Bryant University

HONORS THESIS

Gender and Dissent Effects on Teams' Decision-Making Quality

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Honors Thesis

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Abstract

Research shows that having a devil's advocate improves a team's decision-making quality. This finding has been proven to hold even under a hidden profile condition, where information is shared unequally among the members. Teams with asymmetric information are more likely to combine unshared information leading to superior decision-making when a team member plays the devil's advocate. This experimental study aims to examine whether the gender of the devil's advocate in a three-person team affects the team's ability to succeed in a hidden profile condition challenge. This study utilizes experimental research to observe the effect of the gender of the devil's advocate on the team's decision-making quality. The findings of this experimental study pertaining to its original research question inquiring whether the gender of the devil's advocate affects a team's ability to succeed in a hidden profile condition challenge were not significant. However, our experimental study's main finding suggests female majority teams outperformed male majority teams in this activity. This experimental study, in addition to future experiments exploring this notion further, might contribute to the literature evidence supporting more women participating in decision-making teams.

Introduction

In today's business environment, thriving companies' successful results are what set them apart from the rest. The key to reaching these outcomes is achieving high quality decision-making in the workplace. When a team can effectively use its members' strengths and unique knowledge through constructive group conflict, the highest quality decisions are made. There is a wide breadth of research and literature primarily from scholars studying management, organizational behavior, and communication, that support devil's advocacy as a technique leading to constructive group conflict which ultimately results in higher quality decision-making. This experimental study examined the effect the gender of devil's advocate has on a team's decision-making quality.

Dissent

Research supports dissent as a key tool aiding teams to make higher quality decisions. According to Herbert and Estes (1977), the use of dissenting techniques shines light on biases and insufficiencies, and generates counterproposals and alternatives, thus enhancing executives' confidence in making the best decision. Their article highlighted devil's advocacy as a dissenting method aiding in identifying logical fallacies and inaccuracies in one-sided proposals, which ultimately optimizes decision quality. In an experimental study for which MBA students participated as subjects, Schweiger *et al.* (1986) examined the comparative effectiveness of devil's advocacy and consensus. The study found that devil's advocacy was more effective than consensus in generating high quality recommendations and assumptions. Aiming to extend this work, Schweiger *et al.* (1988) used a sample of "fast track" managers solving multiple problems to test once again the comparative effectiveness of devil's advocacy and consensus. The results

matched those found by Schweiger *et al.* (1986) demonstrating the superiority of devil's advocacy, which yielded considerably better assumptions in terms of validity and importance, as well as higher quality recommendations in comparison to the consensus method. In a later study, Schweiger *et al.* (1989) also found that when comparing devil's advocacy with consensus using rapidly advancing middle and upper-middle managers as subjects, the former leads to a higher level of critical reevaluation of their own assumptions and recommendations among group members than the latter.

Hidden Profile Condition

In most real-world workplace conditions, team members do not share information equally when making decisions. Stasser and Titus (1985) designed the hidden profile condition in an experimental study to replicate this workplace environment. Four-student groups were asked to pick the best candidate for student body president. The students did not possess identical information on the candidates' traits. Each member was given unique information. However, the study implemented an information sampling model in which the information distribution was designed so that the group of students, collectively, had all the information to pick the best candidate. Under the hidden profile condition, a superior or best decision exists, but it remains hidden until all information is shared between the group members. Stasser and Titus (1985) identified the shared information bias that exists in this information sampling model – groups often focus on information that is common or shared by all members and do not share unique information, preventing them from achieving the hidden or superior decision. A subsequent, similar study by Stasser and Titus (1987) suggested that much of a group's discussion is devoted to reiterating already shared information, as predicted by the information sampling model (Stasser and Titus, 1985). Stasser *et al*. (1989) created another study adopting the general

approach used by Stasser and Titus (1987) of creating hypothetical candidate profile descriptions that were designed so that one member possessed some unshared information, whereas all members shared other information in three- and six- person groups. Their study confirmed the prediction proposed by the information sampling model, finding that it was almost as likely for a shared item to be mentioned twice as it was for an unshared item to be mentioned at all. Waddell *et al.* (2013) conducted an experimental study which examined the impact on a team's decision-making quality when there is a team member who plays the devil's advocate within the team under a hidden profile condition. Their study replicated the murder mystery hidden profile scenario used by Stasser and Stewart (1992). A demonstrability task's solution must be based on evidence given to team members; thus, this type of task promotes more extensive discussion and enhances the relevance of unshared information. The unshared information was divided such that three members of the four-person group received critical clues to solving the murder mystery, while the fourth member received shared information only. Their findings suggested that the devil's advocacy technique improved the decision quality of teams under this hidden profile condition. Dissent increases the quantity of information discussed, and members place higher value on the unshared information in order to settle their positions of dissent to solve the demonstrability murder mystery. Their study suggested that teams with asymmetric information are more likely to combine unshared and unique information leading to superior decision-making when a team member plays the devil's advocate.

Gender and decision-making

Research suggests that women and men make decision differently. According to Benko and Pelster (2013), men tend to end conversations once a good idea or solution surges, while women are more inquisitive, wanting to hear everyone's ideas before deciding. Furthermore,

women engage in more collaboration and consensus building to make sound decisions. These findings provide implications for management in the workplace. For example, Deloitte created a training program dedicated to spreading awareness of the differences in decision-making styles and the need to adapt corporate approaches accordingly. As a result, this company has experiences improved interactions with potential clients. Managers should take these findings into consideration when assembling decision-making teams and defining their expected outcomes. Nikolova and Lamberton (2016) wanted to test whether the choice of compromise options, a tendency individual decision-makers often lean towards to, would still hold true when people make joint decisions. They created decision-making teams of two (two males, a male and a female, or two females) and had other subjects make decisions individually. Participants were asked to make decisions, where they could select either extreme items in a set, or moderate alternatives – the compromise option. Their findings revealed that women are always more likely to choose the compromise option, whether alone or paired with another woman or a man. However, the compromise effect did not occur for pairs of men, which tended to choose extreme options, more often than when men decided with women or when men decided individually. Their findings suggest that when deciding together, men feel driven to take actions that are superiorly different from feminine patterns, often leaning towards moderation, and instead choose actions that are typical of masculine patterns, which prioritize extremity. According to psychological research, masculinity's precarious nature constantly seeks proof and validation. These findings also reveal implications for management, as managers should take these into consideration when dealing with decision-making teams and their gender compositions.

Experiment aims and research question

No study has yet examined the effects of gender and dissent on team's decision-making quality. This study proposes to investigate the relationship of devil's advocacy and gender in a hidden profile condition. First, our experimental study analyzes the effects of dissent on teams' decision-making quality using the devil's advocacy technique. Using the findings of Waddell *et al.* (2013) as a basis, our experimental study aims to examine the effects, if any, the gender of the devil's advocate has on a team's decision-making quality under a hidden profile condition. This study is particularly interested on the female gender and whether its findings would support closing the gender gap existing in our society and have more women participating in decision-making positions.

The research question to this experimental study is as follows:

> *Does the gender of the devil's advocate in a three-person team affect the team's ability to succeed in a predetermined hidden profile condition decision-making challenge?*

Methodology

Experimental design

The success of this experimental study mainly depended on a large sample size for two reasons: First, because we were going to implement the hidden profile condition using an asymmetric information problem, we wanted our teams to be made up of at least three members, replicating the group size Stasser *et al.* (1989) used in their study, in order to pool the information unequally among the members. Second, we wanted to create an experimental environment in which we could control for the gender of the devil's advocate in each team, but also for the gender of the

rest of the team members in every permutation. In order to fulfill these two requirements, we came up with the following gender set-ups which dictated what our team types would look like:

Team Type A:	**Team Type B:**	**Team type C:**
Team member #1: Male devil's advocate	Team member #1: Male devil's advocate	Team member #1: Male devil's advocate
Team member #2: Male	Team member #2: Female	Team member #2: Male
Team member #3: Male	Team member #3: Female	Team member #3: Female
Team type D:	**Team type E:**	**Team type F:**
Team member #1: Female devil's advocate	Team member #1: Female devil's advocate	Team member #1: Female devil's advocate
Team member #2: Female	Team member #2: Male	Team member #2: Female
Team member #3: Female	Team member #3: Male	Team member #3: Male

These varying gender set-ups would allow us to isolate the effect of the gender of the devil's advocate on the team's success. The gender set-ups also allowed us to understand the dynamics of male-majority and female-majority teams. Since our sample size was going to be divided into these six different categories or team types, we needed to have a high participation rate in our experimental study. To ensure participation, the best alternative was to have Bryant University students participate as subjects performing the activity during their class time. This would mitigate the risk of losing participation based on will (since the activity would occur during class, students would not use personal time to participate) and on absenteeism (most students

regularly attend class). Originally, we contacted the faculty teaching the Business Policy & Strategy course (BUS400) during the Fall 2019 semester and asked if we could come in during their class to conduct this study using their students as subjects. After the BUS400 faculty approved our request, we contacted the Registrar's Office at Bryant University to get a complete roster of the students enrolled in the BUS400 class. The list was comprised of 282 students, of which 178 were males and 104 were females. The overall gender ratio of Bryant University undergraduate students is roughly 40% female and 60% male. For this specific student list, the ratio was 37% female and 63% male. In order for this experimental study to be successful, we needed to close the gap between female and male subjects. We reached out to Prof. Lori Coakley, who taught the Women and Leadership Strategies for Success and Professional Development course (MGT477) and asked if she would allow us to come into her classes because they had a large female enrollment. After Prof. Coakley accepted, we requested the roster for her classes from the Registrar's Office. The list was comprised of 32 students, of which 26 were females and 6 were males. We created an Excel document with two different tabs, one for BUS400 and one for MGT477 students. From this list, we created three member teams that fit our six predetermined team type set-ups. It is important to note that some students were simultaneously enrolled in both the BUS400 and MGT477 classes during the Fall 2019 semester. To mitigate the repetition of subjects, the team creation process started with the BUS400 course roster. When we moved on to the MGT477 student list to create teams, we removed students who had already been assigned to a team in their BUS400 class. Initially, we created a total of 99 teams of three people between the two classes. Ultimately, however, our sample size was reduced to 74 teams as a result of subjects being absent on the day of the activity, as well as situations in which teams incorrectly recorded their answers to the challenge. The actual sample

size for each of the team type categories for our experimental study were as follows:

Team Type A (19 teams):	**Team Type B (11 teams):**	**Team type C (10 teams):**
Team member #1: Male devil's advocate	Team member #1: Male devil's advocate	Team member #1: Male devil's advocate
Team member #2: Male	Team member #2: Female	Team member #2: Male
Team member #3: Male	Team member #3: Female	Team member #3: Female
Team type D (9 teams):	**Team type E (14 teams):**	**Team type F (11 teams):**
Team member #1: Female devil's advocate	Team member #1: Female devil's advocate	Team member #1: Female devil's advocate
Team member #2: Female	Team member #2: Male	Team member #2: Female
Team member #3: Female	Team member #3: Male	Team member #3: Male

Asymmetric information problem

The problem for this experimental study was based on the Day 4 Weather Challenges (Appendix A) from the Harvard Business School Publishing online simulation *"Leadership and Team Simulation: Everest"* by Professors Michael A. Roberto and Amy C. Edmondson (Roberto and Edmondson, 2017). This problem was chosen because it fits the asymmetrical distribution of information structure. It creates an information-sharing problem that resembles the challenge faced by subjects in the study by Waddell *et al.* (2013) using the hidden profile condition – the information is distributed unequally among the three team members. This simulation is intended to teach students about shared information bias. Students are not aware of this bias when they

begin, but that is the main lesson of the simulation. For this reason, this is a particularly challenging type of group decision-making problem. Prior to our study, a minority of students who completed this simulation were able to solve it correctly.

Procedure

For this activity, students were asked to sit according to the teams which were created from the class rosters. Each team received the following materials:

1. One *Climbing Mt. Everest* information sheet (Appendix B)
2. Three numbered clue envelopes, one for each team member:
    a. Team Member #1 / devil's advocate (Appendix C)
    b. Team Member #2 (Appendix D)
    c. Team Member #3 (Appendix E)
3. One Answer sheet (Appendix F)
4. Three Confidence Survey sheets, one for each team member (Appendix G)

According to the Teaching Note by Roberto and Edmondson (2017), the suggested timetable for the Day 4 Challenges (Appendix A) is 18-20 minutes, so we decided to give the teams 25 minutes to solve the problem. The *Climbing Mt. Everest* information sheet (Appendix B) placed teams in the third camp of Mt. Everest, highlighting that they were getting closer to the summit, and the challenge was for the teams to calculate the weather in Camp 4 to decide whether it was safe to ascend that day or not. In their clues, team members shared some common information. However, as per the hidden profile condition, each team member also had unique pieces of information in their clues. Team Member #1, who was also the devil's advocate, had a devil's advocate role description at the beginning of their clue. This description explained that they were

responsible for encouraging their team members to consider unexplored aspects of the problem, to think more deeply about their problem-solving strategies and to stimulate the discussion to discover plans of action the team would not have otherwise considered. The other two team members did not receive information revealing someone in their team was playing the devil's advocate. After the 25-minute period had elapsed, teams were asked to record their solutions on their Answer sheet (Appendix F), which asked them to write their final temperature calculation. The next question was, "Based on your temperature calculation, is your team climbing today?" Teams were prompted to circle either "Yes" or "No". The correct final temperature calculation, which teams could achieve if team members managed to combine their unshared pieces of information, was -23.6°F. Combining this with the expected wind speed of 40.32 mph would result in frostbite occurring in less than five minutes at Camp 4. Based on the combination of unshared information, teams would have chosen *not* to climb that day. During the remaining five minutes of the activity, each team member measured his or her own confidence in their team's answer on the Confidence Survey sheet (Appendix G). The question to be answered was, "How confident are you in your team's temperature calculations and decision to climb or not to Camp 4?" Team members were presented with a 0-10 scale, with 0 being "Not Confident" and 10 being "Very Confident", in which they were asked to fill only one oval corresponding to a number on the scale. We chose this scale to resemble the Academic Behavioral Confidence Scale (ABC). Sander and Sanders (2003) defined confidence as the intensity of one's belief, trust, or expectation, related to task accomplishment. They found that using an ABC scale (previously known as ACS) allows to explore the impact of different or innovative teaching and learning methods as it lends itself to measure students' confidence related to achieving academic tasks. At the end of the activity, students were asked to place their individual clues and Confidence Survey

sheets inside their envelopes. Team member #1 / the devil's advocate was asked to place the team's Answer sheet and *Climbing Mt. Everest* sheet inside their envelopes, along with their individual clues and Confidence Survey sheets. The envelopes were collected and organized by team number for data processing.

Findings

Decision-making quality

Our first finding corresponds to the original research question of this experimental study. Figure 1 shows the decision quality of teams with a female devil's advocate versus teams with a male devil's advocate. We found that teams with a female devil's advocate performed slightly better than teams with a male devil's advocate. A Chi-square test of independence was performed to explore the relationship between the gender of the devil's advocate and decision quality, shown on Table 1. The relationship of these variables was not significant ($p = 0.573$). For this type of test, a significant p-value must be less than the designated alpha level, which is normally $\alpha = 0.05$.

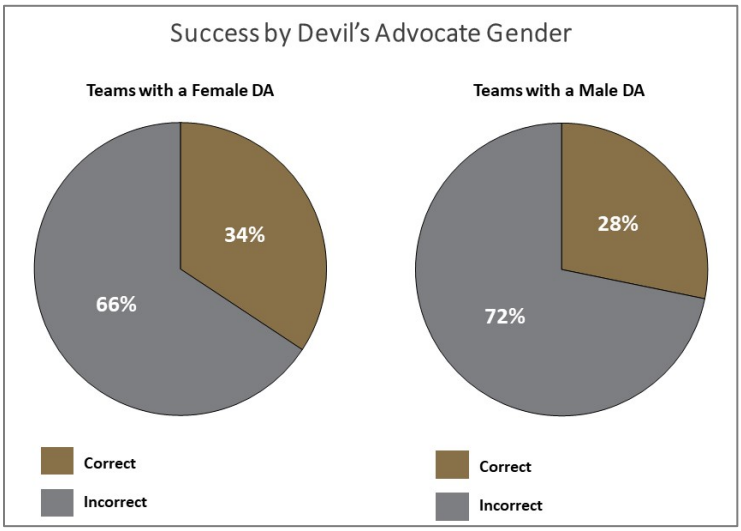


Figure 1 – Success by Devil's Advocate Gender

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.318[a]	1	.573		
Continuity Correction[b]	.098	1	.754		
Likelihood Ratio	.318	1	.573		
Fisher's Exact Test				.621	.377
Linear-by-Linear Association	.314	1	.575		
N of Valid Cases	74				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 10.88.

b. Computed only for a 2x2 table

Table 1 – Success by Devil's Advocate Gender Chi-Square Test

Even though as shown on Figure 1, teams with a female devil's advocate were more likely to answer correctly than teams with a male devil's advocate, this finding was not statistically significant as highlighted on Table 1.

The main finding of this experimental study was unexpected. As shown on Figure 2, we found that female majority teams performed significantly better than male majority teams. We were able to observe the gender majority condition by dropping the devil's advocate variable altogether since this was common to all teams. For example, we defined female majority teams as the teams that originally had a male devil's advocate and two other females (Team type B), those who had a female devil's advocate, a female and a male (Team type F), and those teams in which all team members were females (Team type D). Put another way, a team with either two females out of three members, or three females out of three members is a female majority team. Vice versa, we classified male majority teams in the same fashion. We ran a Chi-square test of independence to explore the relationship of gender majority and decision quality. As shown on Table 2, the *p*-value of this test was .017, revealing a significant relationship between these two variables.

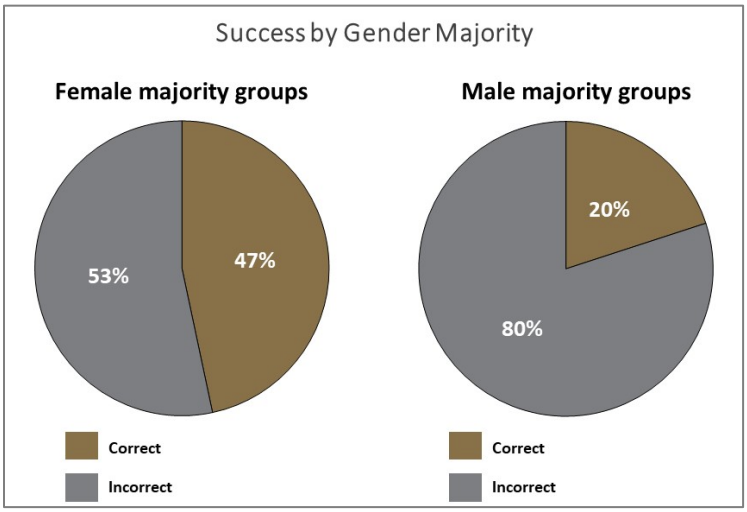


Figure 2 – Success by Gender Majority

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.722[a]	1	.017		
Continuity Correction[b]	4.563	1	.033		
Likelihood Ratio	5.683	1	.017		
Fisher's Exact Test				.022	.017
Linear-by-Linear Association	5.644	1	.018		
N of Valid Cases	74				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.32.

b. Computed only for a 2x2 table

Table 2 – Success by Gender Majority Chi-Square Test

Confidence

This experimental study also aimed to explore the relationship between gender composition of the teams and confidence levels. However, neither of our confidence findings were statistically significant.

Due to the hidden profile condition nature of the problem, when the correct problem-solving technique of sharing all pieces of information had been used by teams, arriving at the correct answer became easier, and when they had done this, it was evident to the team members they had solved the problem correctly. Figure 3 shows that when the correct problem-solving process had been applied, teams rated their confidence level higher. In this case, teams with a female devil's advocate felt slightly more confident than teams with a male devil's advocate. As shown on Figure 3, when an incorrect problem-solving process was applied, the gender of the devil's advocate did not affect the team's confidence, as teams with a female devil's advocate and teams with a male devil's advocate felt equally confident.

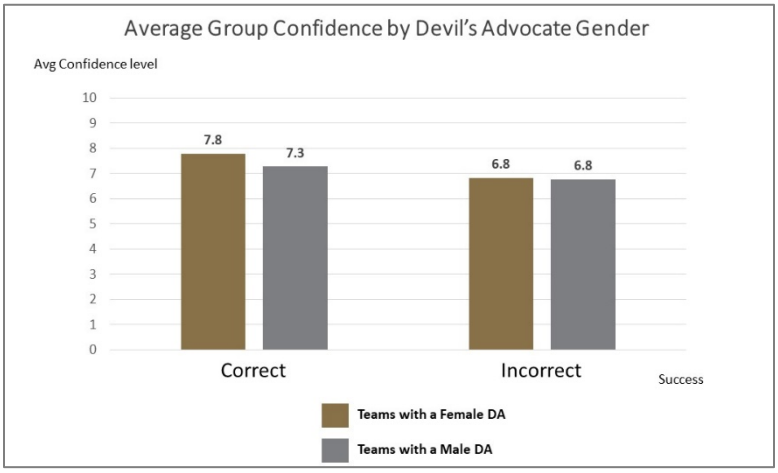


Figure 3 – Average Group Confidence by Devil's Advocate Gender

To examine the relationship of these variables, we ran a One-way analysis of variance test as shown on Table 3. The significance level of this test was .708, which is greater than the designated alpha level, which is normally $\alpha = 0.05$, revealing that this relationship is not statistically significant.

Tests of Between-Subjects Effects

Dependent Variable: Confid_Team

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.457[a]	3	3.486	.602	.616
Intercept	3232.915	1	3232.915	558.366	.000
correct_num	8.608	1	8.608	1.487	.227
Dev_Gen	1.214	1	1.214	.210	.648
correct_num * Dev_Gen	.818	1	.818	.141	.708
Error	405.297	70	5.790		
Total	4060.444	74			
Corrected Total	415.754	73			

a. R Squared = .025 (Adjusted R Squared = -.017)

Table 3 – Average Group Confidence by Devil's Advocate Gender One-Way ANOVA

As with the previous finding, Figure 4 shows the relationship between the gender majority variable discussed above and confidence. female majority teams felt slightly more confident than male majority teams when both correct and incorrect problem-solving processes were applied.

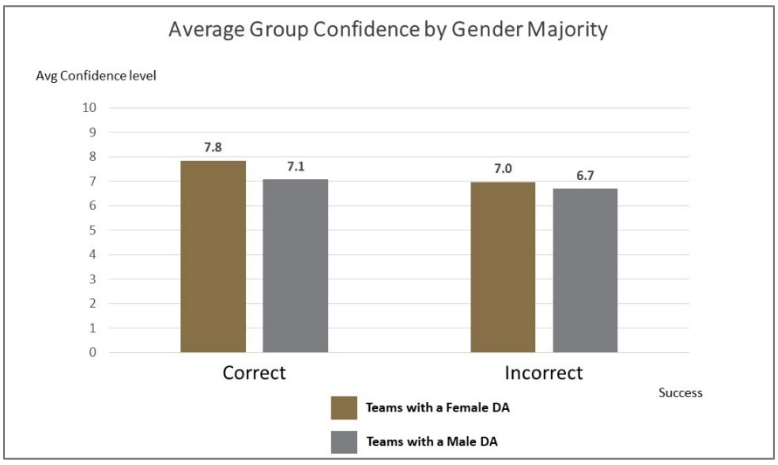


Figure 4 – Average Group Confidence by Gender Majority

Once again, we ran a One-way analysis of variance test as shown on Table 4. The significance level of this test was .706, revealing that the relationship of these variables is also not statistically significant.

Tests of Between-Subjects Effects

Dependent Variable: Confid_Team

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13.005[a]	3	4.335	.753	.524
Intercept	2985.697	1	2985.697	518.931	.000
correct_num	5.556	1	5.556	.966	.329
Gen_Dom	3.977	1	3.977	.691	.409
correct_num * Gen_Dom	.826	1	.826	.144	.706
Error	402.748	70	5.754		
Total	4060.444	74			
Corrected Total	415.754	73			

a. R Squared = .031 (Adjusted R Squared = -.010)

Table 4 – Average Group Confidence by Gender Majority One-Way ANOVA

Discussion

Female majority teams' success

Our experimental study showed that female majority teams outperformed male majority teams. We speculate that the reason behind this finding is that women are more open to dissenting views in groups settings than men. Eagly and Johnson (1990) reported in a meta-analysis comparing leadership styles of women and men that women tend to be more interpersonally oriented and adopt a more democratic or participative style and a less autocratic or directive style than men. In a review of the literature about effects of gender diversity on team performance, Bear and Woolley (2011) found evidence suggesting that team collaboration is largely improved by the presence of women in groups, a view that can be explained by the benefits women bring to group processes. Experimental research also confirms this notion. Berdahl and Anderson (2005) conducted a study suggesting that when in groups, women tend to prefer equality norms more so than men. Their study also proposed that all-female groups had a shared and decentralized leadership structure. Similarly, a study conducted by Mast (2001) showed that all-male groups are more hierarchically structured that all-female groups. Woolley *et al*. (2010) conducted two studies that randomly assigned individuals to groups and asked them to perform a variety of different tasks, such as solving visual puzzles, brainstorming, making collective moral judgments, and negotiating over limited resources. The team members' individual intelligence was measured at the beginning of each session. The findings of these studies supported their hypothesis that a general collective intelligence factor (*c*) exists in groups, and when combining the findings of the two studies, they found that *c* is positively and significantly correlated to the percentage of women in the group. Their findings suggested that groups with more women were associated with a superior collective intelligence given that they exhibit greater equality in

conversational turn-taking, enabling group members to be more responsive to each other and use the skills and knowledge of each member, which would explain why female majority groups were more successful in this experimental study employing the hidden profile condition.

While we speculate that the reason behind the main finding of this experimental study suggesting that female majority teams perform better than male majority teams is that women are more open to dissenting views in group settings than men, our speculation is not the only plausible one. Further research on this topic might uncover alternative explanations to our experimental study's main finding.

Limitations and future research

The main limitation of this experimental study was its sample size. Our original sample size was reduced to 222 students that were put into 74 teams. This sample size was then divided into the six different categories to match each team type. For this reason, the sample size of each of the conditions was relatively small. A second limitation of this experimental study was the type of problem that we used. We only tested for the hidden profile condition, and results might differ for shared information problems, or any other type of information distribution problems. Lastly, the age of the subjects might have affected the results. While this experimental study suggests that college-aged women feel overall more confident than their male counterparts, these results might differ for different age groups.

These limitations should be considered for future research on this topic. This experiment should be replicated using a larger sample size of participants. It would be interesting to examine whether the effects of this study would hold for a larger sample size, and whether our original research question finding, as well as our confidence-related findings would become statistically

significant as a result. A future study might also consider recording the teams' discussions, enabling researchers to observe whether the female attributes described in the discussion section, such as conversational turn-taking, are present, and the ways in which similar traits contribute to the teams' success. This approach might also reveal other underlying explanations for our experimental study's main finding of why female majority groups tend to outperform their male counterparts beyond our speculation.

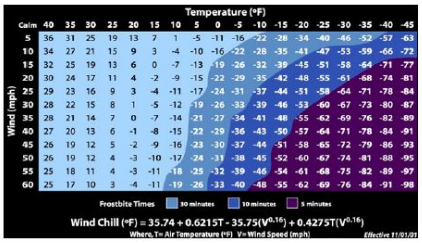
Conclusion

While the findings of this experimental study pertaining to its original question inquiring whether the gender of the devil's advocate affects a team's ability to succeed in a hidden profile condition challenge were not significant, this relationship revealed an interesting pattern that should be further studied. Our experimental study's main finding regarding female majority teams outperforming male majority teams should be studied more in depth. Our speculation about women being more open to dissenting views than men is a good starting point for the creation of a new hypothesis. This experimental study in addition to future experiments exploring this notion further might contribute to the literary evidence supporting more women participating in decision-making teams.

Appendices

Appendix A – Day 4 Weather Challenge from "*Leadership and Team Simulation: Everest*"

Day 4 Challenges

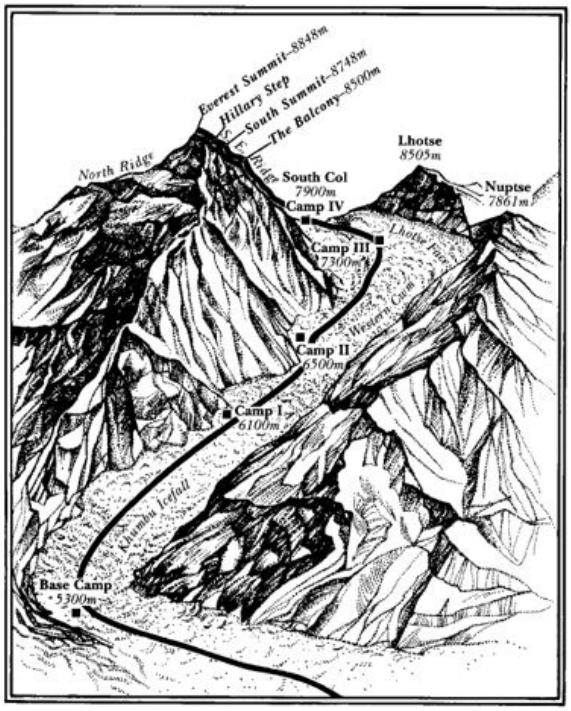
DAY 4: Classic Weather Challenge			
Challenge	Satellite communications equipment at Base Camp has malfunctioned. Because of this, you have a limited amount of weather information available to you this morning. You have been told by the Sherpas back at Base Camp that the temperature is expected to be 15°F below normal at Base Camp today. The team must calculate the weather for Camp 4 to decide if they should ascend to Camp 4 or wait.		
	Temperature Information	**Wind Speed Information**	**Health Information**
Shared Info	Expected temp at Base Camp is 10°F below normal	Expected wind speed at Base Camp is 20% faster than average	
Leader	Avg. temp in May at Base Camp is 7°C		
Physician	Avg. May temp at Camp 4 is 33°F colder than temp at Base Camp		Climbers can survive in conditions producing frostbite in 10 minutes or longer, but not in conditions producing frostbite in 5 minutes
Photographer	Temp in °F = ((9/5) × temp in °C) + 32	Avg. wind speed at Camp 4 is roughly 3 times the wind speed at Base Camp	
Marathoner			Frostbite will occur in 30 minutes at 0°F and winds of 35 miles per hour (mph), or −10°F and 5 mph winds. Frostbite will occur in 10 minutes at −5°F and 35 mph winds, −10°F and 25 mph winds, or −20°F and 15 mph winds. Frostbite will occur in five minutes at −10°F and 60 mph winds, −15°F and 45 mph winds, or −30°F and 25 mph winds.
Environmentalist		Avg. wind speed at Base Camp in May is 11.2 mph	NWS wind chill chart contains frostbite correlation data (more comprehensive than Marathoner's info)
	NWS Windchill Chart 		
Solution	• Avg. temp at Base Camp is 19.4°F (converted from −7°C using equation photographer has) • Expected temp at Base Camp is 19.4°F –10°F, or 9.4°F • **Expected temp at Camp 4 is 33°F colder than Base Camp, so expected temp at Camp 4 is –23.6°F** (this should be entered by the marathoner on the Make Decisions page)	• Avg. wind speed at Base Camp is 11.2 mph • Expected wind speed at Base Camp is 11.2 × 1.2 = 13.44 mph • Expected wind speed at Camp 4 is 13.44 × 3 = 40.32 mph	The combination of expected wind speed (40.32 mph) and temperature (-23.6°F) will result in frostbite in less than 5 minutes at Camp 4. **The team should not hike to Camp 4 on this day.**

Appendix B – *Climbing Mt. Everest* information sheet

Climbing Mount Everest

Background Information:

Mount Everest stands 8,850 meters above sea level, and its summit ridge separates Nepal and Tibet.[i] While working in Calcutta, India, in 1852, Radhanath Sikhdar first calculated that this peak in the Himalayan range stood taller than any other mountain in the world. Several years later, Sir Andrew Waugh, the British surveyor general of India, renamed the mountain after his predecessor, Sir George Everest.[ii] Not surprisingly, the native residents of the region already had a name for the majestic peak. The Nepali people referred to the summit as Sagarmatha, which means goddess of the sky, and Tibetans used the name Chomolungma, which means mother goddess of the universe.[iii] Climbers begin their ascent of Everest at Base Camp, which sits at 5300 meters above sea level (approximately 17,400 feet). Climbers must ascend through a series of other camps on their way to the summit. The summit is over 8,800 meters in altitude (above 29,000 feet).



The dangers of climbing Mount Everest are what make it a world-wide known remarkable and alluring challenge. Your team is about to begin the fourth day of climbing from Camp III, as shown on the map above. Today you are faced with the decision whether it is safe to ascend or not to Camp IV.

Good luck, climbers!

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[i] Mount Everest Web site, <www.mnteverest.net/history.html>, accessed October 15, 2002.

[ii] Jon Krakauer, *Into Thin Air* (New York: Anchor Books, 1998), pp. 13–15.

[iii] Mount Everest Web site, <www.mnteverest.net/history.html>, accessed October 15, 2002.

Appendix C – Team member #1 / devil's advocate clues

Devil's Advocate/ Team Member #1:

You have been selected to play the role of the **devil's advocate** for your team. A devil's advocate is defined as "a person who expresses a contentious opinion in order to provoke debate or test the strength of the opposing arguments." You are responsible for encouraging your team members to consider unexplored aspects of the problem given to you, to think more deeply about your problem-solving strategies and to stimulate the discussion to discover plans of action your team would not have otherwise considered.

Satellite communications equipment at Base Camp has malfunctioned. Because of this, you have a limited amount of weather information available to you this morning. You have been told by the Sherpas back at Base Camp that the temperature is expected to be 10°F below normal at Base Camp today.

You will surely find yourself climbing in some tough weather conditions. Climbers regularly find themselves in conditions in which frostbite occurs in 30 minutes, and even can ascend safely in conditions in which frostbite occurs in 10 minutes. However, it is very dangerous to climb in conditions in which frostbite occurs in five minutes.

The Sherpas have told you that the wind speed at Base Camp is expected to be 20% faster than normal today. You have also been told that the average May temperature at Camp 4 is roughly 33°F colder than temperature at Base Camp.

The team must calculate the weather for Camp 4 to decide if they should ascend to Camp 4 or wait.

Appendix D – Team member #2 clues

Team Member #2:

Satellite communications equipment at Base Camp has malfunctioned. Because of this, you have a limited amount of weather information available to you this morning. You have been told by the Sherpas back at Base Camp that the temperature is expected to be 10°F below normal at Base Camp today.

Note that temperature in Fahrenheit = ((9/5) × temperature in Celsius) + 32.

The Sherpas have told you that the wind speed at Base Camp is expected to be 20% faster than normal today. Historical information indicates that the average wind speed at Camp 4 in May is roughly three times the wind speed at Base Camp.

You have a book in your backpack with some additional information regarding the conditions at which frostbite might occur. Frostbite will occur in 30 minutes at 0°F and 35 miles per hour (mph) winds, or −10°F and 5 mph winds. Frostbite will occur in 10 minutes at −5°F and 35 mph winds, −10°F and 25 mph winds, or −20°F and 15 mph winds. Frostbite will occur in five minutes at −10°F and 60 mph winds, −15°F and 45 mph winds, or −30°F and 25 mph winds.

The team must calculate the weather for Camp 4 to decide if they should ascend to Camp 4 or wait.

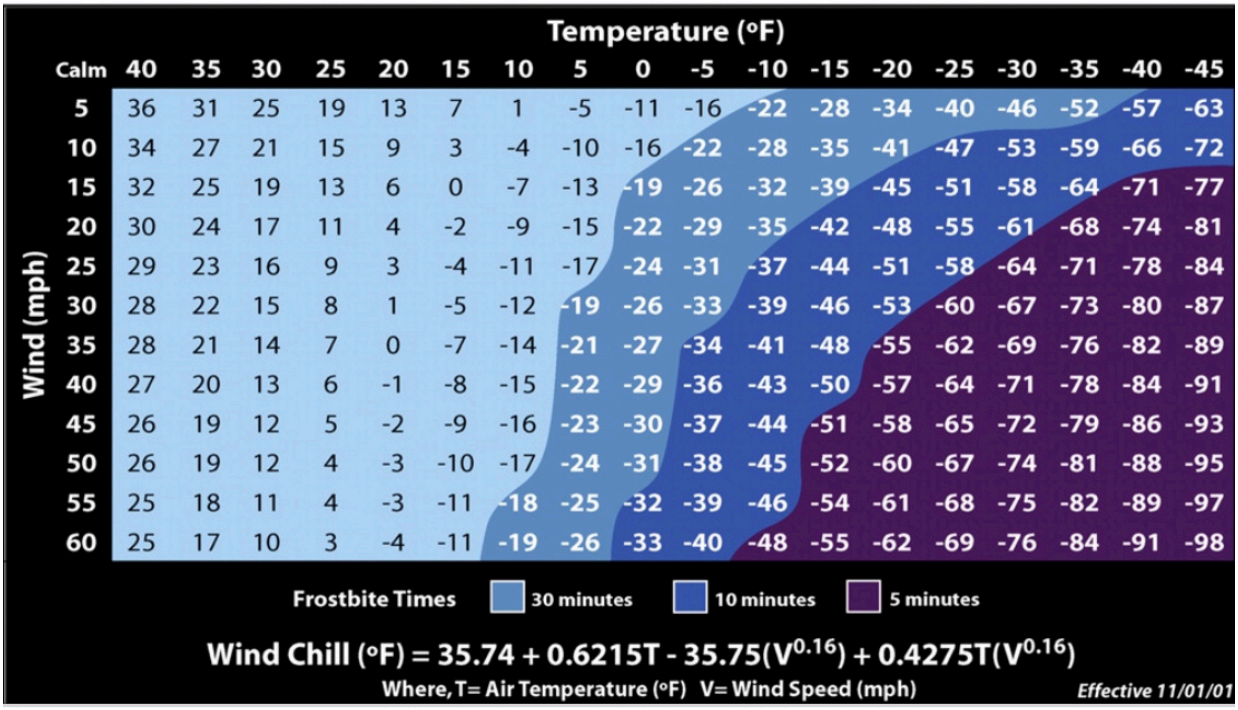
Appendix E – Team member #3 clues

Team Member #3:

Satellite communications equipment at Base Camp has malfunctioned. Because of this, you have a limited amount of weather information available to you this morning. You have been told by the Sherpas back at Base Camp that the temperature is expected to be 10°F below normal at Base Camp today.

Your notes from the research that you did prior to traveling to Nepal indicate that the average temperature in May at Base Camp is -7°C. The Sherpas have also told you that the wind speed at at Base Camp is expected to be 20% faster than normal today.

The average wind speed at Base Camp in May is 11.2 miles per hour (mph). You have a book in your backpack with some additional weather information. In that book, you found this chart:



Wind (mph) \ Temperature (°F)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5		36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10		34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15		32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20		30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25		29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30		28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35		28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40		27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45		26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50		26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55		25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60		25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

Wind Chill (°F) = $35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

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The team must calculate the weather for Camp 4 to decide if they should ascend to Camp 4 or wait.

Appendix F- Answer sheet

Answer Sheet

(One per team)

Final temperature calculation: _____

Based on your temperature calculation, is your team climbing today?

Circle one.

Yes No

Team Number: _____

Course and Section: _____

Appendix G – Confidence survey sheet

Experimental Study - Confidence

* Required

1. **How confident are you in your team's temperature calculations and decision to climb or not to Camp 4?** *
   Mark only one oval.

	0	1	2	3	4	5	6	7	8	9	10	
Not Confident	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very Confident

2. **Team Number**

3. **Course Number and Section**

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