sensors fitted because they are the alternative positions for the default references (P3/P4). This system covers prefrontal, temporal, parietal, and occipital lobes. Shown above are the sensor locations for the EPOC+ using the international 10 to 20 system (Emotiv, 2018).

artifacts from the EEG data. Artifacts are unwanted signals which can originate from environmental noise, experimental error, and physiological anomalies. Artifacts take the form of uncharacteristic EEG signals, for example abnormally high or low amplitudes in comparison to the baseline data. By passing unprocessed EEG data through filters and thresholds that identify these uncharacteristic signals, artifacts can be identified and removed. In the present work, the raw EEG data was initially filtered through a band-pass FIR filter between 0.3 and 55 Hz. Then, EEG channels with significant unusual variance (absolute *z*-score larger than 3 *SD* from the average), mean correlations with other channels, and Hurst exponents were removed

and interpolated from neighboring electrodes using a spherical spline interpolation function. EEG signals were then baseline corrected. EEG signals must be baseline corrected for each individual because EEG is a time-resolving signal. It can often have temporal drifts in activity that are unrelated to the research question at hand. To reduce the effect of these drifts, baseline EEG measures (i.e., activity measured prior to the epoch) are used to correct activity over a post-stimulus interval.

After these steps, we removed epochs with significant unusual amplitude range, variance, and channel deviation. Then, we transformed the remaining epochs through independent components analyses. Independent components with significant unusual correlations with EOG channels, spatial kurtosis, slopes in the filter band, Hurst exponents, and median gradients were subtracted, and the EEG signal was reconstructed using the remaining independent components. Finally, EEG channels within single epochs with significant unusual variance, median gradient, amplitude range, and channel deviation were removed and interpolated from neighboring electrodes within the same epochs. Together, these steps remove all EEG artifacts and allow clean data to be processed.

Alpha Asymmetry Calculations. We calculated alpha asymmetry from alpha power, extracted by bandpass filtering the clean EEG signal within the 8 to 12 Hz range, obtained from the frontal four electrodes in the emotiv epoch system on the left and right hemispheres (Figure 1). Given that electrode placement varied slightly for each participant, we averaged the alpha frequency of the left and right groups of four electrodes (Left: F7, F3, FC5, AF3; Right: AF4, F4, FC6, F8) to create left and right alpha values for each participant, representing the average alpha activity in the left and right hemispheres respectively across the group task. Then, we subtracted the right alpha value from the left alpha value (Coan & Allen, 2004). Thus, positive alpha asymmetry values indicate higher alpha frequency in the left hemisphere in relation to the right hemisphere, which is associated with approach motivation, while higher alpha frequency in the right hemisphere is associated with avoidance motivation (Harmon-Jones & Gable, 2018).

Results

Descriptive statistics are presented in Table 1. All analyses had 80% power to detect the reported effects.[4]

The Effect of Gender on Solo Status (H1)

To test H1, that solo status men are allocated more status than solo status women, we ran a univariate ANOVA on our status measure. Supporting H1,

Table 1. Descriptive Statistics.

Variable	Triad condition	Triad group member	*N*	Mean	*SD*
Status allocation	Majority male	Minority female group members	27	5.35	1.03
		Majority male group members	54	5.59	1.11
		Majority male total	81	5.51	1.08
		Minority male group members	20	5.98	0.58
	Majority female	Majority female group members	40	5.38	1.43
		Majority female total	60	5.58	1.24
	Total	Total	141	5.54	1.15
Unique information shared and repeated	Majority male	Minority female group members	10	2.70	1.34
		Majority male group members	22	2.86	2.17
		Majority male total	32	2.81	1.93
		Minority male group members	12	2.17	1.34
	Majority female	Majority female group members	20	3.40	2.56
		Majority female total	32	2.94	2.24
	Total	Total	64	2.88	2.07
Total involvement	Majority male	Minority female group members	28	16.86	14.18
		Majority male group members	56	17.23	16.85
		Majority male total	84	17.11	15.92
		Minority male group members	21	24.33	18.66
	Majority female	Majority female group members	42	25.17	17.81
		Majority female total	63	24.89	17.95
	Total	Total	147	20.44	17.20

(continued)

Table 1. (continued)

Variable	Triad condition	Triad group member	*N*	Mean	*SD*
Information sharing	Majority male	Minority female group members	21	6.67	4.85
		Majority male group members	37	7.57	7.29
		Majority male total	58	7.24	6.48
		Minority male group members	16	8.63	6.08
	Majority female	Majority female group members	32	9.56	5.42
		Majority female total	48	9.25	5.60
	Total	Total	106	8.15	6.15
Alpha asymmetry	Majority male	Minority female group members	12	0.18	2.81
		Majority male group members	22	−1.08	1.53
		Majority male total	34	−0.64	2.12
		Minority male group members	11	−0.59	1.12
	Majority female	Majority female group members	21	−0.93	1.64
		Majority female total	32	−0.81	1.47
	Total	Total	66	0.72	1.82

Note. Ns vary due to a variety of reasons. Within a given variable there are inherently fewer minority members since there are two majority members for each minority member. Second, all variables were dependent on participants' natural conversations. Indeed, some members did not share any unique information or were not as involved. Thus, the Ns for these variables are expected to fluctuate due to the natural variation reflected in the groups. Regarding the alpha asymmetry variable, some participants did not want to wear the EEG or took it off during the group interaction. Furthermore, depending on hair type and style some EEG signals were not readable. To ensure the validity of the data, only participants with valid trials were included in the alpha asymmetry measurements.

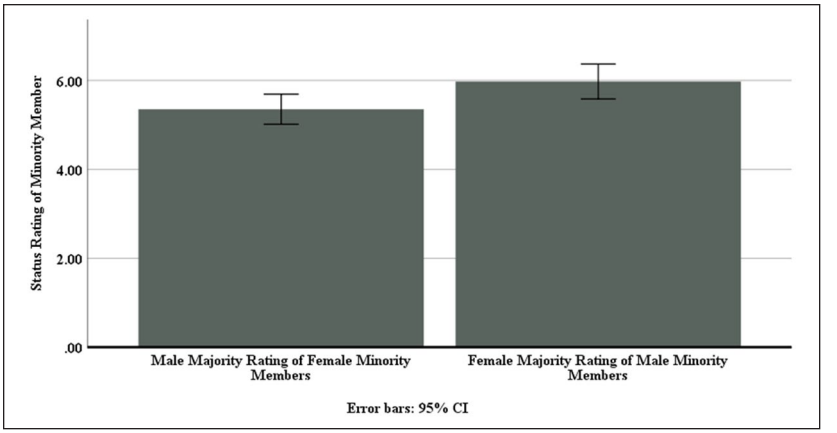

Figure 2. Differences in solo minority ratings from majority members as a function of gender.
Note. Female solo minority members are allocated less status by majority members than male solo minority members.

results demonstrated a main effect of gender, $F(1, 45) = 5.88$, $SE = 0.13$, 95% CI [5.41, 5.92], $p = .02$,[5] such that male majority members allocated female solo minority members less status ($M = 5.35$, $SD = 1.03$) than female majority members allocated male solo minority members ($M = 5.98$, $SD = 0.58$; see Figure 2). To ensure there were no gender differences, for exmaple, to ensure the women in the sample did not allocate higher status to everyone or that men did not allocate lower status to everyone, the same analysis was run on the status ratings of majority men and women. Results demonstrated no significant findings ($p = .41$, $M_{\text{MajorityMale}} = 2.41$, $M_{\text{MajorityFemale}} = 2.63$) suggesting minority members had no significant differences in the status ratings of majority members. Status ratings only differed toward minority members.

The Effect of Solo Status, Gender and Unique Information Sharing on Subsequent Status (H2)

Next, in H2, we predicted that solo status would impose a double burden on female group members such that when they did share unique information, it would result in even lower status allocation from male majority members. To test this, we ran a moderation analysis on solo minority members by deriving unstandardized regression coefficients from 10,000 bootstrap estimates (Hayes, 2013). Using Model 1 in PROCESS, gender (women = 1, men = 2) was entered as *M*, unique information discussed by the solo minority member

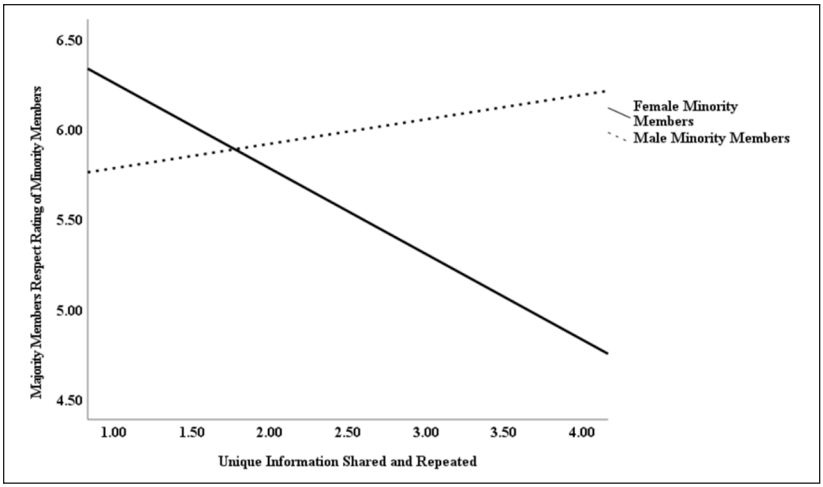

Figure 3. Moderated regression results—information sharing.
Note. Moderated regression results suggest that female solo minority members who share unique information are allocated lower status by male majority members.

was entered as *X*, and the status allocated to that solo minority member by their majority teammates was entered as *Y*.

Results showed that the highest order interaction of gender and unique information shared was significant, $B = 0.61$, $SE = 0.25$, $t(17) = 2.43$, $p = .02$, 95% CI [0.07, 1.14] (see Figure 3). Female solo minority members who shared more unique information were respected less by their male counterparts ($B = -0.47$, $SE = 0.18$, $t(17) = -2.56$, $p = .02$, 95% CI [−0.86, −0.08].

The Effect of Female Minorities on Group Decision-Making Involvement (H3)

Next, we tested whether the lack of respect given to female solo status group members affected group information processing, particularly in the form of total group decision-making involvement (H3). To examine H3 we ran a *t*-test comparing the involvement of female minority members to male minority members. Female minority members ($M = 16.85$, $SD = 14.18$) had less involvement than male minority members ($M = 24.33$, $SD = 18.66$), but this difference did not reach significance ($p = .11$). We also ran a *t*-test comparing the involvement of female majority members to male majority members. Female majority members ($M = 25.16$, $SD = 17.81$) had more involvement than male majority members ($M = 17.23$, $SD = 16.85$) to a significant degree,

$t(96) = 2.25$, Cohen's $d = 0.46$, $p = .03$, suggesting that the presence of a female minority member may inhibit group communication. In line with our findings that male minorities and female majorities were more involved than female minorities and male majorities, it follows that, overall, groups with two females and one male were more involved than groups with one female and two males, $t(48) = 2.12$, Cohen's $d = 0.61$, $p = .04$.[6]

The Effect of Majority Male Regulatory Focus on Minority Female Status in Teams Who Made Correct Versus Incorrect Decisions (H4)

We predicted that male members of male majority groups who make better decisions will be more approached-oriented and thus allocate their female teammate more status (H4). In this task, making a better decision meant correctly identifying the murderer whereas making a worse decision meant failing to find the murderer. In total, 46.9% of all groups solved the murder mystery correctly. Specifically, 46.4% of majority male groups solved the murder mystery correctly, while 47.6% of majority female groups solved the murder mystery correctly. This is generally consistent with previous findings (Lu et al., 2012; Stasser et al., 1995). We predicted that majority males' alpha asymmetry, indicative of their approach versus avoidance motivation, would moderate the relationship between group gender composition and group decision-making performance (H4). To test this hypothesis, we conducted a double moderated regression by deriving unstandardized regression coefficients and 95% bias-corrected confidence intervals (CIs) from 10,000 bootstrap estimates (Hayes, 2013; Model 3). Majority group members' alpha asymmetry values were entered in as *X*, gender and group outcome (correct or wrong decision) were entered as moderators, and the status given to the solo minority member by majority members was entered in as the outcome, *Y*. Results revealed that the highest order interaction of gender, group outcome, and alpha asymmetry was significant at a *p*-threshold of .10, $B = 0.78$, $SE = 0.44$, $t(28) = 1.76$, $p = .08$, 95% CI [−0.12, 1.69] (see Figure 4). Because of the directionality of H4, we also ran a one-tailed *t*-test. Results supported H4, $p = .045$. Consistent with our hypothesis, male majority members in groups who correctly solved the murder mystery tended to perceive female solo minority members as higher status to the extent they demonstrated positive (i.e., left lateralized) alpha asymmetry, $B = 1.04$, $SE = 0.29$, $t(28) = 3.51$, $p < .01$; 95% CI [0.43, 1.64]. In other words, groups who solved the mystery correctly tended to contain majority men with more positive alpha asymmetry and who allocated higher status to female solo minority members. There

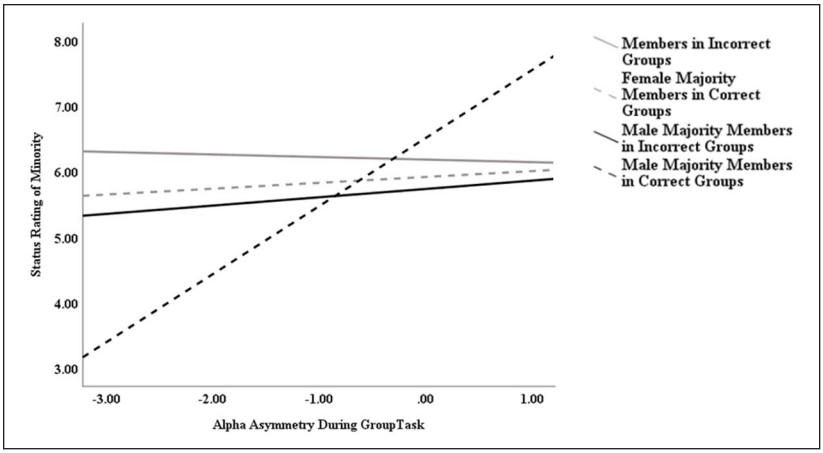

Figure 4. Moderated regression results—alpha asymmetry.
Note. Moderation results suggest that, in groups who correctly solved the mystery, male majority members viewed female solo minority members as higher status to the extent they demonstrated more positive alpha asymmetry (indicative of more approach-oriented behavior). These trends were not seen in women majority members, or groups that solved the problem incorrectly.

was no relationship between these variables in majority female/solo minority male groups (p's $> .62$).

Discussion

Groups are naturally composed of individuals with diverse backgrounds. While diversity between members has the potential to improve group efficiency and performance, it often fails to live up to this promise (Van Knippenberg & Schippers, 2007). Our results suggest that diversity may come at a cost to women who experience solo status, and their groups. We found that female solo status members were allocated less status by their male teammates than male solo status members were allocated by their female teammates. While this may impose a barrier on female minorities, discouraging them from sharing their expertise, our results also indicate a second burden. Even if women can overcome the social risk of sharing unique information, they are punished for doing so. Solo minority women in our study were allocated less status to the extent that they shared more unique information with their groups.

Importantly, our results suggest a novel way to overcome this information sharing bias. Most previous work suggests ways for female group members to earn the respect of their male teammates, essentially making female solo status members responsible for the status they receive, even in hostile environments. Conversely, our results suggest that this responsibility more logically falls with those in positions of power; here, the majority men. When majority men are avoidance-oriented (operationalized as less left-lateralized alpha asymmetry), they tend to discard the unique information of their lower status female teammates, likely because of its inherent risk. However, when majority men are approach oriented (operationalized as greater left-lateralized alpha asymmetry), they tend to accept this risk in favor of developing a larger information pool for the group to draw from, effectively allowing women to exhibit the value of their expertise and gain appropriate respect. In turn, this helps the team as a whole make better collective decisions.

Together, our findings contribute to the groups and social neuroscience literatures in three critical ways. First, we replicate previous work suggesting that male and female solo minority members are treated differently in group contexts, with women being held in lower regard than men (Eagly & Wood, 1982; Fiske et al., 2002). Second, we demonstrate how these altered perceptions of minority group members can negatively impact group communication and decision making. Finally, our findings help to integrate the neuroscience and information exchange literatures, which thus far have remained relatively isolated (Waldman et al., 2015). Specifically, we expand the groups literature by utilizing neuroscience methodologies to index motivation orientations throughout a problem solving task, providing evidence that individuals' alpha asymmetry distribution during the task, related to unconscious approach or avoidance behaviors (Coan & Allen, 2003), interacts with social perceptions of gender to impact group decision-making performance. Given the relationship between alpha asymmetry and approach-avoidance behavior, these processes suggest an unconscious mechanism behind differences in solo minority perceptions and the way solo status minorities are treated in their respective groups.

Our results are particularly impactful since identifying ways to integrate and utilize unique information to enable effective group decision making has been a perennial issue for group scholars (Lu et al., 2012; Stasser & Titus, 2003). Previous attempts to address this issue have focused on the cognitive reframing of the decision task in terms of critical thinking norms or counterfactual mindsets (Galinsky & Kray, 2004; Postmes et al., 2001), or on changing task demands to promote greater information sharing (e.g., ranking final outcome preference; Hollingshead, 1996). While these interventions involve actively shifting perceptions of the task at the group-level, we suggest two

more nuanced drivers of the effect of information sharing in mixed-gender groups: gender of a solo minority and neurological state of the majority. Thus, our results speak to the importance of instituting a neurological approach mindset to facilitate listening to all group members, increase unique information sharing, and ultimately improve group performance. For instance, one interesting avenue for future research could be to utilize strategies that prompt greater left-lateralized alpha asymmetry, for example, via biofeedback or mindfulness manipulations (Allen et al., 2001; Moynihan et al., 2013), to facilitate more optimal group interactions among diverse group members.

Limitations and Future Directions

While making notable contributions, this study is not without limitations. We highlight three here. First, improvements could be made regarding the wireless EEG system as the present system consisted of only 14 channels. Future research would benefit from a system with a denser electrode array, as it would provide a means for a more comprehensive assessment of lateral activity changes, as well as afford the possibility of localizing signals to specific brain regions of interest (e.g., dorsolateral prefrontal cortex, a region integral for complex cognitive processes like intensive decision making). Another possibility would be to use technology such as functional near-infrared spectroscopy (fNIRS) rather than EEG. fNIRS would allow a similar study design to take place focusing on more specific brain regions. fNIRS also allows for hyperscanning, which could reveal neural synchronization dynamics in group settings (Forbes, 2015). Indeed, past work utilizing fNIRS technology has shown frontopolar interpersonal neural synchronization during group interactions (Nozawa et al., 2016). These improvements would help to shed light on the precise nature of information processing facilitators and impediments within diverse groups that vary by status and gender.

Another limitation is that we did not take baseline alpha asymmetry levels. Comparing in-the-moment alpha asymmetry with baseline alpha asymmetry values would provide a means to tease apart whether results were more reflective of individual differences or momentary fluctuations in alpha asymmetry modulated by context. In other words, having this additional measure would help provide insight into whether our findings stemmed from assessing alpha asymmetry among people who may be more approach-oriented in general or whether there was something about the context that affected alpha asymmetry values. While the psychological attributes associated with dispositional or resting state alpha asymmetry are well chronicled (e.g., Thibodeau et al., 2006), given that ultimately all participants were randomly assigned to

a given group, it is unlikely that a sampling bias resulted in men with higher levels of dispositional alpha asymmetry distributions mostly being assigned to male majority groups. In this vein, it would also be valuable to examine other baseline individual differences like participant extroversion. Although not the focus of the current study, personality factors such as extroversion may influence individuals' approach or avoidance motivation (Walker, 2020). Future research is necessary to shed light on this distinction.

Finally, our work also sets the stage for future research to explore other outcomes of status allocation in groups, notably leader emergence. Behavioral work has established that women are often not promoted into positions of group leadership because, as we found here, they are not allocated status equivalent to their behavioral contributions to group tasks (McClean et al., 2018). However, our results indicate that an approach mindset allows majority males to consider information provided by solo status women. Both lab and fieldwork could explore whether this consideration—that is, women being actively listened to (i.e., Kluger & Itzchakov, 2022) and having their knowledge integrated into the group discussion—likewise allowed women to be valued for the information they provide, and thus ascend the leadership ranks of the groups they belong to. The alternative is for women to communicate safer common information, which is likely to be accepted, but unlikely to help groups come up with optimal solutions, or they may attempt to climb into leadership positions without support from their groups, which risks leadership efficacy once in place.

Practical Applications

Our results are also practically meaningful beyond their theoretical contributions. In today's political climate, there is an emphasis on increasing diversity across domains. Understanding how to optimize group outcomes where minority members are present is essential for diversity initiatives to be successful. Our findings provide insight into how these individuals are viewed and treated in regard to status. When minority members are viewed with a more approach-oriented mindset, they are allocated higher status, and their information is integrated into group discussions to the benefit of the group. Previous work on increasing diversity focused on the perspective of the minority (Forbes et al., 2015, 2018; Mills-Wisneski, 2005). We take an alternative approach. We suggest that, because majority members tend to have more power and status than minority group members (Ridgeway & Diekema, 1992), and thus have more sway over the group process, solutions to effective group problem solving may lie in how the majority treats the minority. Therefore, to create meaningful change, recommendations must be made for

both sides. In our case, solo minority women must speak up and share their expert knowledge *and* majority men must accept that knowledge and integrate it into a final collective solution.

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Notes

1. The frontal cortex differs from alternative brain regions such as the parietal lobe, which serves the functions of sensory perception and integration. It also differs from regions such as the occipital lobe, which helps with visual processing and object mapping (Grill-Spector et al., 1998). These alternate regions were not a focus of the present study, as they are not regularly studied in reference to higher-order processes such as approach and avoidance motivation.
2. Alpha frequencies were the main focus of the present study, however other neural frequencies can provide insight into alternative cognitive processes. For example, studies have shown that theta and gamma rhythms are associated with memory processes such as retrieval and encoding (Klimesch, 1999; Nyhus & Curran, 2010) and alpha and gamma rhythms are related to visual processing prioritization (Jensen et al., 2014).
3. Effects did not vary as a function of ethnicity. Thus, all participants are reported in analyses.
4. Sensitivity analyses were conducted for each analysis using G*Power. Sensitivity analyses were calculated for 80% power and a medium effect size f of 0.25.
5. Because the two majority group members in each group were not independent, each minority member's allocated respect score was the average score given to them by the two majority members. In two of the groups, we had a majority member with missing data, reducing our sample size for this analysis to 47.
6. It is also worth noting that groups with members that were more involved were more likely to get the murder mystery problem correct ($B = 0.23$, $SE = 0.01$, 95% CI [0.01, 0.05], Wald $X^2 = 5.26$, $p = .02$), replicating previous literature (e.g., Lu et al., 2012).

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