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Ripening or rotting? Examining the temporal dynamics of team discussion and decision making in long-term teams.

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ABSTRACT

More than a quarter century of research finds that teams often fail to make high-quality decisions. This literature is based on observing team decisions in one-off decision making episodes, when in reality, most teams work together for an extended period of time, making repeated decisions together. Do teams improve or decline on decision making effectiveness over time? To answer this question, this dissertation contributes three studies on team decision making, examining how the processes and outcomes of team decision making evolve over time. In order to study team decision making over time, one needs parallel and comparable tasks on which to observe process and performance. And so, Study 1 developed and validated five parallel hidden profile tasks that require teams to share unique information in order to identify the optimal solution from three options. Using this newly developed battery of tasks, Studies 2 and 3 used mixed-methods to understand team decision making over time in eight 4-person teams. Study 2 was quantitative, examining the discussion and decision quality of teams during multiple sequential decision making episodes. Study 3 was qualitative, exploring the conversational dynamics over time. Quantitative analysis found that teams show an initial increase and subsequent decrease in discussion and decision quality as they work together. Additionally, a qualitative approach identified 18 themes that explain how teams make decisions and 9 additional themes that shed light on why decision making performance fluctuates over time. This dissertation highlights that teams struggle to maintain quality processes when completing decision making tasks that require them to leverage individuals' unique information, such as hidden profiles, and provides guidance on how teams can remedy this shortfall.

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Executive Summary

Making quality decisions is a vital aspect of team success, whether a team of surgeons deciding between competing emergency procedures, an executive board selecting a strategic initiative to ensure an organization's viability, or astronauts deciding which of three failing life systems should be attended to first. Team scholars have developed a rich literature on many of the tendencies, and often shortcomings, that occur when teams make decisions. However, team decision making has been studied almost exclusively using a cross-sectional design. This dissertation investigates team decision making over time. Specifically, I examined how teams exchange important information, how this information shapes their decisions, and how these functions evolve as teams work together.

Chapter 1 reviews existing research on team decision making, focusing on studies utilizing hidden profiles. Hidden profiles are team decision making tasks that require teams to share unique information available to individual team members in order to identify the optimal team decision. In this literature review, I argue that information sharing, a term frequently used in decision making literature, is problematically vague; the exchange of information should be conceptualized as a broader paradigm of discussion quality that includes three distinct information processing attributes: information coverage (how much of available unique information is introduced into discussion), information focus (how much of a discussion focuses on unique information rather than information already available to all team members), and information consideration (whether individuals take into account information presented by team members that run counter to their individual option preference). Additionally, I place discussion

quality within the Input-Process-Output (IPO) decision making model and review antecedents of team discussion and decision quality.

Chapter 2 describes the development and validation of five parallel hidden profile tasks that can be administered across a team's life span to evaluate the processes and outcomes of team decision making over time. Task development and validation involved a five-phase process. In the first phase, five compelling space themed decision making scenarios were developed leveraging popular media and scientific publications. Tasks were designed so that each task presented teams with a best, middle, and worst option to choose from. Additionally, informational items were developed for each scenario that would shape team decision making and either support, negate, or not influence (i.e., neutral informational items) each option. The second phase tested these information items to ascertain their perceived valence and importance. This phase resulted in a finalized list of approximately 40 items for each scenario. The third phase a) made sure that when given full information, individuals preferred the best option and b) distributed the informational items across four roles such that each role preferred the worst option. The fourth phase tested the scenarios using student teams to confirm task functionality. A fifth phase re-evaluated the tasks a year after their initial development and resulted in updates on four of the tasks

Chapter 3 presents a quantitative study of team decision making using the five hidden profile tasks. This chapter answers two primary research questions: 1) what are the ways in which components of team discussion influence decision quality? and 2) how do decision making mechanisms shift as teams remain together and make multiple decisions over time? Findings from this chapter 1) replicate the common information bias in teams operating in isolated and confined, 2) find evidence that teams favor negative information over positive information in team discussion, 3) support that teams consider the net valence (positive information minus negative information) of competing options to identify a preference, and 4) performance trends that demonstrate team discussion and decision quality improves and subsequently decreases as teams make decisions over time. As an additional analysis, I also evaluated how team processes corresponded with trends in team discussion decision quality over time, finding that team processes evaluated prior to decision making tasks did indeed inform the performance of the team.

Chapter 4 is a qualitative counterpart to Chapter 3. I used qualitative analysis of the same sample of teams and activities examined in Chapter 3 to delve deeper into understanding how and why team decision making changes as teams mature. A qualitative approach allowed for a thorough, more inductive exploration of the dynamics that occur during decision making episodes and how they change over time. The qualitative work of this chapter identified a total of 27 themes, across seven distinct components of team decision making, that explain how teams make decisions and why team decisions fluctuated in the manner observed in Chapter 3. Further, this chapter proposed a protocol teams can utilize when making decisions to avoid the pitfalls that befall teams when having to leverage unique individual information to make decisions (see Appendix A).

In summary, this dissertation developed five new tasks that can be used to study, teach, and train team decision making; provided novel insights into the factors and components that inform team decision making; and identified trends that show team decision making initially increases and subsequent declines as teams work together. Findings from the dissertation furthered the theoretical understanding of team decision making and presented guidance to enable teams to make better decisions.

CHAPTER 1

Literature Review

Teams are often tasked with making difficult decisions. Whether a board of directors choosing a long-term financial strategy, a team of doctors and nurses deciding on how to best treat a life-threatening injury, or a jury deciding on innocence or guilt of a defendant, team decisions have meaningful impacts ranging from economic implications to the difference between life and death. History points to numerous instances of teams failing to make the best decision. One specific example is the space shuttle Challenger disaster. Despite data indicating the risk of launching at low temperatures, this information was not adequately shared with the team making the decision to launch (Rogers Commission Report, 1986). The shuttle exploded within two minutes of the launch, killing all 7 crew members as millions watched on television

The Challenger disaster is an extreme consequence of poor team decision making. A vital aspect of modern teamwork, in almost all settings, is making decisions to complex tasks where no single individual has access to all relevant information. Assuming not all individuals possess the exact same knowledge and experiences, teams provide access to a greater pool of information to make an informed decision. However, research shows most teams are not good at this. Meta-analyses of team information sharing (IS) highlight that teams spend a disproportionate amount of time discussing redundant rather than unique information (Mesmer-Magnus & DeChurch, 2009; Reimer, Reimer, & Czienskowski, 2010). On a more fundamental level, these studies support the intuitive inclination that sharing information is vital to quality team decisions but teams often fail to effectively share information when they most need it (Mesmer-Magnus & DeChurch, 2009).

A second noteworthy aspect of team decision making is that teams typically work together over time to make multiple decisions. Previous team studies have identified that teams often stay together 1 to 2 years (Bell & Marentette, 2011). Between these decisions, numerous team factors, such as changes in strategy, motivation to perform, or team cohesion, could influence the approaches to and outcomes of decision making. Additionally, external factors, such as changes in the team's scope of work or access to resources, could fluctuate. Thus, one decision-making period might not be indicative of future episodes.

One particular situation in which the sharing of information is imperative to quality decision making is when team members' individual information directs them towards a suboptimal solution, and only by sharing information can the optimal solution be identified. This type of scenario is defined as the hidden profile paradigm (Stasser & Titus, 1985) and is one of the most fruitful avenues of group and team decision making research (Lu, Yuan, & McLeod, 2012). Lu and colleagues conducted a meta-analysis of hidden profile literature, and their findings complemented the previous studies on broader IS phenomena. Specifically, they found that teams are eight times less likely to identify an optimal solution when individuals possess unique information as opposed to all having the same information, group discussion focuses on common compared to unique information by two standard deviations, and the pooling of unique information (via discussion of unique information) predicts team decision making performance.

This dissertation addresses two central questions: 1) what are the key aspects and components of team decision making? and 2) how do the mechanisms of team decision making evolve as teams work together over time? I conducted three studies triangulating methodologies. In order to explore the role of team development in team information sharing, it is necessary to have a standard battery of tasks that a single team can perform allowing information sharing and decision making to be compared over time. And so, Study 1 develops a battery of hidden profile tasks that can be administered over time. Then, these hidden profile tasks were then performed by eight teams living and working together in a controlled setting, to understand how team development affects decision making processes and outcomes. Study 2 utilizes traditional quantitative approaches to evaluate team decision making. Study 3 uses a qualitative approach to provide additional and novel insights about themes that emerge as teams work together over multiple decision making episodes.

Hidden Profiles: A Tool for Understanding Information Sharing and Decision Making

In 1985, Stasser and Titus introduced the hidden profile paradigm to study information sharing and decision making. The goal of the hidden profile is to create a decision condition where individuals, based on their own information, each prefer a suboptimal choice, but that if all group members were to use all of the information available in the group to make a decision, the group would choose the optimal outcome. Hence, the term ‘hidden profile” refers to the fact that the “best option” is hidden from view of any one person, but if the group shares and uses all of the information known by all of its members, the team can reach a decision of higher quality than any of the individuals, or than any aggregation of the individuals. The hidden profile provides an idealized scenario. One when teams are critical for reaching high quality decisions that no individual could realize on their own.

Studies using hidden profiles generally proceed in two phases. In the first phase, team members receive information about competing options and are asked to individually make an initial preference about which option they think is best, based on their own information. The set of information each individual receives is composed of both common information (that other team members also receive) and unique information (which they solely received). Individuals are not aware which informational items are common versus unique. Further, the informational items are typically dispersed such that individuals favor a suboptimal option as their individual preference. The second phase of the hidden profile tasks allows individuals to discuss their individual information with the group and then to select a preference as a team. Only by considering every individual's unique information can the team factually uncover the best available option - thus discovering the hidden profile that would not be visible to them as individuals.

The hidden profile paradigm launched a wave of information sharing and decision making research for at least two reasons. First, the task presents an elegant manner to control information distribution and observe how information is utilized to shape decision making. The distribution of information, the opportunity to have prior perspective before engaging with a team, and a final decision requiring some form of collaboration involved in hidden profiles present a prototypical design to study the synergy of teams in decision making (Faulmüller, Kerschreiter, Mojzisch, & Schulz-Hardt, 2010; Schulz-Hardt, Brodbeck, Mojzisch, Kerschreiter, & Frey, 2006). The second reason is even more substantial to those interested in teams: the initial findings presented grave concerns about the ability of teams to overcome biases to make quality decisions (Stasser & Titus, 2003). Work prior to hidden profiles already established flaws pertaining to teams making decisions (e.g., groupthink; Janis, 1972); however, in a reflection piece, Stasser and Titus (2003) shared that they “expected that the impact of information in group discussions would be enhanced by distributing among group members. We were wrong.

What we found was quite the opposite" (p.312). The authors further assert that findings opposite of that which they expected helped inspire their subsequent studies and that of others who have made many insightful contributions into how teams make decisions (Stasser & Titus, 2003).

While the hidden profile paradigm has produced a fruitful line of research pertaining to how teams use information to make decisions (c.f., Lu et al., 2012; Mesmer-Magnus & DeChurch, 2009; Schulz-Hardt & Mojzisch, 2012; Stasser & Titus, 2003), an issue with the existing literature is a lack of precision and consistency in terminology and conceptualization of the mechanism for team decision making. As part of this review, I will attend to these challenges. In addressing the issue of terminology, four terms are particularly problematic and require greater clarification: sharing, exchange, pooling, and discussion. The first three terms are often used interchangeably and pertain to information made available to the team in making their decision but range in how they are operationalized. Studies use the terms confusingly to identify both what distinct information is *made available* to the team and how much *attention* this distinct information receives during discussion. These conceptualizations are both theoretically and empirically distinct (Lu et al., 2012). As such, more precise and explicit definitions would be beneficial: *information coverage* and *information focus*.

Information coverage reports how much of a scenario's unique information is made available to the team during their conversation (Larson, Christensen, Abbott, & Franz, 1996; Lu et al., 2012). Information focus represents how much of a team's total conversation focuses on this unique information (Lu et al., 2012; Stasser & Stewart, 1992). Further, to fully understand the magnitude of these terms within a particular scenario, it may be beneficial to think of these terms as ratios (Lu et al., 2012). Information coverage can be conceived as a ratio of unique informational items mentioned out of total unique informational items included in a scenario and information focus is a ratio of discussion of unique informational items (including repeating of items) out of total information items (including repeats) discussed.

The term discussion is also problematically unspecific in the context of hidden profile research. Numerous studies describe theories or findings utilizing the term (e.g., Schulz-Hardt et al., 2006; Schulz-Hardt & Mojzisch, 2012; Stasser & Titus, 1987) but the meaning of these statements is not easily defined. For example, a finding stating team discussion is biased towards common rather than unique information (e.g., Larson, Foster-Fishman, & Keys, 1994) does not convey whether that means teams introduced more total pieces of common information in their conversation, common informational items made up a higher proportion of the conversation, or common information was more thoroughly evaluated during conversation. To avoid this confusion, I propose the following recommendations. First, discussion should be conceptualized as a broad overarching process in which information is both exchanged and considered (Stasser, Vaughan, & Stewart, 2000). Thus, the previously introduced terms of information coverage and information focus are both components of a decision making discussion. Second, I propose another term be introduced to capture attributes of a discussion: *information consideration*. This term can serve as a measure of whether teams evaluate the information that is presented by others. A summary of previous and proposed terminologies related to decision making addressed in this section are included in Table 1 and Table 2, respectively.

Placing these terms within a model for decision making may provide an additional level of clarity. Prior work on hidden profiles identified the input-process-output (IPO) model (McGrath, 1984) as a useful conceptualization of information discussion and decision making

(Lu et al., 2012; Wittenbaum, Hollingshead, & Botero, 2004). Inputs are contextual factors involved in decision making; process entails discussion of information as addressed in the previous paragraphs; and output refers to actual decision quality of the team (see Figure 1). The following sections of this chapter will review findings on information sharing and decision utilizing hidden profiles. The IPO framework will be used to structure this review.

Discussion Quality (Process)

The process component of decision making is an appropriate starting point for a review of decision making as it has been the dominant focus of hidden profile related research (Lu et al., 2012), whether looking solely at differences between unique and common information, how these differences are spurred by contextual factors (i.e., input - process), or whether these differences influence decision quality (i.e., process - output). From the outset of the initial hidden profile study (Stasser & Titus, 1985), it became apparent that common and unique information were treated differently in group deliberation. The extent of these differences is dependent on how the dissemination of information was operationalized. In the most recent meta-analysis of hidden profile studies, more than 20 studies were identified as demonstrating a significant bias towards discussing common information over that of unique information (Lu et al., 2012).

Unpacking these studies using the operations of information coverage, information focus, and information consideration provides both clarity and poses more questions. Using information coverage - the mention of unique (common) information out of total information unique (common) information - to evaluate differences shows that the percentage of common information mentioned during a group decision is two standard deviations higher than that of unique information (Lu et al., 2012).

A similar analysis of information focus was not available due to inconsistent operationalizations pertaining to mentions of informational items (Lu et al., 2012). However, broader conceptualizations considering item repetitions and mentions support that common information is mentioned more frequently than unique information (c.f., Klocke, 2007; Stasser & Stewart, 1992; Stewart & Stasser, 1998). Comparison of information coverage and focus is lacking due to studies including only one measure or definitional ambiguity in operationalizing the terms.

There is no direct data available to compare common and unique information in terms of information consideration. My review of the literature found one study that attempted to examine a similar concept, using the term information use (Dennis, 1996). The study provides limited insight into information consideration as operationalized in this dissertation since information use was determined by whether the information matched the team's final preference and compared information across groups rather than between common and unique information. However, previous theoretical work posits that the mention of information does not mean it is considered (Stasser et al., 2000), and it is probable that biases towards favoring common information will also be observed with regards to information consideration.

Bias towards common information

Three primary factors have been identified as reasons for these apparent biases towards common information (Wittenbaum et al., 2004). One reason is probabilistic - more individuals have access to common information (Gigone & Hastie, 1993; Stasser & Stewart, 1992; Stasser, Taylor, & Hanna, 1989). If only one individual has access to information (which is the case with unique information), the onus of remembering that information and sharing it with the group is entirely on that individual, whereas with common information that burden is shared among multiple parties. If one individual fails to bring up a common fact, another team member may introduce it.

The second bias in favor of common information is preference consistency, where individuals are more likely to share information about an option that they deem is most favorable (Gigone & Hastie, 1993; Mojzisch, Grouneva, & Schulz-Hardt, 2010). Hidden profiles are typically designed so that common informational items are ones that support suboptimal individual preferences. Individuals favor their initial preference so would introduce information (i.e., common information) that would support the team choosing their preference or omit information (i.e., unique unfavorable information) that would undermine this preference (Steinel, Utz, & Koning, 2010).

The third bias in favor of common information is social comparison (Festinger, 1954; Postmes, Spears, & Cihangir, 2001). Individuals are more likely to share information that can be socially validated as being in line with others information, thus common information would be discussed more (Parks & Cowlin, 1996). For example, if Individual 1 mentions a fact that supports Option A and Individual 2 also shares a fact in favor of Option A, the desire to be socially validated likely results in Individual 3 disclosing a fact also in favor of Option A rather than in one favor of Option B, even though they may be the sole team members that knows the fact about Option B.

Decision Quality (Output)

In considering team performance on hidden profiles, it is important to highlight one key and well-established theme: when it comes to hidden profile tasks, teams perform poorly. In the first hidden profile study, only 18% of teams were able to identify the best option whereas 83% of manifest groups (groups receiving full information) selected the best option (Stasser & Titus, 1985). These trends have continued in the 30 plus years since those initial studies, and a robust literature exists demonstrating teams' inabilities to solve hidden profiles (c.f., Brodbeck, Kerschreiter, Mojzisch, & Schulz-Hardt, 2007; Schulz-Hardt & Mojzisch, 2012; Wittenbaum et al., 2004). Lu et al.'s (2012) meta-analysis established that teams solving hidden profiles are eight times less likely to choose the best option than a manifest team. In conceptualizing performance on hidden profile tasks, Galinsky and Kray (2004) suggest utilizing an expected solution rate of no higher than 30%.

To address why team decision quality on hidden profile tasks is so poor, I will utilize an information availability and information utilization framework adapted from Schultz-Hardt and Mojizsch (2012).

Information Availability

One explanation for the poor performance of teams when it comes to quality decision making in the context of hidden profile tasks is explained by the findings pertaining to information coverage and focus addressed in the previous section. Logically, if teams do a poor job of disclosing meaningful information, they are not likely to identify the best option. However, initial empirical support for the relationship between discussion quality and decision quality was mixed. Some studies supported the sharing of information as predictors of team decision quality (e.g., Stasser & Stewart, 1992; Stewart, Billings, & Stasser, 1998; Stewart & Stasser, 1998) while others did not find a significant relationship between the two (Greitemeyer, Schulz-Hardt, Brodbeck, & Frey, 2006). Subsequent meta-analyses found discussion quality, measured in broad terms of information sharing, did, in fact, predict decision quality (Mesmer-Magnus & DeChurch, 2009).

An explanation for initial mixed findings stems from the previously mentioned lack of precision and consistency in how information sharing was defined. Meta-analysis using information coverage and information focus operationalized similar to this proposal found that both information coverage and information focus correlated with decision quality (Lu et al., 2012). Comparison between the two operationalizations showed that information coverage had a larger effect size, suggesting that information coverage - the introduction of unique items into conversation - is the more important of the two information sharing measures. This finding lends itself to a minimum information coverage threshold perspective (Lu et al., 2012; Stasser & Titus, 2003).

The threshold perspective suggests that one of the reasons teams perform poorly in making the correct selection on hidden profile tasks is that they fail to introduce a sufficient amount of unique informational items about the optimal option to elevate it from the alternatives. For example, say that Option A has six facts that support it as the best option and none of these facts are common across team members. Conversely, Option B has 4 common facts that support it as the best option that are known by all team members. Assuming that all facts are weighted equally, at least 5 facts from Option A would need to be introduced to the group in order to identify it as a superior alternative.

In reviewing the literature for this dissertation, I found no studies explicitly exploring information thresholds in relation to quality decision making. As part of this dissertation, I examine whether information coverage thresholds predict decision quality. Further, since information coverage and information focus have both been established as predictors of decision quality, this dissertation also evaluates how information consideration, a new variable proposed to evaluate discussion quality, also predicts decision quality.

Utilization of Information

The second explanation for the poor performance in selecting the optimal solution for hidden profiles is what individuals do with the information presented to them. This issue is connected to the previously established initial preference bias (e.g., Faulmüller et al., 2010; Gigone & Hastie, 1993; Schulz-Hardt et al., 2006) where individuals identify an option pre-discussion and favor that preference as they engage in group decision making. The previous section addressed how the pre-discussion preference manifests itself in what information individuals disclose and withhold information that would support their preference. However, the pre-discussion bias extends beyond the exchange of information. When hearing others' information, information that is aligned with an individual's pre-discussion preference is perceived as more valuable (Klocke, 2007). To further demonstrate the dominance of initial preference, research shows that if individuals receive a personalized information set favoring a suboptimal option and subsequently receive all of a scenario's information, individuals still tend to select their initial preference informed by skewed and limited information rather than the optimal option that could be identified from the full set of information (Faulmüller et al., 2010; Klocke, 2007). This points to a major challenge in team decision making. It appears that even if there are no biases in the sharing of information, individuals will still prefer their initial preference and limit a team's potential for making the best decision.

Inputs

The final IPO category is inputs. While inputs are the starting point of the IPO model, I saved them for last as they are the least clearly defined of the three categories in the context of decision making. In part, this is because input variables are amorphous if studied on their own without consideration of their relationship to process and output. For example, evaluating team dynamics without considering discussion quality or decision quality would not provide much insight into the broader topic of team decision making. A second rationale for discussing inputs last is I propose reconceptualizing some variables that have previously been evaluated as moderators between information sharing and decision quality. Specifically, task attributes were framed as a moderator between information sharing and decision quality in previous meta-analytic work (Lu et al., 2012). However, I believe it is also useful to consider task attributes as antecedents to the sharing of information. If a task is structured such that individuals prefer differing options, this will influence how much information individuals share (Schulz-Hardt et al., 2006). This conceptualization falls in line with definitions of IPO categories that establish task characteristics as a type of input variable (Marks, Mathieu, & Zaccaro, 2001). Thus, this review of decision making inputs will include some variables that have previously been presented as moderators. Further, due to the plethora of hidden profile publications, this review will pull from the most recent meta-analytic findings when available and focus on variables relevant to this dissertation topic.

Task Attributes

One key input in team decision making is *demonstrability*. As mentioned above, demonstrability describes the extent to which the task has a right or wrong answer. With hidden profile tasks, highly demonstrable tasks (also referred to as intellective tasks in the literature) have an objective calculation, whereas low demonstrability tasks (also referred to as judgmental tasks) involve subjective interpretations of performance (Laughlin & Ellis, 1986; Mesmer-Magnus & DeChurch, 2009). Meta-analysis showed no significant effect in information coverage between common and unique information on high versus low demonstrability tasks; however, analysis of decision quality effect sizes showed that significant difference exist between task types, with teams completing hidden profiles nearly 7 times less likely to solve a low demonstrability task than a high demonstrability task (Lu et al., 2012).

Another meaningful input pertaining to hidden profiles is *hidden profile strength*. The premise of hidden profiles is that individuals receive information sets that lead them to prefer suboptimal options if not able to access other individuals' information. Hidden profile strength refers to the extent that all team members prefer the same suboptimal option (Kelly & Karau, 1999; Lu et al., 2012), where strong hidden profiles are ones in which all individuals prefer the same suboptimal preference and weak hidden profiles are ones in which there is a heterogeneity of pre-discussion preferences. Meta-analyses of hidden profile strength found that discussion quality, measured as information coverage, was not significantly different between strong and weak task design (Lu et al., 2012). Task strength did influence decision quality, with strong hidden profiles significantly decreasing the probability of teams selecting the best option (Lu et al., 2012).

Non-significant findings between these two task attributes and information sharing preferences favoring common information is somewhat surprising given that these relationships are supported by prior empirical work. Prior meta-analysis on information sharing showed that low demonstrability tasks result in bias favoring common information coverage (Mesmer-

Magnus & DeChurch, 2009; Reimer et al., 2010). Extant work on preference heterogeneity also runs counter to the findings pertaining information sharing, demonstrating that weak hidden profiles, operationalized as pre-discussion dissent, resulted in more unique information coverage (Schulz-Hardt et al., 2006). While this finding comes from a singular study, it is also founded in theory that suggests that individuals in consensus are more likely to make premature decisions (Davis, 1973; Gigone & Hastie, 1993, 1997) and that dissent would create motivation to share unique information (Schulz-Hardt et al., 2006; Schulz-Hardt & Mojzisch, 2012).

The incongruences in the relationship between these task attributes to information sharing while consistency in relationship between task type and decision quality require further attention. Conceptually it is apparent these task attributes affect how teams approach decision making. However, the mechanisms through which these inputs influence output is unclear. I propose that these deficiencies suggest that measuring the process through which decision making is made solely through information pooling is limiting and including additional measures of discussion quality could be beneficial. Also, hidden profile tasks used in meta-analyses may present dissimilarities between tasks that have not been controlled for and administration of parallel hidden profile tasks while testing additional discussion quality variables will provide additional clarity.

Team Attributes

Attributes of teams are another meaningful type of input in team decision making. One such attribute is *motivation*. Initially, poor performance on hidden profiles were considered to be the result of cognitional factors - teams were not able to effectively leverage the information available to them (e.g., Stasser & Titus, 1985). However, turn of the century research on hidden profiles shifted against a single factor focus to recognize that both cognitive and motivational factors were important in the discussion of information and subsequent decisions (Wittenbaum et al., 2004). This early framing of motivation disparaged the use of hidden profiles to study team decision making, arguing that hidden profiles created artificial decision making environments and that real world team members would have numerous reasons to intentionally withhold information for personal benefit. Motivation to not disclose information in real life settings is valid as personally held information may make an individual indispensable as an employee or team member; however, this assertion further validates the shortcomings of teams to make quality decisions as highlighted with hidden profile tasks. Hidden profiles typically present team settings in which individuals receive no incentive to sub optimize the overall performance of the team. Thus, hidden profile studies should stimulate high levels of motivation to disclose information in a decision making setting and yet extensive evidence shows that teams fail to fully leverage the information available to them.

Two particular motivation types have been used to study the compelling finds associated with hidden profile research. The first is epistemic motivation (De Dreu, Nijstad, & van Knippenberg, 2008; Nijstad & De Dreu, 2012), where group members high in epistemic motivation engage in “deep and systematic information processing” (Nijstad & De Dreu, 2012, p. 90). High epistemic motivation has been shown to correlate with teams repeating unique information in discussions and better decision quality (Scholten, van Knippenberg, Nijstad, & De Dreu, 2007). An explanation for this is that epistemic motivation is likely to make individuals more considerate of minority perspectives (Nemeth, 1986), especially if the minorities are perceived to hold expertise relevant to the decision (Sinaceur, Thomas-Hunt, Neale, O'Neill, & Haag, 2010).

The other form of motivation, which represents some of the initial motivational criticism of hidden profiles, is social motivation (De Dreu et al., 2008; Nijstad & De Dreu, 2012). Social motivation is the desire of individuals to act pro-self (i.e., in their own self-interests) or pro-social (i.e., in the best interest of the group). Studies comparing teams primed to be pro-social showed that these teams introduced more unique information, were more willing to revise initial (incorrect) preferences and reached higher quality decisions than their pro-self counterparts (Toma & Butera, 2009). Pro-self motivated teams intentionally withheld information and distorted unique and critical information (Steinel et al., 2010).

These motivation findings provide evidence for evaluating not only what information teams utilize in making their decisions, but also the team attributes that may influence what and how information is used to make decisions. The decision making tasks utilized in this dissertation exclude any incentives for individuals to prefer an individual preference over one that is best for the team. However, they highlight that broader team attributes (such as cohesion and confidence, which are discussed below) likely affect decision making.

Another team attribute that impacts team decision making is *cohesion*. While there are numerous and evolving perspectives on team cohesion (e.g., Baron & Kerr, 2003; Festinger, 1950; Zaccaro, 1991), the broad overarching conceptualization of cohesion is a set of forces or factors that keep capture a team's closeness and willingness to work together or stay together as a group (Beal, Cohen, Burke, & McLendon, 2003; Dion, 2000). Theoretically, the implications of this team attribute are mixed for tasks such as hidden profiles that require individuals to share unique information differing in preference to those held by the team. On one hand, strong cohesion could be an antecedent of conformist thinking that results in groupthink (Janis, 1972). On the other, cohesion could help to foster team climates in which individuals feel comfortable and even encouraged to engage in productive conflict (Tekleab, Quigley, & Tesluk, 2009). Empirical work using the hidden profile paradigm favors the latter. Meta-analysis on the relationship between unique information sharing and cohesion showed that two are significantly and positively related (Mesmer-Magnus & DeChurch, 2009). Notable in this finding is that the Mesmer-Magnus & DeChurch work conceptualized the sharing of information as predicting team cohesion. The IPO model approach used in this dissertation conceives of the two variables in the reverse chronological order, where cohesion influences what and how information is discussed. The relationship between cohesion and decision quality in hidden profile tasks has largely been understudied, but there is evidence to support cohesion results in higher quality decisions (Trindel, 2007) that aligns with extant work promoting cohesion as beneficial to teams needing to select a single solution at the expense of other options (Zaccaro & McCoy, 1988).

A third team attribute relevant to team decision making is *confidence*. Two aspects of hidden profiles make confidence a particularly interesting attribute to examine. First, prior work on decision making found that individuals desire to reach a sufficient level of confidence in a judgement before making a decision (Maheswaran & Chaiken, 1991) and teams increase confidence by discussing (Heath & Gonzalez, 1995; Sniezek & Buckley, 1995). This suggests that teams reporting high levels of confidence are likely to spend more time discussing information than those who report low confidence. However, the relationship between confidence and discussion does not necessarily guide a team to discuss unique rather than common information. Secondly, most hidden profiles tasks are designed to guide individuals to prefer the same suboptimal solution. In line with the prior discussion of dissent, hidden profiles could lead teams to having a false sense of confidence with their preferences and prevent them from thoroughly reviewing all information available to them. Review of the hidden profile literature did find prior research including confidence measures in completing hidden profile tasks (e.g., Savadori, Van Swol, & Sniezek, 2001, who focus on judge advisors in teams) but fails to directly explore the relationships between confidence to decision and discussion quality. A notable exception is a study evaluating concepts of information sharing and decision making that found a negative relationship between confidence and decision quality (De Dreu & Beersma, 2010). This study also found a negative relationship between confidence and information sharing. However, information sharing was operationalized as self-reports on perceived sharing behaviors.

Team Performance over Time

One aim of this dissertation is to utilize the hidden profile paradigm to further understanding of how teams share information, make decisions, and what factors influence these outcomes. However, the major aim of this dissertation is to inform the team decision making literature on the role time plays as teams work together during multiple decision making episodes. As outlined in the Recurring Phase Model of Team Processes (Marks et al., 2001) one IPO episode leads to another IPO episode. Specific to team decision making, this means that when teams make decisions over time, their approach and results should influence future approaches and results. Figure 2 presents a summary of the IPO model for decision making when considering multiple decision making episodes, accounting for the inputs, process, and output variables identified in the previous section of this document.

In my review of the hidden profile literature, I was unable to locate even a single study that examined team decision processes longitudinally. This dissertation's use of hidden profiles over time presents a novel contribution to understand the temporal components of information sharing and resulting decision outcomes. The broader literature of teams over time provides informative considerations relevant to this dissertation. First, it is not surprising that little is known about information sharing and team decision making over time. Team scholars have identified the longitudinal study of teams as one of the most neglected aspects of teams research (Kozlowski & Bell, 2003; Joseph E. McGrath & Argote, 2001). As an example, a review of teams literature in top academic journals found that less than 25 percent of team studies included longitudinal measures in their studies (Mohammed, Hamilton, & Lim, 2009). The current understanding of information sharing and decision making in teams is informed by cross-sectional study design, and applying these findings to teams that work together over time is problematic due to Type I and Type II temporal issues: one-off observations may not hold over time and one-time measurements may underestimate the strength of long-term effects, respectively (Harrison, Mohammed, Mcgrath, Florey, & Vanderstoep, 2003). This dissertation will evaluate how the inputs, processes, and outputs of information sharing and decision making reviewed in prior sections change when teams make decisions over time.

A fundamental consideration in changes that teams experience over time is whether their performance improves as they work together. The broader literature on team performance over time provides competing narratives. There is support that teams working together over time should improve in their performance, as members become more familiar with one another and have more opportunities to improve processes and affect (Dyer, 1985; Harrison et al., 2003). Conversely, it is tenable that teams working together over time will see decline in performance, as more exposure to fellow team members could increase the likelihood of conflict (Arrow & Mcgrath, 1993) or teams may become overly confident in their ability to perform (Goncalo, Polman, & Maslach, 2010; Nijstad & De Dreu, 2012). Thirdly, team performance could remain steady over time (e.g., Chen, Kanfer, DeShon, Mathieu, & Kozlowski, 2009). This is not to say that team processes and dynamics do not evolve but, rather, that their cumulative effect is neutralized. A final and broader conceptualization between time and team performance is that one should not consider time to have a uniform effect on teamwork variables (Kozlowski & Bell, 2003; Joseph E. McGrath & Argote, 2001). This perspective suggests that a team's performance is likely to fluctuate as a team works together over time. This dissertation evaluates performance trajectories specific to both discussion and decision quality as teams work together.

Furthering Science while Acknowledging Criticism

While the hidden profile paradigm is an effective tool to study how teams utilize information to make decisions, it is not without limitations. The primary criticism of hidden profiles centers around whether it is a realistic representation of decision making situations teams might encounter in the real world (Schulz-Hardt & Mojzisch, 2012). Hidden profiles are designed such that there are no incentives for an individual to withhold information at the determinant of the group. This may not always be the case in organizational teams where individuals may in fact have competing motives to withhold information for potential self-benefit (e.g., Wittenbaum et al., 2004), such as maintaining expertise. The frequency of hidden profiles in practice is also uncertain, as there is no clear way to identify hidden profile scenarios where only by combining unique information can a team identify an optimal solution. Simulations assuming that the distribution of information across members follows a random process indicate that the average frequency of hidden profile type information distributions (i.e., a strong hidden profile in which all members prefer the same suboptimal preference) in decision making is 1-5%, with a maximum of 23% (Schultze, Faulmuller, Schmidt-Hieber & Schulz-Hardt, 2012). Despite these limitations, hidden profiles present the only meaningful way to observe synergy in team decision making and thus are invaluable in studying how teams make decisions (Schulz-Hardt & Mojzisch, 2012).

Qualitative Analysis: A Deeper Dive into Decision Making

The previous sections outline the benefits and learnings from using hidden profiles to study team decision making. One additional limitation of the existing decision making literature pertains not to the hidden profile activity, but how scholars have evaluated what happens while teams engage in the task. Specifically, the findings reported in the review of the literature were all generated using quantitative methods. This has resulted in a hidden profile literature that includes more than 100 scholarly articles on the topic but is still "ignorant" about the intricate factors that shape decision making (Sohrab, Waller, & Kaplan, 2015, p. 31). To fully understand what transpires within a team as it makes decisions and how these processes change as teams work together to make decisions, this dissertation includes a qualitative study of teams completing hidden profile tasks. Including a qualitative analysis in the study of the same activity provides new and richer findings about the activity and its processes (Fetters, Curry, & Creswell, 2013). Specifically, a qualitative approach elucidates the causes of currently understood decision making phenomena, as well as identifying novel factors that influence how teams make decisions.

Program of Research Summary

This dissertation aims to further the understanding of how teams make decisions. The dissertation consists of three studies. First, Study 1 develops and validates a sequence of hidden profile scenarios that can be used to evaluate team information sharing and decision making. Study 2 administers these tasks to five teams and evaluates changes in processes and outcomes as teams work together to make decisions. Study 3 reviews these decision making episodes using qualitative analysis to capture additional trends and explanations for fluctuations in team performance.

The subsequent sections will explicate each study in detail. In combination of these three studies, this dissertation provides a rich understanding of mechanisms that inform how teams make decisions. Additionally, this dissertation concludes with implications, limitations, and future directions for understanding and improving team decision making.

CHAPTER 2

Study 1 - Development and Validation of Hidden Profile Scenarios

Since the introduction of the Hidden Profile paradigm in 1985, numerous thematic scenarios have been used to evaluate information sharing and decision making, including selecting the best political candidate (e.g., Stasser & Titus, 1985), solving a murder mystery (e.g., Stasser & Stewart, 1992), and choosing a candidate for university position (e.g., Postmes et al., 2001). Given that the aim of this dissertation is to evaluate information sharing and decision making over time, a sequence of hidden profiles scenarios is necessary to achieve this aim. While existing hidden profiles present compelling scenarios, they are limited in that they are designed as one-off activities and lack related follow up versions. Alternatively, given the disparate themes of existing scenarios, compiling existing tasks into a sequence would likely result in a disjointed amalgamation lacking a cohesive narrative that would engage participants. The purpose of Study 1 is to address this deficiency in available hidden profile materials by developing five parallel and related hidden profile tasks that can be administered throughout a team's lifespan and used to understand how team development affects decision making.

Method

To ensure hidden profile tasks that are both engaging and could remain relevant for an extended period of time, the overarching theme of space exploration was selected. Specifically, five scenarios were conceptualized as follows: Scenario 1 (Gravity) presents team members with three failing systems on the International Space Station, asking them which of the three was most urgent for repair; Scenario 2 (Fire in the Sky) asks a team to decide which one of three identified asteroids poses the greatest threat to Earth and should the focus of a redirect mission; Scenario 3

(Interstellar) introduces the team to three hypothetical planets and the team must decide which planet presents the best attributes for potential human colonization; Scenario 4 (The New World) asks a team to choose between three landing sites on Mars; and lastly, Scenario 5 (Fast Five) requires the selection of a fifth individual to be added to an existing four person space team. Summary of the five hidden profiles is provided in Table 3.

The five hidden profile tasks were designed using a four-phase design. The first phase included the design of the scenario and the development of corresponding informational items. The second phase evaluated the importance and valence of informational items. Thirdly, individuals responded to sets of information containing items about competing options and were asked to indicate both choice preferences and evaluate informational items presented to them. The fourth phase presented finalized hidden profile scenarios to four-person teams. Details of these phases will be expounded in subsequent sections.

Phase 1 - Task Design and Development

Phase 1 consisted of crafting five space-themed storylines and the development of informational items pertaining to each scenario. The topics of scenarios were informed by popular media focusing on space exploration. For example, Gravity (Cuaron & Heyman, 2013), Fire in the Sky (Wizan, Black, & Lieberman, 1993), and Interstellar (Nolan, Obst, & Thomas, 2014) were the titles of recent films about space exploration. New World and Fast Five were titles and scenarios developed through the amalgamation of actual space scenarios and movies. Supporting information was then researched using publicly available data produced by NASA and other prominent space agencies. All details and information presented in the scenarios were intended to be scientifically sound while also comprehensible to those without a science or engineering background. I completed Phase 1 working closely with a team of subject matter experts (SMEs) including two senior faculty members each of whom authored a report on team issues and space exploration for NASA, three PhD students in Psychology, three PhD students in Communication, and four Communication undergraduate students. The larger team worked collaboratively to generate storyline, informational items, and to revise and iterate on one another's content to create clear, engaging tasks that balance the need to provide technical details in a manner accessible to a general audience. Each scenario was designed to present participants with three competing options. Each option then contained informational items that supported selecting that option (good/favorable information), condemning selecting that option (bad/negative information), and neutral items that would not influence option preference. In line with prior hidden profile scenarios, the three options were distinguished from best to worst based on the number of good to bad items they received (Stasser & Titus, 1985). For example, the best option receives 6 good information items and 4 bad informational items, while the worst option receives 6 bad informational items and only 4 good informational items. The middle option receives an equal amount of good and bad information (3 and 3, respectively). A similar distribution of good, bad, and neutral items was included in all five scenarios, presented in Table 4.

To ensure sufficient quality informational items were created for each option, Phase 1 included the construction of double the informational items needed that would be needed in the finalized scenario. For example, Table 4 shows that the best option will consist of 6 good, 4 bad, and 4 neutral items, totaling 14 total items; twice that number of items were created. Thus, Phase

1 resulted in approximately 80 informational items for each of the five scenarios. No participants were necessary for this phase of the study.

Phase 2 - Item Evaluation

Phase 2 consisted of validating the informational items developed in Phase 1. Participants received a survey that included the decision scenario, the three options, and a large pool of items corresponding to each option. For each item, participants rated: how important do you think this information is (1= extremely unimportant, 7 = extremely important) and whether the item supported your choosing the corresponding option.

Participants. Participants were recruited using Amazon's Mechanical Turk. Mechanical Turk provides sample participants significantly more diverse than typical American college students, provides data at least as reliable as traditional methods, and allows for speedier iterations of experiments (Buhrmester, Kwang, & Gosling, 2011; Mason & Suri, 2012). To be eligible to participate in Phase 2, participants had to have completed at least an undergraduate degree and be based in the United States. In addition to completing the survey pertaining to informational items, participants were assigned an attention check in which they were required to identify the three options in a given scenario. A total of 154 participants both completed the survey and passed the attention check, with the number of participants ranging between 30 and 32 participants for each scenario.

Item Testing Results. A total of 147 items (29 items for scenarios 1-3 and 30 items for scenarios 4 and 5) were retained for Phase 3 testing. These items received at least 65% agreement from participants on intended valence and importance ratings ranged from 1.116 to

6.663. Note this range includes neutral items, which are intended to have low importance scores. Further details on items retained for Phase 3 are provided in Table 5.

Phase 3 - Information set evaluation.

Phase 3 was designed to test sets of information and to evaluate the decisions they generated from individual respondents. There were two types of information sets evaluated during this phase for each scenario. The first set represented an individual with the full set of informational items (29 for scenarios 1-3 and 30 for scenarios 4-5). The second distributed information across four profiles (each depicting a role in the hidden profile scenario) so that each set contained between 22 and 24 items. Similar to the previous phase, all participants were asked to evaluate the items they received. Additionally, participants were required to rank the three options in their scenario from 1 (best) to 3 (worst) and provide comments on how they reached their conclusion.

Participants receiving a full information list of scenario items were expected to identify the best option as their preference. Participants receiving role based information were expected to function differently. For scenarios 1-3, informational items were distributed such that they would lead an individual to identify a worst option as their preference. An example of how information was distributed is provided in Table 6. Scenario 4 and 5 utilized a modified item distribution approach. These scenarios were designed to create disagreement between initial preferences (i.e., a weak hidden profile; Kelly & Karau, 1999). Information was distributed into information sets in these scenarios with the intention of having two individuals prefer the worst option, one individual prefers the middle option, and one individual prefers the best option. An example of this distribution is provided in Table 7.

Participants

In Phase 3, participants were also recruited via Mechanical Turk. Eligibility requirements were the same as in the previous phase with the additional filter that Phase 2 participants were excluded from participating in Phase 3. Phase 3 also contained attention checks. In addition to being able to identify the three options within a scenario, participants randomly were asked to accurately identify to which option the informational item they were reviewing corresponded.

Phase 3 required between two and five rounds of testing and editing to ensure that both items and item sets performed as expected. In addition to importance and valence scoring, participants' free responses for selecting their preferred options were used to modify items and the distribution of items across roles. When items needed modification, both the full information set and role sets were subsequently tested to make sure revisions did not create unanticipated shifts in item set performance.

A total of 1,460 participants completed information set surveys and passed the attention checks in this phase. Of these, 36 respondents were eliminated from the validation based on the quality of their responses to how they ranked their preferences (e.g., “I ranked items based on alphabetical order” or “I guessed). A total 1,424 responses were ultimately considered in Phase 3 validation of this study.

Information Set Results

Phase 3 validated that when receiving full information, individuals selected the intended best option at least 50% of the time, with a range between 54% and 80%. Additionally, Phase 3 helped to calibrate how informational items to be distributed across four individuals in a team. For scenarios 1-3, the intention is that individuals would favor the same suboptimal decision.

That suboptimal decision was selected by at least 70% of participants for each of the three scenarios. Scenarios 4 and 5 represent an alternative configuration where individual pre-discussion preferences are distributed across the three options. The finalized versions of Scenarios 4 and 5 achieved this goal, with preferences for any specific option ranging between 27% and 35%. Table 8 presents a summary of option preferences across the four information sets as well as results when individuals are presented with a full set of information.

Phase 4 - Team Testing

The final phase of Study 1 validated all five scenarios in a team context, where individuals receive their allocated role information, make a preference, and then come together as a team to make a shared decision.

Method

Graduate students were recruited to complete the task in 4 person teams. None of these students were involved in the development of this task but were broadly familiar with the hidden profile task paradigm. The student teams helped both evaluate whether the tasks worked as intended in a group setting as well as provide feedback on potential points that need clarity or restructuring.

Team Testing Results

The graduate student teams that completed the tasks were able to identify the best option in all five scenarios. This performance is not indicative of how most teams will perform on this task as the participants were both familiar with the paradigm and were made aware that their participation in completing the tasks was part of a validation process. However, having the tasks completed in a group setting confirmed that the optimal solution could be identified even when individuals receive limited information. Additionally, feedback from the participants confirmed that the scenarios provided a level of detail that presented an engaging and challenging team decision simulation.

Phase 5 - Scenario Revision

The five tasks were re-evaluated one year after initial development in preparation for another round of data collection. The motivations for re-evaluation were three fold. First, feedback from Gravity indicated that choosing between three failing systems of disparately different nature (i.e., oxygen systems compared to computer systems) may bias respondents toward oxygen, a life or death resource needed for human survival, despite facts explaining it is not the most vital or time sensitive of the failing systems. Thus, Gravity was reconceptualized such that participants must select which one of the three modules on the International Space Station is in most urgent need of repair. The revised scenario presents characteristics of the three modules that influence quality of life for the crew and the ability to achieve mission success but removes the perception that the selection of a particular option is life threatening.

The second motivation for revisiting the tasks was to redesign New World and Fast Five such that all team members favor the same suboptimal option. The existing versions of the scenarios distributed information across roles such that individuals favor competing pre-discussion preferences. A team configuration where individuals differ in their pre-discussion option preference (i.e., a weak hidden profile) offers a distinct decision making scenario compared to one where all team members prefer the same suboptimal option (i.e., a strong hidden profile; e.g., Lu et al., 2012). Since the focus of this dissertation is to observe how decision making evolves over time, removing the distinction of the weak hidden profile tasks will provide more comparable decision making episodes and provide additional clarity of the temporal effects on teams sharing information and reaching decisions.

The third motivation was simply to identify ways to improve the scenarios. In particular, I wanted to ensure that if given full information, an individual would select the best overall preference at least 66.7% of the time. Since there are 3 options, chance alone would result in any given option being selected 33.3% of the time. In order to strongly justify that the “best option” is in fact objectively better than the other two, I decided to increase the validation threshold to 66.7% - so that participants choose it at twice the rate that would result by chance alone. Examining Table 8 shows three of the existing scenarios fell below this 66.7% target. The initial validation showed that participants with complete information chose the “best overall option” most of the time, but less than 66.7% of the time. The percentage choosing the “best overall option” in each scenario were initially: Gravity (54%), Fast Five (57%), and Fire in the Sky (65%).

Method

Scenarios were reviewed using the approach outlined in Phase 3. Initially, each of the five existing scenarios were evaluated using 100 Mturk participants receiving full information sets. If a scenario did not reach the 66.7% target, informational items were revised based on respondent feedback and scenarios were re-administered until the scenarios reached the 66.7% full information preference rate. Subsequently, each scenario’s role information sets were updated and also administered with the goal of 66.7% of participants selecting the worst overall option as their individual preference. In total, the scenarios required between 1 and 7 rounds of administration to achieve the desired total information and role information preference rates.

Scenario Revision Results

The revisions associated with Phase 5 improved the existing decision making scenarios by ensuring that the scenario and information provided within lead demonstrate a preference for the best overall option at twice the likelihood of chance. Role information has also been adjusted such that all the decision scenarios present a strong hidden profile in which all team members are likely to prefer the same suboptimal option. Lastly, one of the decision making tasks, Gravity, has been revised to present participants more comparable options from which to decide. Table 3 includes the updated description of the Gravity scenario.

The revisions of Phase 5 are not a suggestion that the existing decision making tasks developed in Phases 1-4 are deficient. This fifth phase corresponded with an additional data collection and an opportunity to review the tasks such that the tasks were all of a similar information structure. Increasing the target preference rate of the optimal option was an opportunity for continuous improvement on tasks to study how teams make decisions. Further, the revised tasks from Phase 5 are not intended to be direct replacements for the previous versions. The design of the original Gravity with its disparate failing systems and the distributed individual preferences of the original New World and Fast Five provide unique tools through which to study team decision making that are thoroughly validated, engaging, and topically coherent. As such, both the original and revised tasks will be included in the study of team decision making in subsequent chapters of this dissertation.

Contribution

Study 1 generated five parallel hidden profile scenarios that can be used to study how a) teams share information and utilize this information to make decisions and b) how information sharing and decision making evolves over time. The latter is a particularly novel contribution to the domain of decision making as review of the hidden profiles in existing literature are used in one-off settings and represent disjointed topics and themes that hinder their sequential administration to teams. Further, these five tasks are easily adaptable to both electronic and hard copy versions. This coupled with a universally appealing theme of space results in compelling tasks that can be used in future decision making studies beyond that of this dissertation.

CHAPTER 3

Study 2 - Team Discussion and Decision Making over Time

Do teams improve or decline in their decision quality over time? While much of the research on team decision making focuses on one-shot decisions, most teams in organizations make repeated decisions. An open question with real world importance is how decision dynamics unfold over time. We might expect that teams get better at making decisions, that they learn how to efficiently process information and share perspectives, that they learn what arguments will and will not fly, and that over time their capability improves. Conversely, we might expect the opposite. Perhaps teams together for a long time stop listening to each other, they tune out information, or their intense relationships introduce baggage and bias into the process of weighing alternatives and arriving at a decision.

In order to explore these dynamics, Study 2 utilized the hidden profile decision making tasks created in Study 1 (Chapter 2) to study information sharing and decision making in 8 teams living and working together in a space analog at NASA in Houston, TX. Through utilization of these tasks, this dissertation builds on existing knowledge pertaining to how teams discuss information, how this information influences the quality of team decisions, and antecedents that influences discussion and decision quality. Additionally, these tasks were used to provide insights into how the relationships between the inputs, processes, and outputs evolve over time. This chapter explores two research questions.

RQ1. What are the ways in which the components of team discussion influence decision quality?

RQ2. How do these mechanisms of decision making evolve over time?

Components of Team Decision Making

The first set of hypotheses posited to answer RQ1 focus on building upon existing understanding of the mechanisms through which teams make decisions. These mechanisms include what information teams introduce into discussion, how teams discuss this information, and how team discussion informs team decisions.

Discussion Quality (Process)

The most commonly researched aspects of decision making using the hidden profile paradigm focus on process and outcomes (Lu et al., 2012). A distinction between this dissertation and that of extant hidden profile research is that the process phase of decision making is typically conceptualized strictly as “information sharing” (see examples in Table 1) whereas this dissertation proposes a broader orientation of discussion quality that includes the information available to the team during a decision making episode (information coverage), the utilization of information in the discussion (information focus), and whether information expressed is recognized by other team members (information consideration) - a new evaluation introduced in this dissertation.

Common Information Bias. One of the most established aspects of team decision making captured through the use of hidden profile tasks is the bias of teams towards discussing common information over that of unique information (Lu et al., 2012; Mesmer-Magnus & DeChurch, 2009; Schulz-Hardt & Mojzisch, 2012; Stasser & Titus, 1985). Common information is information known to all members of a team and unique information is known only to a single individual. Common information bias means that teams favor common information over unique information. This bias shows in two ways. The first is that common information is more likely to be introduced into conversation than unique information. This dissertation refers to the information introduced into conversation as information coverage. The second form of common information bias is that teams spend more of their discussion talking about common information. This dissertation refers to this type of difference as information focus.

The first hypothesis in this study is a replication of the information sampling bias from previous research. I expected that the two established measures of discussion quality (i.e., information coverage and information focus) to adhere to the common information bias trends established in the literature. Additionally, I introduced a new construct to evaluate team discussion that measures if team members mention information first introduced by others. I called this measure information consideration and I expected it to follow the trends of the two other discussion quality measures. Accordingly, I proposed:

> *Hypothesis 1: Team discussions favor common over unique information in terms of information coverage (H1a), information focus (H1b), and information consideration (H1c).*

Valence Bias. While prior research established that common information dominates group discussion, research has yet to meaningfully explore the effect of the valence of information on team discussion. Valence of information refers to whether the informational item supports selecting an option (i.e., positive information) or provides support to not select an option (i.e., negative information). Two prior studies found that negative information is more likely to be shared than positive information (Dose, 2003; Stewart, 1998). However, both studies are plagued by methodological limitations including confounds between positive and negative information with common and unique information and disproportionate amounts of positive to negative informational items. Both studies also utilized a personnel hiring scenario as the team decision. Stewart and colleagues speculated that a hiring decision could make negative information more salient than in other decision scenarios (Stewart, 1998; Stewart & Stewart, 2001), bringing into question whether the findings from these studies hold true across various decision types.

This dissertation examined whether indeed teams demonstrate a bias towards negative information. In line with Stewart's findings and broader research suggesting individuals find negative information more important than positive information (e.g., Klein 1991; Skowronski and Carlston 1989; Vonk 1993), I posited that negative information is more likely dominant in team discussion than positive information. I expected this negative information bias to be consistent across the three measures of discussion quality (information coverage, focus, and information consideration). Thus, I posited:

> *Hypothesis 2: Team discussions favor (H2a) negative unique information over positive unique information and (H2b) negative common information over positive common information, in terms of both information coverage, focus, and consideration.*

Decision Quality (Outcome)

Hidden profiles are designed so that the worst overall option is the one most likely to be preferred by individuals before group discussion and the information that would help a team identify a better alternative is dispersed among the team. One of the explanations for the poor performance of teams on hidden profile tasks is related to a necessary threshold of information exchange about the optimal option needing to be reached in order to identify it is a superior alternative to the pre-discussion preference (Lu et al., 2012; Stasser & Titus, 2003). This means that individuals need to introduce enough unique information about what they think are suboptimal options to help them realize that the option they initially preferred is not the best and a hidden superior alternative exists.

For example, on a four person team, each team member received the same three positive pieces of information about Option A and one unique positive piece of information about Option B. The total positive pieces of information for Option B equal to four and are greater than the total pieces of positive pieces of information for Option A. However, each individual would need to share their unique information about Option B to reach a total greater than what each individual already knows about Option A. Thresholds represent the number needed to identify a better alternative and can vary based on the hidden profile task. One of the theories of why teams do poorly on hidden profiles is they do not introduce enough of their information to reach this threshold.

This explanation lends itself to broader problem solving theory that competing options are selected based on the net valence of the options, known as the group valence model (GVM; Hoffman, 1961, 1979; Hoffman & Kleinman, 1994). The GVM provides three key concepts related to decision making that have implications for the RQs posed in this dissertation. First, for an option to be considered a viable solution, it must reach some adoption threshold (Hoffman, 1961, 1979; Hoffman & Kleinman, 1994). This adoption threshold represents some difference between the positive and negative valence of items included in a discussion and the specific amount would vary by situation. Second, the GVM demonstrates that teams select the option with the greatest positive net valence, which is the difference between positive and negative valence (Hoffman & Kleinman, 1994). Third, it is the valence of options established as a team, rather than individuals' valence of the options, that determines which option will be selected (Hoffman & Kleinman, 1994). This third finding is particularly relevant for hidden profile research because it supports that teams can overcome individual pre discussion suboptimal preferences to identify the best option.

Hoffman's empirical GVM work did not use hidden profiles but rather a straightforward personnel decision making task that required a team to select one of five potential employees (Hoffman & Kleinman, 1994). Measures of valence were calculated by counts of positive and negative statements made about an option (Hoffman, 1979; Hoffman & Kleinman, 1994), rather than the content of those statements, which is fundamental to the hidden profile paradigm. Additionally, Hoffman's work with the GVM focused on how teams solve a problem or make a decision, rather than the quality of that solution or decision. As part of this dissertation, I examined whether indeed principles of the GVM apply to hidden profile decision making tasks and will incorporate the nuance of evaluating discussion based on information coverage, focus, and consideration as distinct measures of option valence.

Building on Hoffman's work, I expected that net valence will predict which option teams select in hidden profile decision making tasks. Each option's net valence was calculated as positive to negative information included in the team decision, measured using the three discussion quality variables of information coverage, focus, and discussion. And, in line with Hoffman's findings, I predicted that the option with the highest net valence relative to the alternatives will be the one teams select.

As an exploratory analysis, I evaluated whether hidden profile decisions lend themselves to some adoption threshold (AT). The evaluation of thresholds relied on option valence scores outlined above and were examined in two ways. First, I explored whether team option preferences all meet some net valence score. For example, Hoffman and Kleinman (1994) found that all selected team options in their personnel hiring scenario possessed a minimum net valence score of 15 in terms of positive to negative statements about that option. I investigated whether an adoption threshold exists for selected options' information coverage, focus, and consideration scores. An information coverage threshold suggests some amount level of total positive to negative information needs to be achieved for teams to consider that option the best (e.g., preferred team options are ones whose difference in positive to negative information introduced in discussion exceeds 5), and a threshold for information focus indicates that all preferred options meet some level of conversation dominance (e.g., teams select the option whose discussion constitutes at least half of all the points discussed). I also examined whether team preferences meet some information consideration threshold, where a certain amount of unique information must be acknowledged by a team member other than the one who initially presented it (e.g., teams select options which have at least three informational items supported by an individual other than the one who shared them).

The second exploratory analysis accounts for the design of hidden profiles to include an optimal solution that needs to be discovered by a team. Using the same evaluations of discussion quality (i.e., information coverage, focus, and consideration) as in the previous exploratory analysis, I attempted to determine whether some threshold was achieved in cases when teams indeed select the best overall option.

Hypothesis 3: Teams select the option with the highest net valence (positive information shared relative to negative information shared) as their preferred option as measured via (H3A) information coverage, (H3B) information focus, and (H3C) information consideration.

Exploratory Question 1: Is there an information coverage, focus, and/or consideration threshold that all options selected by a team meet?

Exploratory Question 2: Is there an information coverage, focus, and/or information consideration threshold for when teams select the optimal solution as their preference?

Influence of Time on Decision Making

The second research question and corresponding hypotheses focused on how team decision making evolves over the life of the team. The teams literature contains extensive research on team decision making and a growing amount of work on team function over time, but there is little overlap between the two, particularly through the fidelity offered by the hidden profile paradigm.

Performance Trends

Team attributes, processes, and outcomes are dynamic phenomena (Kozlowski, 2015). The evolution of these phenomena offers four competing trajectories: 1) improvement over time, 2) degradation over time, 3) remain constant over time, and 4) fluctuate over time. For example, as a team works together, members may become more committed to one another, resulting in an increased level of cohesion. Alternatively, as teams work together, they may encounter more conflict and become less cohesive. Even these examples are overly simplistic conceptualizations of what transpires as teams as teams work together. If observing only two time points, conclusions can support one of the first three trajectories proposed; however, an underlying premise of these conclusions is the linear development of teams and team performance. Empirical and theoretical work warns against assuming that time imposes a uniform effect on variables related to teamwork (Kozlowski, 2015; Sonnentag, 2012). A noteworthy benefit of creating five decision making tasks described in Study 1 is that the dynamics of team decision making can be observed over multiple time periods. Thus, this dissertation was able to capture fluctuations in mechanisms that drive team decision making. Accordingly, the temporal hypotheses of this dissertation included nonlinear predictions. Further, I posited that these trajectories corresponded to the input, process, and output variables of team decision making. The rationale for this thinking is explained below.

Discussion Quality (Process) Temporal Trajectories

As previously discussed, temporal research on decision making, particularly relying on team members exchanging information as is the case with hidden profile tasks, is lacking. Thus, predictions of trends pertaining to discussion quality must look to broader literature. Work on team communication found that new teams communicate less effectively than teams who have worked together over time (Foushee & Helmreich, 1988). Additionally, prior work on familiarity found that knowing one’s teammates facilitates performance (Harrison et al., 2003). These findings suggest that working together is likely to improve team decision quality.

However, research findings also warn of potential negative effects on discussion from prolonged collaboration. As teams work together over time, they may become too confident in their ability to make quality decisions (Leedom & Simon, 1995). This could result in them not fully examining all the informational items available to the team when making decisions. Interestingly, a study of couples found that when imposing a system that required each individual to remember a certain task (as would be the case in a hidden profile), couples who knew each other intimately performed poorer than those who were strangers (Wegner, Erber, & Raymond, 1991). Combining these findings, I posited that team discussion quality initially increases and then reaches a point at which it begins to decline over a team's life span. An initial increase and subsequent decrease in discussion quality aligns with prior work on communication (and corresponding team performance) of teams (Katz & Allen, 1982).

Hypothesis 4: Discussion quality, construed as information coverage (H4a), focus (H4b), and consideration (H4c), initially increase and subsequently decrease as teams make decisions over time.

Decision Quality (Outcome) Temporal Trajectories

The premise of hidden profile tasks is that the discussion of information (or lack thereof) is the mechanism that drives quality decision making in teams. Without the discussion of unique information, teams cannot logically identify the best option. Thus, the trends predicted in Hypothesis 4 pertaining to discussion quality should guide team preferences, and the decision quality of teams should follow a similar pattern to that of discussion quality. I posited that team decision quality will follow the trends of discussion quality, initially increasing and subsequently decreasing as teams work together over time.

Hypothesis 5: Decision quality initial increases and subsequently decrease as teams engage in decision making over time.

Method

Sample

The five hidden profile tasks developed and revised in Study 1 were administered to 8, 4-person teams participating in NASA's HERA (Human Exploration Research Analog). HERA is a two-story, four port unit habitat that represents an analog for simulation of space exploration missions (Cromwell & Neigut, 2014). This study includes five teams participating in Campaign 4 (C4) and three teams from Campaign 5 (C5). Each team was involved in 14 days of pre-mission training then ingressed into the HERA habitat for 45 day missions. The hidden profile tasks were administered on mission days -4 (training), 6, 14, 20, and 34. One of the teams from C4 was not able to complete the full 45 day mission due to Hurricane Harvey and were removed from the simulation on mission day 23, thus only completing four hidden profile tasks.

There were differences between Campaigns 4 and 5. Each campaign has a set of science investigations that differ from campaign to campaign. One notable difference was the emphasis on sleep deprivation in C4 and privacy in C5. Crews participating in C4 operated under sleep deprivation conditions that allowed only 5 hours of sleep on the days teams completed the decision making tasks. The sleep deprivation condition was removed in C5; however, the HERA habitat in C5 was modified to reduce privacy and overall usable space (Edwards & Abadie, 2019).

HERA eligibility requirements dictated that all participants were between the ages of 26 to 55, no taller than 6'2", possessed an advanced degree an advanced degree or equivalent years demonstrating technical skills, and demonstrated motivation and work ethic similar to the "Astronaut stereotype" (Cromwell & Neigut, 2014). Teams varied in their gender composition.

Two of the teams consisted of four males (4M), two teams were majority male, composed of three males and one female (3M, 1F), and four crews were gender balanced, with two males and two females (2M, 2F).

Procedure

The procedure for teams completing the hidden profile decision making tasks was as follows. Participants were provided a link to a Qualtrics survey. Upon accessing the survey, they were asked to identify their role on the team - previously established as part of HERA training. Role selection dictated which information set individuals received and to ensure all four team members received unique information sets. Participants were allotted 15 minutes to read the scenario description, review information for each option, and select an option they think is optimal, second best, and the worst. After all team members submitted their preferences, the team was given 25 minutes to discuss the scenario collectively and select an optimal option as a team. Teams needed to collectively agree on an option, but after selecting the preferred team option, each individual was asked which option they considered best based on information they received and group discussion.

Subsequently, individuals were provided with a list of informational items and asked to identify which pieces of information were discussed as a team. This list includes all the unique informational items distributed among the team members and six distractor items that were not included in the scenario. Upon completion of task specific questions, individuals completed questions evaluating team processes.

Measures

Discussion Quality

I measured three distinct variables pertaining to discussion. *Information coverage* captured what percentage of information was introduced into a team's discussion (Larson et al., 1996; Lu et al., 2012). Information coverage was scored as a percentage with the numerator representing pieces of information introduced and denominator the total pieces of information contained in the design of the task. Thus, the numerator is determined by team performance and the denominator is an objective number that would apply to any teams completing the task. For example, if a decision making task includes 12 pieces of unique information but only 6 pieces of information were introduced in the discussion, the team would receive a unique information coverage score of .50 (6 divided by 12).

Information focus evaluates the percentage of team discussion that focuses on a specific type of information (Lu et al., 2012; Stasser & Stewart, 1992). This score includes both the initial introduction of a piece of information and any subsequent mentions of that information out of total information mentioned. Information focus is also a percentage score, but unlike information coverage, the denominator is determined by the team's discussion, rather than the design of the decision making task. For example, if a team discussion includes 10 mentions of common information and 5 mentions of unique information, their common information focus score is .67 (10 divided by 15).

Information consideration is a novel variable introduced by this dissertation that aims to capture how information introduced by one team member informs team discussion and subsequent decision making. Information consideration leverages the information coverage and focus concepts and provides two measures of consideration: consideration coverage and consideration focus. The difference between these consideration scores and the previously mentioned information coverage and information focus measures is they only account for mentions of information by an individual other than the one who introduced them in the discussion. For example, if team member 1 introduces a piece of information that is neither acknowledged nor repeated by any other team member, that piece of information is not counted towards that team's consideration coverage or consideration focus score.

To obtain discussion quality scores, transcripts of the decision making tasks were analyzed by two coders, an approach used in extant scoring of hidden profile studies (e.g., Klocke, 2007; Toma & Butera, 2009). Each coder independently reviewed the task and counted every time a piece of information included in the scenario design was mentioned. A mention was defined as an instance during which an individual introduced a piece of information, affirmed information, acknowledged not having that information, or posed a question pertaining to a piece of information. Counts of mentions were contained per individuals' statements, which were conceptualized as an uninterrupted communication by an individual. As such, if an individual made a statement that mentioned a piece of information twice, this mention was only counted once. The only instances a statement received two mentions counts pertaining to the same information item was if an individual provided an insight about a piece of information and also asked a question about a piece of information. The rationale for this approach is that a question sparks additional attention to the informational item above that of disclosing a fact. Lastly, if a mention changed the meaning of that informational item from the original intent (i.e., changing the valence, probability of an outcome, or connecting the information with the wrong decision option), it was not counted as a mention.

After independently completing an initial scoring of a task, coders met to review any discrepancies. The coders discussed all discrepancies until consensus was reached. The most common sources of discrepancies included determining whether a piece of information was shared without its meaning being changed, whether an utterance was specific enough to connect to a specific informational item, and whether a mention was a statement or question. Once one iteration of the task (i.e., one crew's episode) was scored and discussed by the coders, all other crews' performance of that task were scored and reviewed before moving on to the next task. For example, all sessions of Interstellar were scored before moving on to score Gravity. In total, 4162 statements were analyzed across the eight crews. When working independently, the two raters scored 3432 (82%) of these statements identically. All discrepancies in scoring were reviewed by both raters and discussed until a consensus was reached on how each statement should be scored. The consensus rating was used in the analysis.

The result of this scoring provided team counts of all the informational items on each decision task. Further, these informational items were matched with corresponding attributes such as which of the three decision options the information corresponded with, the valence of the information, and whether the information was common or unique. Information counts were then aggregated by these labels to generate discussion quality scores pertaining to information coverage and information focus.

To generate consideration coverage and consideration focus scores, as part of the transcript analysis process, I identified the crew member first to mention each piece of information. I then created a second set of counts where all mentions by that individual for that specific information item were removed. For example, Individual A was the first to introduce

Information 1 into a conversation and contributed a total of 4 mentions about Information 1 during the conversation, the team's mention counts for Information 1 were reduced by 4. This secondary set of counts was used to develop consideration coverage and consideration focus scores.

It should be noted that only informational items that were positive or negative in valence and common or unique in distribution were included in discussion quality scores. Campaign 4 teams completed two tasks that contained partially shared information, where some but not all teammates received the information as part of their pre-discussion information set that was either positive or negative in valence. Since partial information was not a primary focus of this dissertation and only some teams completed tasks that included non-neutral partial information, it was excluded from the calculations of discussion quality except for determining option valence scores (Hypothesis 3). Additionally, teams received some unique information that was neutral (e.g., "The asteroid was being actively studied by scientists at the Dearborn Observatory in Illinois"). Coding of transcripts revealed that some teams intentionally made an effort to exclude the neutral items from their discussion. Because neutral information also was not intended to affect decision, it was excluded from discussion quality calculations.

Decision Quality

Decision quality was measured via a team's response to which of the three options they selected as their preference to a scenario. The most recent meta-analysis on hidden profile decisions, in line with prior research, utilized a yes/no approach to evaluating decision quality (Lu et al., 2012). However, the scenarios developed in Study 1 contain three options to choose from with one of the options is intended to represent a middle option when its positive and negative information is considered, so I also evaluated decision quality using a yes/no approach to whether the team chose the best option, as yes/no approach as to whether the team avoided the worst option, and a score to measure of whether teams selected the best (2), middle (1), or worst option (0).

Time

The five administrations of the decision making tasks occurred on HERA Mission Days -4, 6, 14, 20, and 34 for both Campaign 4 and Campaign 5 teams. These days were converted to time point variables of values 1, 2, 3, 4, and 5, respectively, for analysis.

Option Valence

Option valence scores were calculated for each time a team completed a decision making task. Good information mentions received a value of +1 and bad information received a value of -1. Option valence scores were derived using similar concepts to discussion quality (i.e., observed information coverage, focus, and consideration) to generate a team's positive and negative informational item score for each of the three options. These positive and negative scores were aggregated to generate a *net option valence score* for each option.

For example, if Option A has 3 positive informational items and 4 negative informational items mentioned during the team's discussion, the coverage net valence score for Option is -1 (3 positive items minus 4 negative items). From a focus perspective, if there are 25 item mentions and 7 of them are positive while 10 are negative, it would have a coverage net valence of -3. Neutral items were excluded from net valence scores since they are designed to not influence team preferences, making each neutral item's valence score 0.

Option valence scores were used to evaluate direct relationships between the various valence configurations (i.e., information coverage and focus) and team performance on decision making tasks, as discussed in Hypothesis 3.

Adoption Thresholds

Adoption thresholds were analyzed by reviewing teams' decision making results and corresponding valence scores. This approach was modeled after work by Hoffman (e.g., Hoffman, 1961; Hoffman & Klein, 1994) that examined teams choosing between potential personnel hires and found that all team preferences met a valence threshold (of +15 in their study).

It is worth noting that Hoffman's work on the adoption threshold was proposed in the broader context of team problem solving where teams could decide not to choose a preference, if the options fail to reach an adoption threshold valence (Hoffman, 1961). Since the tasks used for this dissertation require teams to make a decision/selection, teams are likely not considering whether their options meet some threshold indicating a viable solution but focus solely on which option is best relative to others. Thus, the option valence adoption threshold I described above for all selected options may represent a minimum valence value surpassed by some options that were not selected as a team's preference. To better understand the presence of adoption thresholds in decision making tasks that require a preference be selected, I examined a secondary form of adoption threshold that identifies a minimum valence value that only selected options reach.

Team Processes

In addition to the aforementioned team decision making variables described above, this dissertation includes a number of team process variables that measure the climate of the team prior to engaging the five team decision making tasks. These process variables are broad team process measures that were administered throughout the life of the team. These are established measures and are not meant to serve as additional theoretical relationships but rather as additional considerations that can help to understand the mechanisms that shape team decision making.

As part of compiling team processes scores, I include reliability and analysis scores, including intraclass correlation coefficients (ICC1 & ICC2; Bliese, 2000) and within-group interrater reliability ($r_{wg(j)}$; James, Demaree, & Wolf, 1993; Newman & Sin, 2018), as appropriate when referent shift items are reported by individuals to reflect a shared team property. ICC1 and 2 values and $r_{wg(j)}$ were computed for the following team constructs: team identity, team action processes, team viability, team implicit coordination, and team status conflict. Cutoff values for Rwg are typically set at 0.70 (James et al., 1993) and ICC(1) values above 0.10 are generally considered large enough for aggregation (Bliese, 2000). These constructs are all defined in detail below.

General Team Process Measures

General team process variables consist of measures from a broader team processes survey administered regularly throughout the team's HERA campaign. The five team process constructs that were evaluated as part of this dissertation are team identity, team action processes, team viability, team implicit coordination, and team status conflict.

The administrations of general team processes results included in this dissertation are ones most proximately completed prior to when teams complete the decision making tasks; the exact days of the general team processes survey in this study were on HERA Mission Days 5, 10, 15, and 33 for Campaign 4 and Mission Days 4, 10, 18, and 31 for Campaign 5. The first decision making task is completed during pre-mission training without a corresponding general team process survey so general team process measures were available only for decision making episodes 2 through 5. A summary of when team process surveys were completed by the teams in relation to when they completed the decision making tasks are provided in Table 9 (for Campaign 4) and Table 10 (for Campaign 5).

Team identity. The team identity measure is adapted from work by Hinds and Mortensen (2005) and is the extent to which individuals see themselves as interconnected to their team. Participants were asked to "select the picture that best describes your relationship with the entire crew" from six graphical representations between self and team (see Figure 3). The pictures were scored on a scale of 1 (very different) to 6 (very close) where a 1 indicates a very weak team identification and a 6 indicates very strong team identification. Identity is elicited from each individual crew member and is aggregated at the team level. For team identity, aggregation metrics support aggregation to the team level. Across the four time points, r_{wg} (median) ranged between 0.83 and 0.91, and ICC(1) values ranged between 0.44 and 0.68, exceeding the minimum needed to justify aggregation. Scores were averaged across team members for use in subsequent analyses. Table 11 includes all the aggregation metrics for team processes at each time point.

Team Action Processes. Team action processes are the interdependent acts of team members directed toward goal accomplishment (Marks, Mathieu, & Zaccaro, 2001). The team action processes measure is a response to the prompt of "on work tasks, your crew actively works to..." on five processes: 1) monitor how well we are doing, 2) balance the workload among the team, 3) assist each other when help is needed, 4) communicate well with each other, and 5) smoothly integrate our ideas. The response scale for each item includes 1=never, 2=rarely, 3=occasionally, 4=sometimes, 5=frequently, 6=usually, and 7=every time. Coefficient alpha was computed to determine acceptable reliability of the five item scale. Cronbach's alpha suggests that this measure is reliable (Time 2 = 0.86, Time 3 = 0.88, Time 4 = 0.88, Time 5 = 0.95) and these time points correspond to the order of completed decision making tasks, with Time 2 corresponding to the second decision task. Metrics support aggregation to the team level. Across the four time points, r_{wg} (median) ranged between 0.84 and 0.95 and ICC(1) values ranged between 0.22 and 0.65 (see Table 11), exceeding the minimum value needed to justify. Scores were averaged across team members at each time point for use in subsequent analysis.

Team Viability. Team viability is a measure of a team's "sustainability and capacity for success future performance episodes" (Bell & Marentette, 2011, p. 279). The team's viability is measured using an eight item construct that is adapted from previous work by Resick, Dickson, Mitchelson, Allison, and Clark, 2010 and includes additional recommendations from Bell and Marentette (2011). Items are scored on a 7 point Likert scale (strongly disagree to strongly agree) and include 1) I really enjoy being part of this HERA crew, 2) I feel like I am getting a lot out of being a member of this HERA crew, 3) I wouldn't hesitate to participate on another task with the same HERA crew, 4) if I could leave this team and work with another HERA crew, I would (reverse-coded), 5) this team does not have what it takes to be effective in long-duration space exploration missions (reverse coded), 6) this team has the capacity for long-term success, 7) this team should not continue to function as a unit (reverse coded), and 8) this team has positioned itself well for continued success. Reliability and interrater scores similar to team action processes were calculated for team viability. Cronbach's alpha minimum ranged between 0.82 and 0.92 across the four time points. Additionally, the metrics support aggregation to the team level. r_{wg} (median) scores ranged between .70 and 95 and ICC(1) values ranged between 0.69 and 0.95 (see Table 11), exceeding the minimum needed to justify aggregation. Scores were averaged across team members for use in subsequent analysis.

Team Implicit Coordination. Implicit coordination refers to a team's ability to adapt, adjust, and integrate team members behaviors during tasks (Fisher, Bell, Dierdorff, & Belohlav, 2012). Participants are asked to what extent they agree to four items: 1) members of my team provide task-related information to other members without being asked, 2) my team proactively helps individual members when they need assistance, 3) my team monitors the progress of all members' performance, and 4) members of my team effectively adapt their behavior to the actions of other members. Responses fall on a 7 point Likert scale ranging from strongly disagree (1) to strongly agree (7). Cronbach alpha values ranged between 0.82 and 0.93 across the four time points, justifying averaging the four items per individual. The r_{wg} (median) and ICC(1) metrics supported aggregating team implicit coordination scores to the team level, with scores ranging between 0.91 and 0.96 and 0.93 and 0.96, respectively, across the four time points (see Table 11), exceeding the minimum needed to justify aggregation. Scores were averaged across team members for use in subsequent analysis.

Team Status Conflict. Status conflict captures the extent of dispute in a team's social hierarchy (Bandersky & Hayes, 2012). Participants answered four items: 1) my team members frequently took sides (i.e., formed coalitions) during conflicts, 2) my team members experienced conflicts due to members trying to assert their dominance, 3) my team members competed for influence, and 4) my team members disagreed about the relative value of members' contributions. Response options fall on a 7 point Likert scale of (1) strongly disagree to (7) strongly agree. Teams status conflict scores were evaluated similarly to the other team processes measures. Aggregated individual scores were averaged to compute a team score. Cronbach's alpha was computed and found the four item scale reliable (with values ranging between 0.80 and 0.91 across the four time points). However, the r_{wg} (median) scores and ICC(1) values metrics suggest individuals' scores should not be aggregated to the team level. r_{wg} (median) values ranged between 0 and 0.41 and ICC(1) between -0.05 and 0.40 across the four time points, respectively (see Table 11). This suggests that team members disagreed in their perception of status conflict and aggregating these scores may not result in a meaningfully representative team measure. But, as an exploratory analysis, I did aggregate team status conflict to the team level and evaluate how it corresponds with team decision making.

Team Processes Summary. Team identity, team action processes, team viability, and team coordination met the criteria for aggregation to the team level. I therefore created average scores at the team level for each time point. One exception was status conflict. The r_{wg} and ICC (1) scores of this variable fell below established thresholds for aggregation, however I did not conduct an exploratory analysis of this variable at the team level. In addition, as an exploratory analysis, I computed ICC(1) for each crew by time. Those results are shown in Table 12. In general, what Table 12 shows is that within each crew, there was high consistency in levels of each construct over time and large differences across crews. However, data constraints prevent further exploration of between crew differences in a multilevel analysis (i.e., small sample size).

Analyses

Due to the unique nature of my sample in that teams spend 45 days together, recruitment and screening of individuals to participate in HERA studies is a time consuming process, and it takes months of preparation for each team to complete the HERA analogue, my sample was limited to 8 teams. While this sample sheds rich insights into how teams work together over time, the size limits the power and generalizability of inferential statistics. Thus, the primary analysis in this study is the review of descriptive statistics pertaining to discussion and decision quality variables. I also report nonparametric tests as supplementary information to examine whether trends observed from descriptives are statistically supported.

Nonparametric statistics are statistical tests that do not make numerous or stringent assumptions about the population typical of parametric tests, such as a) the independence of observations, b) observations must be drawn from normally distributed populations, or c) these populations must have the same variance (Siegel, 1957). Many nonparametric tests use ranks of the observations as their data to evaluate relationships between variables (Siegel, 1957). The nonparametric tests used in this study are intended to serve as a secondary perspective on the data rather than as a conclusive barometer of whether findings are meaningful and significant. If descriptives and nonparametric tests support similar trends, this was interpreted as support for this trend. Findings in which descriptives identify a trend not supported by nonparametric tests were interpreted as partially supported hypotheses that require future study. Analyses where neither descriptives nor nonparametric tests supported a hypothesized trend were interpreted as a lack of support for that hypothesis.

Table 13 summarizes the hypotheses in this study and the nonparametric test used to evaluate them. Hypotheses 1-2 were tested using the Wilcoxon signed rank test (Wilcoxon, Katti, & Wilcox, 1970) to determine discussion differences between common and unique and favorable and unfavorable information, respectively. This test is the nonparametric equivalent of the dependent-samples t-test. The test accounts for whether the difference between two paired variables results in a positive or negative value (similar to the sign test) but also includes the magnitude of the differences in its analysis (Woolson, 2008). Statistical findings using this test indicate that there is a non-zero difference between the scores of the two categories being compared.

Hypothesis 3 utilized a chi-square goodness-of-fit test (Bentler & Bonett, 1980; Rogerson, 2010) to evaluate whether teams select the option with the highest net valence in their decision making episodes. The chi-square goodness of fit test is a well-known method for determining whether observed frequencies deviate from their expected values (Bentler & Bonett, 1980; Rogerson, 2010). Given that each decision making task completed by teams presents 3 options to choose, the pure chance of choosing any option is 1 in 3. I tested Hypothesis 3 by comparing the observed value of a team's highest net valence option being the option they selected as their preference compared to an expected value of one-third of all tasks completed (13) and the observed value of teams not choosing their highest valence option to and expected value of two-thirds of all tasks completed (26). Significant findings lend support to the proposition that teams consider net valence scores when selecting their preference.

Hypotheses 4 and 5, which focus on changes in discussion and decision quality over time, were analyzed using a Skillings-Mack test (Skillings & Mack, 1981). The Skillings-Mack test is Friedman-type test statistic, a nonparametric test that functions similar to a repeated measures ANOVA. The Skillings-Mack and Friedman tests produce identical results when analyzing the same complete data sets; however, the Skillings-Mack test is better suited in the case of missing data (i.e., an unbalanced block design) and small samples (Skillings & Mack, 1981). Given the small sample size of my data and the fact that one of the crews completed one less task than the others, I determined the Skillings-Mack test is advantageous over the traditional Friedman test since the Friedman would require the team with the missing data point to be omitted from my analysis. The Skillings-Mack tests ranked observations within each block (i.e., team performance over time) from 1 to k_i where k_i is the number of treatments in the block (1 to 5 for teams completing all five tasks). The Skillings-Mack test calculates a value for missing observations using the formula $(k_i + 1)/2$. Since the crew with the observation contained data for four time points, the missing observation was given a rank value of 2.5 $(4 + 1)/2$ for all analyses. Once ranks were determined for all 8 teams, the test generated a test statistic (T) comparing the averaged ranks at each of the five time points and using a chi-squared distribution with k -1 (4) degrees of freedom to determine statistical significance.

Additionally, this dissertation reviewed team process measures as potential competing explanations for observed changes in team decision making. Team processes were also evaluated using the Skillings-Mack test to determine whether changes in team processes matched the patterns observed in team discussion and decision quality.

Results

Hypothesis 1

Hypothesis 1 proposed that teams favor common information over unique information in terms of a) information coverage, b) information focus, and c) information consideration. Information coverage is an evaluation of what information was introduced into discussion. To test for a difference in information coverage, I counted every common, non-neutral distinct piece of information introduced into discussion and divided this score by the total number of common, non-neutral information that was presented in the task to develop a task coverage score. I did this across all tasks completed by a team to create team common information coverage scores. I then repeated this process for unique, non-neutral pieces of information and compared the scores for each team. The summary of these results is presented in Table 14.

Descriptive statistics support that teams covered more common information ($M = 0.96$, $SD = 0.03$) than unique information ($M = 0.73$, $SD = 0.08$) by a margin of over 20%. The range of coverage scores also convey a prevalence of common information (minimum = 0.92, maximum = 1.00) over that of unique information (minimum = 0.63, maximum = 0.88), with both a tighter range of values and with the lowest common coverage score greater than the highest unique coverage score. A Wilcoxon signed-rank test comparison of common to unique coverage across the eight teams also found the difference between team common and unique information coverage to be significant ($Z = 2.52$, $p < .05$), highlighting that all eight teams covered more common information than unique information. H1a was supported; teams favored common over unique information in terms of information coverage.

Information focus counted the same informational items as used in calculating coverage, but in addition to counting whether a piece of information was introduced, I also counted repeated mentions of that information. A unique information focus score was derived by summing the counts of unique information items mentioned during discussion and dividing that score by the total of both unique and common information counts. A common information focus score was derived similarly, with common information as the numerator. Table 15 provides a summary of crew information focus scores. The mean difference in discussion focus on common information (M = 0.57, SD = 0.04) is nearly 15% greater than the focus on unique information (M = 0.42, SD = 0.04). As was the case with information coverage, the range of scores for common focus (minimum = 0.54, maximum = 0.64) contains a minimum score greater than the maximum score of unique focus (minimum = 0.36, maximum = 0.47). A Wilcoxon signed-rank test found the difference between teams' focus on common and unique to be significant (Z = 2.51, $p < .05$), with all eight teams focusing more on common information. H1b was supported; teams favored common over unique information in terms of information focus.

Information consideration consists of two parts: consideration coverage and consideration focus. These scores were derived using the same principles as the coverage and focus scores discussed above, except they exclude counts of the first person to introduce a piece of information. Table 16 provides a summary of teams' consideration coverage scores. Consideration coverage scores follow similar trends to that of information coverage. Common consideration coverage (M = 0.76, SD = 0.10) exceeds unique consideration coverage (M = 0.50, SD = 0.11) by over 25%. The range of coverage scores for common consideration coverage (minimum = 0.57, maximum = 0.88) contains a minimum value greater than the maximum value of unique consideration coverage (minimum = 0.37, maximum = 0.71) scores. A Wilcoxon signed-rank test found the difference between teams' common and unique consideration coverage scores to be significant ($Z = 2.51$, $p < .05$), with all eight teams covering more common information. H1c was supported; teams favored common over unique information in terms of information consideration *coverage*.

The results of consideration focus scores are presented in Table 17. Common information ($M = 0.62$, $SD = 0.05$) received a greater consideration focus than unique information ($M = 0.38$, $SD = 0.05$) by 23%. The range of common consideration focus (minimum = 0.55, maximum = 0.68) scores contain a minimum value greater than the maximum score of unique consideration focus (minimum = 0.32, maximum = 0.45). A Wilcoxon signed-rank test found the difference between teams' common and unique consideration focus scores to be significant ($Z = 2.51$, $p < .05$), with all eight teams focusing on more common information. H1c was supported; teams favored common information over unique information in terms of information consideration *focus*.

In sum, Hypothesis 1 that teams favor common information over unique information was supported. In line with existing literature on hidden profiles (e.g., Lu et al., 2012), these results show teams favor common information over unique information when evaluated as both coverage and focus. Extending prior work, I found this common information bias holds when examining information consideration as well.

Hypothesis 2

Hypothesis 2 posited that team discussion favors negative information (information that supports not choosing the corresponding option) over positive information (information that supports choosing the corresponding option). These comparisons were made of similarly distributed informational items to reduce confounds, so I compared the differences between common negative and positive information (Hypothesis 2a) separately from the differences between unique negative and positive information (Hypothesis 2b). Further, these hypotheses were further separated into analysis of information coverage, information focus, and information consideration (coverage and focus).

Unique Information

Table 18 presents the summary of differences in unique negative and positive information coverage. Comparison of the mean coverage scores show that unique negative information (M = 0.79, SD = 0.13) is more likely to be introduced than unique positive information by (M = 0.68, SD = 0.17) by a little over ten percent, with ranges between 0.60 to 0.95 and 0.48 to .089, respectively. Also notable is that unique information valence coverage differences varied across teams. Five of eight teams introduced negative information at a higher rate than positive, two teams introduced more positive than negative, and one team tied. A Wilcoxon signed-rank test did not find a significant difference between unique negative and positive information coverage (Z = 1.35, p > .05) despite a majority of teams favoring negative information. H2a was partially supported in terms of information coverage; the descriptives support higher negative information coverage but these results were not statistically supported.

Table 19 presents the summary of unique negative and positive information focus differences. The focus score of negative information (M = 0.57, SD = 0.09) is nearly 15% higher than the focus score of unique positive information (M = 0.43, SD = 0.09), with ranges of 0.41 to 0.67 and 0.32 to 0.59, respectively. At the team level, six out of eight teams focused more on unique negative information. A Wilcoxon signed-rank test found the difference between unique negative and positive information focus nearly significant ($Z = 1.96$, $p = .05$). H2a is supported in terms of information coverage; the descriptives show teams focus more on negative unique information during discussion and these results would likely be statistically significant if observed in a larger sample size.

Table 20 and 21 present the summary of unique valence consideration coverage and focus differences, respectively. The difference between unique negative consideration coverage ($M = 0.54$, $SD = 0.15$) and unique positive consideration coverage ($M = 0.46$, $SD = 0.07$), with scores ranges of 0.36 to 0.79 and 0.36 and 0.62, is less than 10%. Only three teams have a difference score greater than 5%. On the other hand, the difference between unique negative consideration focus ($M = 0.61$, $SD = 0.88$) and unique positive information ($M = 0.39$, $SD = 0.88$), is a notable 21%. This difference is also highlighted by the range of focus scores for unique negative and positive information of 0.42 to 0.72 and 0.27 and 0.58, respectively, with negative information almost 20% higher at both minimum and maximum values. Wilcoxon signed-rank tests supported observations from the descriptives. Differences between unique consideration coverage scores was not significant ($Z = 1.52$, $p > .05$) while differences between unique consideration focus score scores were ($Z = 2.38$, $p < .05$). H2a was not supported in terms of consideration coverage; these findings suggest there is no valence difference in unique information a team member will mention that is not their own. However, H2a was supported in terms of consideration focus; individuals' focus more on other's unique information that supports eliminating one option (negative information) rather than information that helps select another (positive information).

Common Information

Valence differences in common information coverage was the first H2b hypothesis tested. Table 22 displays the coverage scores of common negative and common positive information. This table shows that while six of the eight teams trend more on positive common information ($M = 0.97$, $SD = 0.02$) than negative common information (($M = 0.94$, $SD = 0.04$), a trend in the opposite direction of this hypothesis, both coverage scores are quite high and minimally different, with an average difference of less than three percentage points. The range of coverage scores for negative (minimum = 0.88, maximum = 1.00) and positive (minimum = 0.94, maximum = 1.00) information are also quite similar. Further, a Wilcoxon signed-rank test failed to find a significant difference between common negative and positive information coverage ($Z = 1.70$, $p > .05$). H2b was not supported in terms of information coverage; the results show negative and positive information is equally introduced into discussion when that information is available to all team members.

Next, I analyzed valence differences in common information focus. Table 23 presents a summary of common negative and positive information focus scores. Two out of eight teams focus more on common negative information ($M = 0.48$, $SD = 0.08$), three teams focus more on common positive information ($M = 0.52$, $SD = 0.08$), and one team focuses on both types of information equally. The mean difference between the two is less than four percent. The ranges of both scores are quite similar: the range of negative focus is 0.37 to 0.60 and the range of positive focus is 0.40 to 0.63. A Wilcoxon signed-rank test did not find a significant difference between common negative and positive information focus is ($Z = 0.85$, $p > .05$). H2b in terms of information focus was not supported; I did not find that discussion focus favors negative common information over positive common information.

Lastly, I evaluated valence differences in information consideration. Table 24 presents the results of team common information consideration coverage scores. Seven of eight teams scored higher on common negative consideration coverage and the mean consideration coverage score of common negative information ($M = 0.84$, $SD = 0.08$) is approximately 14% larger than that of common positive information ($M = 0.71$, $SD = 0.13$) of all crews. The range of negative and positive consideration coverage scores are nearly identical but with scores about 10% higher for negative information (minimum = 0.64, maximum = 0.96) than positive information (minimum = 0.51, maximum = 0.86). A Wilcoxon signed-rank test found a significant difference between common negative and positive information consideration coverage ($Z = 2.38$, $p < .05$). H2b was supported in terms of information consideration coverage; these results support the hypothesis that teams favor common negative information over that of common positive information in the conceptualization of consideration coverage.

Results of valence differences in common consideration focus are presented in Table 25. Five of eight teams scored higher on negative consideration focus. However, the mean negative consideration focus score ($M = 0.51$, $SD = 0.09$) was minimally higher than that of positive information ($M = 0.49$, $SD = 0.09$). The range of scores were similar for negative (minimum = 0.38, maximum = 0.63) and positive (minimum = 0.38, maximum = 0.62) information. A Wilcoxon signed-rank test did not find a significant difference between common negative and positive information focus is ($Z = 0.56$, $p > .05$). H2b was not supported in terms of information consideration focus; findings do not suggest teams focus more on negative common information than positive common information in discussion.

Summary of Hypothesis 2 Results

Taken together, Hypothesis 2, that teams favor negative information over positive information, is partially supported. Eight configurations of discussion quality were reviewed: coverage, focus, consideration coverage, and consideration focus for unique and common information. Of these eight configurations, four provide support for teams favoring negative information over positive, with three of the four pertaining to unique information. The support for H2 is as follows. First, unique *information coverage* descriptive scores support that teams introduce more negative information, but the team differences were not statistically significant. Second, u*nique information focus* descriptives also support that negative information receives more focus than positive information though the result was not significant. Third, both descriptive statistics and significance testing support that *unique consideration focus* favors negative information. Fourth, c*ommon consideration coverage* differences between negative and positive information were significantly different.

Hypothesis 3

Hypothesis 3 proposed that teams will select the option with the highest net valence score as their preference, as measured via a) information coverage, b) information focus, and c) information consideration (coverage and focus). Net valence was determined by assigning favorable information item mentions a score of +1 and negative information item mentions a score of -1 for each of the three options in a decision making episode.

Hypothesis 3a tested highest valence as predictor when scored using information coverage. Table 26 contains the counts of how many times teams selected the option with the highest net coverage score. In total, teams selected the highest net coverage score in 54% (*SD* = 27%) of decision making episodes. I further analyzed these findings using a chi-square goodness-of-fit test to evaluate whether selections of the highest coverage options were greater than expected values of making preference selections by chance (1 in 3). The observed outcomes were indeed higher than those expected by chance, X^2 (1, N = 39) = 7.39, $p < .05$. These results provide support for H3, that information coverage net valence scores predict team preferences. It is worth noting that the relationship between highest net information coverage score and option selected vary largely across teams. Some teams chose the option with the highest net coverage score in 80% of their tasks, while one team never selected the option with the highest score.

I evaluated information focus net valence scores similarly to coverage. Teams selected the option with the highest information net valence score in 51% (*SD* = 20%) of their decision making episodes (Table 27). Analysis of chi-square goodness-of-fit test supports that the observed results are greater than that of simply choosing by chance, X^2 (1, N = 39) = 5.65, $p <$ .05. H3b was supported; information focus net valence scores predict team preferences above chance.

Analysis of information consideration net scores produced contrasting results. See Tables 28 and 29 for net valence consideration coverage and consideration focus outcomes, respectively. Teams selected the option with the highest consideration coverage net valence score in 64% (*SD* = 28%) of their decisions and chi-square goodness-of-fit test supports that the observed results are greater than that of simply choosing by chance, X^2 (1, N = 39) = 16.62, $p <$

.05. Conversely, teams chose the option with the highest consideration focus net valence score only in 44% (*SD* = 27%) and chi-goodness-of-fit test indicate these observed rates are in fact no higher than simply choosing by chance, X^2 (1, $N = 39$) = 1.86, $p > .05$. These findings support consideration coverage net valence scores as meaningful predictors of team preferences, but not consideration focus scores.

Overall, Hypothesis 3 that teams select the preference with the highest net valence received mixed support. All discussion quality net valence scores were found to be meaningful predictors of team preference, with the exception of consideration focus. Comparing the selection rates across the four discussion quality measures (see Table 30) adds additional clarity of between team differences in which form of valence most influences their decision making (coverage or focus). For example, Team 1 is more influenced by coverage than focus, but Team 5 is the opposite. This table also shows that consideration coverage net valence scores appear to be the most meaningful predictors of team preferences.

For greater perspective into the role of valence in decision making, I analyzed the total counts of informational items without considering whether the items are positive or negative and their relation to preference selection. Decision options with the highest information coverage, information focus, consideration coverage, and consideration focus were selected at rates of 39%, 35%, 36%, and 44%. These results were evaluated using chi-goodness-of-fit tests and none of the four rates were statistically different than selecting an option by chance. This finding indicates that discussion scores that do not account for the valence of information are not meaningful predictors of team preferences.

As part of Hypothesis 3, I proposed two exploratory questions aimed at identifying a valence score threshold that when met ensures an option is selected. Review of team results failed to identify any such thresholds for two reasons. First, teams do not always choose the option with the highest net valence, thus the data contained valence scores of not selected preferences equal to or greater than selected options. Second, net valence scores are sensitive to the context of a team's discussion. For example, in one decision making episode a team did not share all the negative information included in the scenario which resulted in two options with a net coverage score of +3. This score is noteworthy because if fully mentioning all information once, the maximum net coverage score of an option in each scenario is +2. Conversely, there were instances when teams selected an option with a negative net score, but that score was indeed the highest score relative to the net scores of the other three options. These findings demonstrate that net scores are determined by each decision making episode, not by task or team, and suggest a threshold approach does not apply in evaluation of net valence scores.

Hypothesis 4

Hypothesis 4 posited that discussion quality will initially increase and subsequently decrease as teams make decisions over time. In line with previous results, in this section I discuss the components of discussion quality in the order of information coverage (H4a), information focus (H4b), and information consideration coverage and focus (H4c), respectively.

Information Coverage

Table 31 displays the results of team information coverage for the five time points teams completed the tasks. Time 3 represents the highest coverage score and the lowest variance in coverage scores (M = 0.92, SD = 0.09), which is roughly 10% higher than the coverage scores at

Time 1 (*M* = 0.81, *SD* = 0.15). Scores at Time 4 (*M* = 0.87, *SD* = 0.09) and 5 (*M* = 0.87, *SD* = 0.08) are equal to each other, slightly lower than at Time 3, and higher than at Time 1. This conveys a pattern of coverage scores increasing, then slightly decreasing but not below baseline levels. While a Skillings-Mack test did not show significant differences for team coverage scores across time (*T* = 5.17, p > .05), the mean rank scores generated by test of at the five time points convey support for a peak information coverage performance at Time 3 (*M* = 3.81, *SD* = 1.60) , with a decline in performance after this time point (see Table 32). I also reviewed information coverage scores as only unique and only common information. The results were similar to the total coverage scores: trends suggest a peak in coverage at Time 3 followed by decline in performances, but changes that were not found statistically significant with this sample size. H4a was partially supported; trends in information coverage scores demonstrate an increase and subsequent decrease over time but these differences were not significant.

Information Focus

Table 33 presents a total count of positive and negative, unique and common information mentions (including repetitions) by teams over time. While this table conveys a general decline in total mentions of information, the results are not central to research questions in this dissertation. Instead, the primary use of these numbers is to develop the ratio of unique information focus, with the counts of only unique information mentions divided by total information mentions. Team unique information focus peaks at Time 3 (*M* = 0.50, *SD* = 0.08) and subsequently declines but not below the mean focus score at Time 1 (see Table 34). Similar to the coverage score, the Skillings-Mack test did not find significant unique focus score differences across time (*T* = 5.17, p > .05). Also, in line with information coverage scores, focus score ranks peak at Time 3 (*M* = 4.00, *SD* = 0.76) and subsequently decline (See Table 35). Since the common information focus ratio is directly proportional to unique information focus (common focus = 1 - unique focus), trends of common focus scores are not discussed in this analysis as the trends are directly inverse to unique focus. Hypothesis 4b is partially supported; trends in unique information focus show a peak at Time 3 and decline after, but these differences were not significant.

Information Consideration

Table 36 presents team consideration coverage scores over time. These scores convey a trend of increasing and subsequently decreasing discussion quality scores, with scores peaking at Time 3 (*M* = 0.72, *SD* = 0.16). In line with information coverage, performance decreases and plateaus at Time 4 (*M* = 0.64, *SD* = 0.12) and Time 5 (*M* = 0.62, *SD* = 0.11), but not below the score at Time 1(*M* = 0.61, *SD* = 0.17). A Skillings-Mack test did not find the differences between consideration coverage scores over time to be significant ($T = 4.08$, $p > .05$), but ranks scores of consideration coverage also supported Time 3 (*M* = 3.88, *SD* = 1.46) as peak consideration coverage performance and decline after (see Table 37). Supplementally, I also analyzed just unique and just common consideration coverage. Both data sets support the trends identified above. A notable distinction is that the Skillings-Mack test found the difference between unique consideration coverage scores across time to be significant ($T = 13.01$, $p < .05$). I then ran a Wilcoxon signed-rank test for post hoc analysis of the difference between the pairing of each time period (a total of 10 tests). After a Bonferroni adjustment of the ten tests, none of the pairings were significantly different, however, the biggest difference scores were between Time 3 - Time 2 ($Z = 2.54$), Time 3 - Time 1 ($Z = 2.32$), and Time 3 - Time 5 ($Z = 2.23$). H4c (consideration coverage) was partially supported; trends in total, unique, and common consideration coverage scores indicate a peak in performance at Time 3, but only unique scores were found to be significant between five the time points.

Analysis of consideration focus found similar to trends to the broader focus trends. Table 38 shows that unique information focus peaked at Time 3 (M = 0.48, SD = .10) and declined after, but not below Time 1. The Skillings-Mack test did not find the difference between unique consideration focus scores across time as significant (T = 6.36, p > .05) but rank scores also peaked at Time 3 (M = 4.00, SD = 0.76) and declined after (see Table 39). H4c (consideration focus) was partially supported; unique consideration focus peaked at Time 3 but differences between the five time points were not significant.

Summary of Hypothesis 4

As a whole, the discussion quality measures used in this dissertation demonstrate trends that support Hypothesis 4 that team performance increases then decreases over time. Information coverage, (unique) information focus, and information consideration scores all peaked at Time 3. After Time 3 these scores declined and plateaued. However, this decline is not below initial performance at Time 1. An observation that was not hypothesized but observed in the data was a decline in discussion quality (most prevalent using information coverage and focus measures) at Time 2. So, while the data trends support the hypothesis that discussion quality performance increases then decreases over time, this analysis produced a more nuanced observation that performance first decreases, then increases, and then decreases again.

Hypothesis 5

Hypothesis 5 proposed that team decision quality follows trends of discussion quality, where teams improve in their decision quality performance and then decline. I analyzed decision quality performance using three conceptualizations: whether or not teams chose the best scenario option, whether they the worst one option, and scoring the quality of the team preference as best (2), middle (1), or worst option (0).

Select Best Option

The results of the whether teams chose the best option show that Time 3 is by far the best decision quality performance time period (see Table 40), with 63% of teams selecting the best answers at this time point. The worst time period for teams choosing the correct answer is Time 5, with only a 14% success rate. All other performance time points were equal with a 25% success rate. A Skillings-Mack test on these results did not find a significant difference in teams choosing the best option across the five time points ($T = 3.04$, $p > .05$); however, as expected, rank scores (see Table 41) support that Time 3 ($M = 3.75$, $SD = 1.13$) is the best decision quality episode and Time 5 is the worst ($M = 2.50$, $SD = 0.76$). Overall, the maximum team performance was the selection of three correct responses (Teams 1 and 6) and the minimum was not selecting any correct responses (Teams 2 and 8), with the total success rate across all teams of 31% (as seen on Table 40). In sum, H5 in terms of choosing the best is partially supported; trends suggest Time 3 is the best performance period and Time 5 is the worst, but differences in time were not significant.

Worst Option Avoidance

As part of decision quality analysis to determine whether teams show an increase and then decrease in performance, I also evaluated performance as decision making episodes during which teams avoid the worst option. The design of the hidden profiles is intended to make the worst option the most prevalent pre-discussion preference. Selecting even the middle option suggests some quality in team decision making quality. The trends of these results support those just discussed (see Table 42). Performance peaked at Time 3 (where only one team picked the worst option) and the lowest decision quality time point was Time 5 (which despite having one less decision making episode than other time points, was the time point at which the worst option was selected the most). The scores at the other three time points were the same. The review above of best selections highlights that teams make the best decisions at Time 3 and the fewest best decisions at Time 5. The operationalization of decision quality as choosing the worst option highlights that teams make the most worst decisions at time 5 and the fewest worst decisions at Time 3. These trends support the hypothesis, though a Skillings-Mack test on these results did not find a significant difference across the five time points ($T = 1.80$, $p > .05$).

Overall, the evaluation of decision quality as avoiding the worst option identifies four top performing teams that avoided the worst option in 80% of their decision making episode, with the possibility that Team 2 would also join this distinction if completing all five tasks. This is in contrast to Team 2 being included as tied for the worst performing team when measuring decision quality as choosing the best option. However, the avoidance of the worst option as a measure of decision quality still identifies Team 8 as the poorest decision maker.

Quality of Preference

The results of decision quality when evaluated as best (a score of 2), middle (a score of 1) and worst (a score of 0) mirror the trends highlighted in the two other conceptualizations of decision quality discussed above. Table 43 shows that decision quality peaks at Time 3 ($M =$

2.50, *SD* = 0.76), is poorest at Time 5 (*M* = 0.20, *SD* = .78), and is a three-way tie at Times 1, 2, and 4 (*M* = 0.88, *SD* = 0.84). Despite score trends that support the hypothesis, the Skillings-Mack test failed to find a significant difference across the five time points ($T = 3.65$, $p > .05$). Evaluation of team decision making by accounting for best, middle, and worst options as distinct outcomes supports that Teams 1 and 6 are the best decision makers and Team 8 as the poorest performer. H5 is partially supported when evaluating performance as best, middle, and worst; the score trends show a peak performance at Time 3 and poorest performance at Time 5 but decision quality were not found to be significant across the five time points.

Overall, the trends in decision quality, measured as the best answer, avoiding the worst answer, and quality of team preference, lend support for Hypothesis 5 that decision making quality improves over time and then decreases. Specifically, performance stays steady at Times 1 and 2, increases at Time 3, returns to baseline level at Time 4, and drops below baseline at Time 5. At this time, Hypothesis five can only be partially supported because despite the trends fitting the posited pattern, I was unable to find statistical difference in decision quality across time.

Further, decision quality outcomes demonstrate that teams struggle in making quality decisions when completing hidden profile tasks. The highest team performance in identifying the best option was a success rate of 60% (two teams). The highest team performance in avoiding the worst option was 80% (four teams). And, the prevalence of the best (31%), middle (33%), and worst option (36%) being selected across all teams is no different than chance (see Table 44).

Additional Analysis

I conducted additional analysis to determine whether team processes provide insights into team discussion and decision quality, reviewing whether the patterns of team processes across time correspond with the outcomes found in Hypotheses 4 and 5. Teams completed the first decision making task prior to completing a team process survey, so I focused my comparison of trends to decision making episode two through five. Thus, a corresponding performance pattern would entail the highest (positive) team process scores at Time 3 with a subsequent decrease.

The first team process I evaluated was Team Identity. Team identity scores do not correspond with trends of discussion and decision quality (see Table 45). Team identity was actually at its lowest at Time 3, with all the other scores nearly identical. Not surprisingly, the Skillings-Mack test resulted in a small, non-significant result ($T = 0.66$, $p > .05$).

Secondly, I analyzed team action processes (TAP). TAP scores do correspond with discussion and decision quality (see Table 46): the scores peak at Time 3 ($M = 6.27$, $SD = 0.71$) and are lowest at Time 5 ($M = 5.94$, $SD = 0.92$). Scores at Time 4 ($M = 6.23$, $SD = 0.48$) are quite similar to Time 3 and greater than at Time 1 ($M = 6.08$, $SD = 0.52$), following trends more similarly to that of discussion than decision quality. A Skillings-Mack test did not identify a significant difference in TAP scores across time ($T = 5.42$, $p > .05$).

The third dynamic that I analyzed is team viability (TV). TV scores are presented in Table 47. The highest TV scores occurred at Time 3 ($M = 6.42$, $SD = 0.73$) and the lowest at Time 5 ($M = 6.15$, $SD = 0.96$). Scores at Time 2 ($M = 6.31$, $SD = 0.67$) and Time 4 ($M = 6.30$, $SD = 0.64$) were nearly identical. The Skillings-Mack test did not identify a significant difference in TV scores across time ($T = 6.71$, p > .05); however mean ranks supported the trends observed in team decision quality.

Team implicit coordination (TIC) is the fourth team dynamic variable I analyzed. TIC scores (see Table 48) are similar to those of TV, with a peak at Time 3 ($M = 6.34$, $SD = 0.53$), a low at Time 5 ($M = 5.97$, $SD = 1.05$), and nearly the same scores at Times 2 ($M = 6.23$, $SD = 0.67$) and 4 ($M = 6.20$, $SD = 1.05$). Thus, the trends of TIC support the general trends observed in discussion and decision quality, but more closely resemble decision quality. The Skillings-Mack test did not detect a significant difference in TIC scores across time ($T = 2.67$, $p > .05$).

Lastly, I planned to analyze team status conflict (TSC). However, analysis of Rwg and ICC(1) scores showed scores below the established threshold to aggregate individual scores to a team score. These results indicate that team members varied greatly in their perception of team status conflict and that a team measure would not provide a representative depiction of status conflict within the team. The source of discrepancy in status conflict, an established and validated measure, may merit further study about these teams' dynamics. As an exploratory analysis, I calculated average TSC scores and conducted a Skillings-Mack test comparing scores against time. The means at the four time points showed that Time 3 was the lowest conflict point (M = 2.13, SD = 0.86) and Time 5 was the highest (M = 2.43, SD = 0.88), supporting a performance peak at Time 3 and low at Time 5. But, the mean ranks of TSC identified Time 4 as the lowest conflict point and differences in scores across time were not significant ($T = 0.61$, $p > .05$). These results suggest TSC did not exhibit a temporal pattern similar to discussion and decision quality

Overall, the review of team process variables suggests that team processes, specifically team action processes, team viability, and team implicit coordination, correspond with the general trends observed in the analyses of team discussion and decision quality, corresponding more similarly to decision quality's attribute of Time 5 representing the low. The trends of these three team dynamic variables also indicate they correspond with one another. Team identity, however, did not follow the trends observed in team discussion and decision quality and that of the other three team processes mentioned above. Lastly, team status conflict lacked the interrater agreement to justify aggregating individual scores to the team level; however, as an exploratory analysis, team scores were calculated, and the results did not suggest a correspondence between TSC and discussion and decision quality.

Relationships between Discussion, Decision, and Team Process Measures

As a post hoc analysis, I created a correlation matrix of team discussion, decisions, and process measures discussed in this chapter (see Table 49). The relationships between measures were evaluated at the team level (collapsing scores across time points) using Spearman's Rho (r_s), a non-parametric alternative to a Pearson's correlation that uses rank scores to determine whether a monotonic relationship exists between two variables (Puka, 2011). Examining these intercorrelations shows correlations among measures of a given type correlate, e.g., discussion quality measures correlate with other discussion quality measures, but no significant correlations were observed between measures of different categories (e.g., discussion quality with process). Four significant relationships were observed: (1) coverage and consideration coverage discussion quality measures (r_s = .88), (2) selection of best option as preference and overall decision quality of preference measures of decision quality (r_s = .91), (3) avoidance of worst option and overall decision quality of preference as measures of decision quality (r_s = .88), and (4) team viability and team implicit coordination team process measures (r_s = .79). No significant relationships were identified between the three measure types (i.e., discussion quality, decision quality, and team process). As in previous analyses, the number of teams in this study limits the statistical method that can be used to analyze these relationships, the power of these statistical analyses, and the inferences that can be drawn from a lack of statistical significance. It is tenable that indeed some of these relationships will be found to be significant when evaluated with a larger sample of teams.

Discussion

This chapter examined the various components that influence team decision making: the distribution of information among team members and the valence of the information. Additionally, this chapter investigated how the mechanisms of decision making evolve over time. Pertaining to the components of team decision making, I introduced three hypotheses. First, I hypothesized that teams would succumb to the common information bias that has repeatedly plagued teams completing tasks in which individuals receive both common and unique information (e.g., Lu et al., 2012; Mesmer-Magnus & DeChurch, 2009). I also hypothesized that team discussions would favor negative information (information that detracts from selecting an option) over that of positive information (information that supports selecting an option). Lastly, I hypothesized that teams would use net valence scores of discussion to select their preference.

My investigation of team decision over time consisted of two hypotheses. I hypothesized that over time, teams would experience an improvement in discussion quality and a subsequent decrease in performance as they worked together over time. I also hypothesized that the quality of team decisions would follow a pattern similar discussion quality and thus show an increase followed by a decrease over time. As an additional exploratory analysis, I evaluated how team processes over time corresponded with changes in discussion and decision quality.

In this chapter, I also introduced a new approach to evaluating discussion quality: information consideration. Information consideration represents an attempt to capture whether team members acknowledge and incorporate information introduced by other team members. Information consideration was included as a measure of discussion quality in all hypotheses that examined discussion quality as a function of decision making.

Common Information Bias

All eight teams included in this study demonstrated a bias in favor of common information over that of unique information as evaluated by all four measures of discussion quality (information coverage, information focus, information consideration coverage, and information consideration focus). These findings provide two meaningful insights. First, information coverage and information focus results replicate the common information bias repeatedly supported in the hidden profile literature (e.g., Lu et al., 2012; Mesmer-Magnus & DeChurch, 2012). However, this is the first hidden profile study I know of completed by space teams in isolated and confined environments like that of HERA. Bell and colleague's (Bell, Fisher, Brown, & Mann, 2018) warn to not assume research findings generalize to different contexts. This study supports that astronaut teams, which are likelier to be better trained, more educated, and more motivated to maximize team outcomes than traditional teams, also succumb to the same discussion biases.

A second novel insight from evaluating information bias is that the new measure of discussion quality that I introduce in this dissertation, information consideration, both demonstrates further evidence of common information bias and can provide new insights into how common information bias manifests in discussion. For example, the smaller unique consideration coverage and consideration focus scores, relative to unique information coverage and unique information focus scores, show that even if unique information is introduced into conversation, other team members are reluctant to discuss it.

Valence Bias

Hypothesis 2 of this study examined whether teams favored informational items that detract from selecting a corresponding option (negative information) over those that support selecting an option (positive information). The question of a team bias towards negative information has been studied prior (e.g., Dose, 2003; Stewart, 1998), but the findings were ambiguous. This study accounted for confounds between information distribution (common or unique) and information valence in its analysis to generate precise conclusions about the influence of information valence in discussion.

The main insight from this study pertaining to valence is that teams do indeed demonstrate a negative valence bias, but this valence bias manifests itself in unique information. Teams tend to introduce more negative information into discussion and focus more on negative information during discussion, although these differences were not statistically significant. Unique consideration focus scores also showed a (significant) difference negative in positive information, conveying that individuals spend more time discussing others negative information than their positive information. It is also notable that unique consideration coverage did not indicate a valence difference, suggesting teams are willing to acknowledge others negative and positive information equally, when operationalized as at least one individual mentioning this information.

Analysis of common information did not identify the valence difference bias observed in unique information. This suggests that the observed negative valence bias has more to do with the implication of the information than whether it is positive or negative. Unique negative information in these hidden profiles provide information that discourage selecting the most dominant preference (but which is the worst overall option) while unique positive information supports selecting a minimally supported preference (but which is the best overall option). The findings in Hypothesis 2 suggest that teams are more concerned with information that suggests they need to abandon their strongest preference than choose the best preference. A potential explanation for this behavior is that choosing to abandon an established preference is deemed a bigger decision than identifying an alternative.

Net Valence

This study applied Hoffman's (1961) group valence model theory to the hidden profile paradigm to evaluate whether the net valence of competing options determines team preference. The highest information coverage, information focus, and consideration coverage were found to predict team preference significantly above chance. In fact, the best predictor of team preference was consideration coverage, demonstrating the importance of others acknowledging information in team decision making. The findings that team decisions are informed by the information they discuss supports that teams are rationale in their decision making. However, these results are also troubling because the net valence scores teams are using to make decisions are inaccurate due to common information bias, and to a lesser extent negative unique information bias. Thus, the findings pertaining to net valence scores as predictors of valence suggest that common information bias influences decision quality, as well as team discussion.

Discussion Quality over Time

One of the truly unique contributions of this dissertation is that it examines how team discussion evolves over time. All four measures of discussion quality (i.e., information coverage, information focus, consideration coverage, and consideration focus) demonstrated trends that supported the proposed hypothesis that team discussion quality improves and then declines over time, although these differences were not significant. Two meaningful insights stand out from the results of analyzing discussion quality over time. The first is that differences related to time are a story of unique information. To illustrate, the range between the highest and lowest average common information coverage and common consideration coverage across the five decision making tasks is approximately 6% and 8%, respectively. The range of average unique information coverage and unique consideration coverage is approximately 29% and 25%, respectively. These figures make it clear that teams' introduction of unique information into discussion changes as they work together.

A second interesting insight about discussion quality (in terms of unique information) is the pattern in performance. I hypothesized a discussion quality increase and subsequent decrease, which is supported in trends observed at Time 3 (peak in performance) and subsequent periods (Times 4 and 5 return to slightly above initial task). However, I did not expect to see a drop in performance between Time 1 and 2. This is a trend that merits further study in the future. I propose two potential explanations. One is that the initial transition into isolation and confinement takes a toll of individuals and team dynamics; the first task is completed pre-isolation as part of training, so Time 2 is the first task completed during the simulation. An alternative explanation is the possibility of a cyclical nature to team decision making, where teams put forth varying levels of effort during the episodes. The latter supports the position that the relationship between team and time is not uniform (Kozlowski & Bell, 2003; Joseph E. McGrath & Argote, 2001).

Decision Quality over Time

The second unique aspect of this study is evaluating how the quality of team decisions evolves over time. I hypothesized that decision quality would follow the pattern of discussion quality and show an increase and subsequent decrease and used three separate ways to measure decision quality (choosing the best option, avoiding the worst option, and rating the quality of decision). The hypothesis was partially supported, with all three measures of discussing quality peaking in performance at Time 3 and declining after that period, although differences in decision quality were not significant across the five time points. However, decision quality deviated from discussion quality trends in two ways. First, decision quality did not show a Time 2 decline. In fact, Time 1, 2 and 4 produced the same decision quality results. The second deviation is that Time 5 was the lowest decision quality performance episode of all five time periods. These trends suggest that factors other than discussion quality influence decision quality.

As a whole, teams struggled making quality decisions when completing hidden profile tasks. When combining performance across all time periods, the rate at which teams chose the best, middle, and worst options is no different than chance. Additionally, the 31% rate at which teams identified the best option is in line with the 30% to 35% rate found in one-off studies (Schulz-Hardt & Mojzisch, 2012; Stasser & Stewart, 1992; Stewart et al., 1998). When considering all time points, the decision quality of the teams in this study did not benefit from five episodes of decision making.

Additional Analysis: Team Processes

The additional analysis I performed was to evaluate trends in team processes proximal to when teams completed their decision making tasks. These analyses found that three team processes (team action processes, team viability, and team implicit coordination) correspond to the patterns observed with decision quality, with the highest score at Time 3, similar scores at Times 2 and 4, and lowest score at Time 5. Team processes corresponding more with decision than discussion quality patterns suggest that factors other than these dynamics influence how teams discuss information, but these dynamics help inform how teams make their decisions.

It is worth noting that my analysis of team processes represented process using the team mean, or average of the individual team members. While this is convention, it may also be the case that for some types of team processes, such as status conflict, variance may be more telling. In fact, low agreement among members of the team may itself be an indicator of status conflict within the team. If individuals disagree about status conflict, this could be a source of more conflict in the future. Additionally, high interrater agreement could be representative of a response bias and not reflective of true agreement among raters (James et al., 1984; James et al., 1993), so teams with lower agreement scores might be providing more accurate insight into actual team dynamics and those instances merit further exploration.

Contributions to Team Decision Theory

This chapter contributes to the team decision literature in three ways. First, it introduces a new way to measure team discussion quality via the term consideration coverage. Adding to established concepts of information coverage and consideration coverage, information consideration accounts for the discussion of information beyond the individual who delivered it. The use of information consideration, in its two forms of consideration coverage and consideration focus, in all the hypotheses tested in this chapter demonstrated that this construct provides unique insights into how teams incorporate various types of information into their discussions as well as how this information influences decision making.

The second contribution of this chapter is providing clarity about the components of decision making. The findings in this dissertation confirmed previously established biases in favor of common information over that of unique information in team discussion (Lu et al., 2012; Mesmer-Magnus & DeChurch, 2012). This dissertation also explores the notion of information valence. Previous work on this topic is limited and confounds positive and negative information with common and unique information (Dose, 2003; Stewart, 1998). This dissertation provides an apples to apples comparison of teams favoring negative valence over that of positive valence, especially when it comes to unique information. Further, this dissertation evaluates how information valence informs team preferences, showing that teams use some conceptualization of net valence in evaluating preferences.

The third contribution of this dissertation is to shed light on how team decision making evolves over time. This dissertation shows that teaming is a nonlinear experience and that team decision making performance, in the form of discussion and decision quality, both increases and subsequently diminishes as teams work together. While the hidden profile literature is rich with insights about what teams do well and poorly when having to leverage distinct individual expertise to make quality decisions (e.g., Sohrab et al., 2015;), this dissertation is the first on the topic that can speak to trends that occur over multiple teaming episodes.

Contributions to Practice

The findings of this dissertation provide meaningful insights and guidance to practice in two ways. The first is linked directly to the unique context of the teams participating in this study. These teams completed decision making tasks part of broader NASA sponsored research to understand challenges that might confront space teams as they work together for extended periods of time in isolated and confined environments (Cromwell & Neigut, 2014). This dissertation shows that (analogue) astronauts suffer from the same information biases that hinder more traditional teams. This similarity suggests that other existing findings on team decision making (e.g., initial preference bias and social validation bias) will also generalize to space teams, and leaders in charge of preparing and supporting future teams equip teams to be familiar and resistant to these biases. Further, this study dismisses the notion that teams can overcome these limitations without any interventions or countermeasures just through shared decision making experience.

The second applied implication of this study supports generalizing findings from space teams to more traditional work teams. Again, since the common information biases of the teams in this study match those of existing literature, there is reason to believe the other findings in this study will also emerge in traditional teams. This suggests that team supervisors, leaders, and members should be concerned that team biases in the discussion of information influences how teams select their preferences (Hypothesis 3) and issues in discussion and decision quality will persist over time (Hypothesis 4 and 5), if no interventions are introduced. Without interventions, this study suggests teams should only be permitted to make a limited number of decisions together because the benefits of previous decision episodes dissipate.

Limitations

Two limitations should be kept in mind when considering the conclusions of this study. The first is sample size. As previously discussed, this dissertation relies on a unique field setting that limited the number of teams that can be studied and analyzed to eight. As such, this study relies on trends and nonparametric statistics to draw conclusions. With an increased sample size, future analyses can include more robust methodologies, such as multilevel modeling, to account for the fact that performance across time is nested within teams.

A second limitation of these findings is the timing of the decision making tasks. Tasks were completed on mission days -4, 6, 14, 20 and 34. Since the administration of the task was not equally spaced out, there is a possibility that more proximate episodes could be more similar in performance than episodes which are further apart; however, I did not find evidence of this. It is also worth noting that the last day teams completed the decision making task was 11 days prior to their last day as a team. It is possible that the Time 5 performance was affected by the third quarter effect (Bechtel & Berning, 1991) and that a task later in the mission might see improved performance scores, although the existence of a third quarter effect is debated (Kanas et al., 2007). Lastly, general team process measures were completed by the teams from one to five days before they completed the decision making task. It is possible that perceptions of these processes changed in the time between teams completed their evaluation and performance of the decision making task.

Future Directions

The results from this study inspire a number of future directions on research on team decision making. One future direction is further study of how teams use information. The introduction of information consideration in this study is one attempt to measure whether teammates use information introduced by others on their team. However, this measure, like those of coverage and consideration, is based strictly on whether someone else on the team mentions the information. Additionally, acknowledging a piece of information does not mean an individual perceived it as valuable in shaping their opinion. An individual could mention a piece of information not their own in an effort to dismiss it, especially if it runs counter to their preference. And, even if an individual considers another's information, they may assign it a different weight or importance than their own information. I propose that future hidden profile research attempts to gauge the weight individuals assign to information (likely through survey), in addition to tracking whether the information was included in the discussion, to both assess whether others information is perceived as less important and how these perception differences change as teams work together over time.

Another future research direction is to develop additional meaningful measures of discussion quality. Current conceptualizations of common and unique information are based strictly on task design. If not everyone on the team states that they have a given piece of information, there is no way for the team to know everyone received this information. Current measures fail to account for how many people mention a piece of information and simply evaluate if and how many times a piece of information is mentioned. A measure such as information acknowledgement could account how many individuals mention a piece of information. Future work could then evaluate how information acknowledgement influences team preferences and whether information acknowledgement rates and their relationship to preference change over time as teams work together.

A third future direction is to consider how team decision making impacts team dynamics. As part of this study, I evaluated whether team dynamics influence team decision making and found support that they do. Future research could examine how team decision making episodes influence team dynamics. Teams could complete a pre and post test to evaluate change in team dynamics from participating in the episode. And, future work could examine how the quality of discussion and decision correspond to team dynamics. Further, future work could evaluate whether the post task team dynamics of one task predict team performance on the subsequent decision making task.

CHAPTER 4

Study 3 - Thematic Analysis of Decision Making over Time

The previous chapter used numerical representations of decision making to better understand what information teams introduce into discussion, how they discuss this information, how these various discussion scores relate to decision quality, and how these scores change as teams work together. And while these results are meaningful, they do not tell the full story of teams working together. The previous chapter speaks to what happens when teams make decisions, but still leaves much to be discovered about why these trends occurred. This chapter aims to provide explanations for the quantitative trends identified in the previous one and add new insights into what happens as teams work together.

Study 3 of this dissertation utilized qualitative analysis to address the question of how team decision making evolves over time. In the past, quantitative and qualitative studies were perceived as antithetical to one another (Fetters et al., 2013; Pope & Mays, 1995); however, more progressive perspectives on research have shown that incorporating both quantitative and qualitative analyses can provide greater understanding of complex processes (Creswell & Fetters, 2004; Curry et al., 2013), such as team decision making. While quantitative analysis (conducted in Study 2) can help to address questions of correlation and effect size, qualitative methods help explore why and how phenomena occur (Pope & Mays, 1995).

Some of the specific observations in Study 2 especially point to the value of adding a qualitative lens to understand team decision making over time. In particular, the finding that team discussion quality improved and diminished over time presents a perplexing trend that qualitative analysis may be able to explain. Additionally, a qualitative approach may provide an explanation for why discussion is fairly steady from Time 4 to Time 5, but decision quality worsened. Study 2 generated novel insights about trends in team decision making. The goal of adding a qualitative analysis to this data set is to explore the causes of these trends, as well as identify additional trends that might be missed strictly using a quantitative approach.

Study 3 uses thematic analysis, as a complement to Study 2, to understand the mechanisms that shape decision making in teams over time. I reviewed transcripts and videos decision making episodes to understand the tendencies, strategies, and dynamics emerge as team complete tasks that require them to leverage each individual's information in order to make optimal decisions. A specific focus of my observations was the process through which teams established preferences between competing options.

The previous chapter discussed the concept of option valence as calculation of positive to negative informational items. However, valence can be conceptualized as a broader concept. Valence can be thought of as simply a force, and the option with the greatest force is the one most likely to be selected by a team (Lewin, 1935; Hoffman, 1961). An assumption of hidden profile literature is that teams determine the valence of options by aggregating their positive and negative informational items. However, it is possible that teams use other metrics to determine the valence of options, such as the amount of team members who support the option, the status of an individual in the group who supports the option, or even the enthusiasm of advocacy for a particular option (Hoffman, 1961).

In addition to identifying how teams establish the valence of competing decision options and other factors that influence team decision making, Study 3 evaluates how team decision making changes over time. Decision making schemes are established and revised via team discussion (Davis, 1973). For example, the conceptualization of valence used to determine a preferred option is in itself a type of decision making scheme utilized by teams (Hoffman & Klein, 1994). The teams participating in this study are presented with five distinct opportunities to establish their approach to completing these tasks. Using a qualitative approach, I am able to identify novel changes that either are not captured using a strictly quantitative data or identify the source of the change captured in quantitative findings.

Study 3 provides a rich contribution to Study 2 in the understanding of team decision making over time. While Study 2 focuses on changes in the use of information as teams make decisions over time via a quantitative approach traditionally used in the hidden profile literature, Study 3 leverages a qualitative perspective to shed new light on the drivers that influence information sharing and team decision making.

Method

Study 3 uses a qualitative technique known as thematic analysis. Thematic analysis "is a method for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a data set" (Braun & Clarke, 2006, 2012). A primary driver in selecting this method is its focus on identifying patterns, highlighting similarities and differences across a data set (Braun & Clarke, 2006). This focus on patterns and the evolution of patterns aligns with examining temporal effects on team decision making. Further, thematic analysis is adaptable to various study contexts, can examine issues at various scope of analysis, and facilitates both deductive (theory driven) and inductive (data driven) findings (Braun & Clarke, 2006, 2012). It is also worth noting that the method's systematic approach counters criticisms leveled at qualitative work that it lacks a consistent, scientific approach (Braun & Clarke, 2006, 2012).

I used thematic analysis to evaluate the entire decision making process, from when individuals independently review their information at the start of a task to when they reach a conclusion (and any subsequent comments they make after submitting their decision). Thematic analysis is useful in both capturing key themes in a single decision making episode and comparing how these themes vary between decision making episodes. In an effort to capture the full richness of team discussion and how decision making evolves, I reviewed both the transcripts of team decisions and video footage of teams completing the tasks.

To demonstrate various insights that can be gathered through the use of thematic analysis, the following are examples from recent studies using this method. A study of employee interactions among co-workers found that informal communication serves to help individuals evaluate and process their perceived organizational membership (Fay, 2011). Thematic analysis of surgical teams identified three themes that facilitated successful interdisciplinary collaboration (Gillespie, Chaboyer, Longbottom, & Wallis, 2010). Work with air traffic controllers found that three types of approaches were used to modify aircraft plans with other controllers and that these modifications resulted in three types of modified plans (Gyles & Bearman, 2017). These examples show that thematic analysis can aid in the understanding of a phenomena that could be missed by strictly quantitative approaches, and this approach is beneficial in various contexts and areas of study.

Sample

Study 3 represents a parallel convergent mixed method design. In a parallel convergent design, qualitative (i.e., recordings and transcripts of team interactions) and quantitative (i.e., survey responses) data are collected during a similar timeframe, analyzed separately, and then merged to produce a rich understanding of the specific context and phenomenon being studied (Fetters et al., 2013). I reviewed the transcripts and video recordings of the 4-person HERA crews, described in the previous chapter, after each team finished their 45 day HERA campaign. Figure 4 and Figure 5 provide a brief overview of the HERA crews that participated in this study, their occupational background, and a team patch that they created to represent their team and its mission. Table 50 provides a summary of the data from HERA Campaign 4 and 5 that was reviewed in completing the thematic analysis.

Analysis

My thematic analysis of team decision making followed Braun and Clarke's (2006, 2012) 6 phase process. Phase 1 focused on becoming familiar with the data. For Phase 1, I reviewed one decision making task of each of the teams included in the study to develop initial understanding of the data. In Phase 2, I generated an initial code and evaluated the data using these codes. Phases 3, 4, and 5 included searching for themes, reviewing themes, and defining and naming themes, respectively. These phases required the coded data to be sorted into themes that capture distinct aspects of the data. While each phase represents a chronological sequence, thematic coding is a "recursive process" that often requires back and forth between the phases (Braun & Clarke, 2006, p. 86). I reviewed data and themes multiple times to ensure key themes were identified and supported. The final phase was the production of a report on the analysis. The result is a thorough description of the themes found in the data as well as a set of concrete examples of these themes and is found below.

My review of the data utilized a case study approach (Yin, 2017), where each team represents a case of team decision making over time, studied from start to end. Each team was analyzed individually across the five decision making episodes, identifying decision making mechanisms and capturing changes in team decision making over time. Once each team was individually analyzed, I used a cross-case analysis to compare findings across teams. Using a cross-case approach helped identify similarities and differences between teams (Yin, 2017) as they make decisions over time. Thus, a case study approach facilitated an understanding of each team's approach to decision making and how this approach changed, as well as a comparison of teams.

I analyzed the data using both a deductive and inductive perspective, as is often the case in thematic analysis (Braun & Clarke, 2012). A deductive approach suggests that evaluation of the data is informed by theory (Braun & Clarke, 2012). Extant literature summarized in previous chapters highlighted the importance of information sharing in team decision making when no single individual has access to full information. Thus, a primary focus in review of data gravitated toward information exchange and how teams use this information to come to a decision.

An inductive approach, which is driven and informed by the data itself (Braun & Clarke, 2012), was used to evaluate broader aspects of discussions during decision making episodes and how teams determine the valence of competing options. I avoided speculating about what these trends may be, as there is support for avoiding hypotheses or predictions when conducting inductive coding to aid in generating novel insights (Braun & Clarke, 2006).

As a final phase of analysis, I again reverted to a deductive approach to gain insights from broader theory relevant to decision making. Specifically, I reviewed Hinsz, Tindale and Vollrath's (1997) seminal work on group information processing and mapped their nine components of group information processing to the coding system I developed during my review of the data. I then reviewed my codes again to account for any relationships between codes elucidated by including Hinsz et al.'s model. Notably, each of the components of the group information processing model were present in the codes I identified.

A driving distinction between qualitative and quantitative analysis is that quantitative analysis includes statistical analysis that speaks to a numerically represented relationship between variables, whereas qualitative methods attempt to get more to the nature of phenomena with zero to minimal statistics (Fetters et al., 2013; Fielding, 1993; Hsieh & Shannon, 2005). Additionally, thematic analysis is distinct from other forms of qualitative analysis. Thematic analysis is often confused with content coding. A content coding approach aims to describe an observed data set by identifying prevalence (i.e., counts) of various phenomena (Bloor & Woods, 2006). Thematic analysis, on the other hand, is more suitable for identifying key ideas within a data set, providing a purely qualitative, detailed, and nuanced account of the data (Braun & Clarke, 2006). Content coding is more suitable for answering questions about *how many* times particular phenomena occur during team decision making, while thematic analysis is intended to answer questions of *what* happens during team decision making, with a focus on distinct ideas rather than the frequency of ideas (Vaismoradi, Turunen, & Bondas, 2013).

I highlight that uniqueness of thematic analysis and its focus on ideas rather than counts for two reasons. The first is that it serves as the foundation of the analysis I completed for all decision making episodes included in Study 3. The second is especially pertinent to my study of how team decision making evolves over time. I focused my analysis on identifying novel themes that emerged as teams worked together and statements by team members that spoke to performing decisions together over time, rather than changes in counts, as is typical of quantitative and content coding approaches.

Results

My review of team decision making episodes initially generated 64 codes. These codes were collapsed into 36 superordinate codes or code categories. Further, my review of tasks identified 7 components of decision making that contained all the code categories that I observed. These 7 components are 1) team preference, 2) information review, 3) roles and functions, 4) team dynamics, 5) strategy, 6) pre-discussion, and 7) post discussion. A summary of these components and the code categories of which they are composed are provided in Figure 6. This figure includes how pre-existing components of group information processing map (Hinsz et al., 1997) onto the components and codes I identified; it should be noted that each of the team decision aspects identified in Hinsz et al.'s model were accounted for in the codes I identified.

The results of my thematic analysis of team decision making are presented below into sections. The first covers overall themes I discovered from analyzing teams. This section includes explanations of each of the seven components I identified and themes relevant to each of those components. The second section addresses themes relevant to team decision making over time.

Themes in Team Decision Making

Team Preference. As outlined previously, a primary focus Study 3 is to determine how teams make decisions. Preference selection is the component of the decision making process that encapsulates all themes relevant to teams establishing their preferred option for each scenario. The following are themes that emerged pertaining to preference selection.

Individual Preference is the Primary Driver in Team Preference Selection. I found that the key variable that determined the valence of competing options was individual preference. Information was exchanged and this information sometimes updates individual preferences, but ultimately the decision on what preference to choose was based on how many people wanted it. Four observed aspects pertaining to the selection of preferences support this finding. First, not one of the eight teams that completed the decision making tasks, in any of the total 39 decision making episodes, compiled a shared list of all the informational items introduced in the scenario. Nor did any teams ensure that each individual's information set contained all the information they discussed during the task. This indicates that a pooled set of information was not an essential decider on what option to select.

A second observation was that while teams did not create a compiled information set, they actively tracked individual preferences. This tracking happened at the beginning of discussions (e.g., "So, what'd everyone put first?"; Team 4, Time 1, Role 4, less than one minute into discussion), middle of discussions (e.g., "[You] want to do Nakita, Ariel, Marianna?" Team 7, Role 2, 8 minutes left in discussion), and end of discussions (e.g., "You still put A?" Team 3, Role 3, final two minutes of discussion). In fact, one team (Team 2) went as far using a white board to make a tally the number of preferences for each option (see Figure 7). Teams actively managed tracking each individuals' preferences and making sure that each had an accurate and updated understanding of those preferences. This same effort was not put forth in tracking informational items.

A third observation that supports individual preferences as drivers in preference selection was the language used to communicate preferences. Individuals expressed preferences as a personal choice rather than using team (or "we") language. Examples of this include:

> "Well I put C" (Team 3, Time 5, Role 3)
>
> "I'm B or C." (Team 4, Time 3, Role 3)
>
> "I'm going to say one, two, three…" (Team 5, Time 1, Role 4)

The final observation relevant to this theme is that individuals shifted their preferences without any new information being presented. For example, during Team 5's fifth decision making task, it was established at the onset of the discussion that three of the team members preferred the same option (the worst overall option) and one individual preferred a different one (the best overall option). The team decided to let the minority member share her information about the option. While sharing their own informational item, they decide to change their answer, saying "it's going to hit Western Europe. I kind of want to change my answer…" (Team 5, Time 5, Role 3). To be clear, the Europe information was a piece of information the individual already knew, so it did not contribute a new understanding of the scenario for this person. One of the team members even encouraged this individual to hold off on changing their preference, "Wait until you get the other one[s]" (Team 5, Time 5, Role 1), referring to facts about the other options. Despite discussion of additional information, which can only hurt the dominant preference since it is the worst option and all its good information is common, the individual still changed their preference to group's.

The Triumvirate as Threshold. A second theme that emerged from the data pertaining to preference selection was that if an option achieved a threshold of three individuals supporting it as their preference, that option was the one that was selected as the team's choice. Reaching the three person threshold resulted in one of three responses from a fourth member of the team. The first was for the outsider to modify their preference to that of the three. The example of Team 5 just discussed is an example of this shift. Another example evident is evident in Team 7. Without sharing any other crew members sharing information, the minority preference holder shows a willingness to change preference and even provides their own information to support this shift: "I guess I could see why A would be important, because you're losing one of your critical health stations" (Team 7, Time 1, Role 1). In both examples, the individual went the majority's team preference both in terms of team decision and personal decision. Both shifts also resulted in the individual being moved to endorse the worst option.

A second response to the three was for the outsider to become a *quiet dissident.* The quiet dissident conveys a shift in preference that agrees with the other three team members, but when they completed the post decision survey, they indicate a preference different than the one agreed upon by the team. Examples of these responses include "let's do that" (Team 4, Time 2, Role 3) or "I think you've converted me, I agree" (Team 8, Time 1, Role 1). In these cases, the individual remains unconvinced but withholds their dissident from the rest of the team during the discussion.

The third response to the three person threshold is for the fourth individual to become a *vocal deviant*. In these instances, the dissenting crew member would express that they do not agree with the team but allow the team to move forward with the dominant preference as the team's selection. An example of this is captured by Team 5's decision making process at Time 3. The team reached a three person threshold and wanted to finalize the decision. Upon recognizing three other team members preferred the same option, the fourth team member responded with, “That’s fine. Go with B. I’m still staying the same way. If it’s three to one, that’s the answer.”

Team Preference as Selection and/or Elimination. The third theme pertaining to team preference adds an additional perspective to how options are ranked or chosen the best solution. Specifically, identifying an option as the team’s preference can entail saying that it is the best of the competing options. I label this as *selection*. Below is an example selection exchange from Team 4, Time 4:

> Role 3: So I think B is the most likely candidate
>
> Role 1: I also said B
>
> Role 4: I said B
>
> Role 3: Alright. We’re in agreement

The other approach is elimination. Elimination identifies a preference by eliminating other options as not viable. In this case the preference is not chosen because of its favorable attributes, but rather survives being discarded because of its unfavorable attributes. For example, Team 5 at Time 5, chose their preference “only because we can redirect the other two” (Role 3). Essentially, the other two options were eliminated from consideration because they could be redirected, leaving the remaining option as their preference.

Three additional aspects related to this theme were found in my analysis. The first is that many teams use both elimination and selection in identifying their preference. Specifically, teams would eliminate one of the options and focus their selection between one of the two remaining ones. An example of this is apparent in Team 5’s discussion at Time 4. With ten minutes remaining on the task, one of the team members asks the team “so we’re writing out [B] at this point I think?" This propelled the team to eliminate this option and focus on choosing between the remaining two options.

A second aspect of this theme is that team pre-discussion consensus is relevant to selection and elimination. Existing hidden profile research shows teams are more likely to select an option if all individuals prefer the same option (Lu et al., 2012, Schultz-Hardt et al., 2006). I found that pre-discussion consensus of an option not being anyone's top choice can also result in its elimination. For example, upon realizing all individuals ranked the same option third, an individual on Team 8 (at Time 3) states "we are agreeing Nikita's number three." Number three indicating it is the worst option and as a result the team seized to consider it as a potential preference. It in fact was the best overall option.

This tendency in the context of hidden profile type decisions, where tasks are designed such that the best overall option is the worst when looking at only individual information, identifies consensus as a two-way risk. One of choosing the worst option and one of eliminating the best, doubling the chance of consensus leading to a suboptimal decision.

A third aspect of selection and/or elimination is that criteria shape preferences. For example, Team 8 decided that their criteria for the best option during their third decision making episode was to identify the "bad things that may hinder them" and selected the option with the least negative information about it. This resulted in the team reviewing all the negative pieces of information about each option. Taking a negative information approach, however, limits a team's ability to identify the best option because the tasks are designed such that the worst option has six negative pieces of information, the best option has four, and the worst option has six. Thus, a team selecting an option based on the least “bad” information favors the team selecting the middle option.

Initial Preference as Referent. A fourth theme I observed about team preference is that one’s initial preference serves part of their identity in team decision making. As I discussed previously, teams actively tracked the option preferred by each individual. But individuals’ initial preference carried additional significance. One such example is evident in a decision making episode involving Team 2**.** After the team selected their preference on their third decision making episode, one of the team members recognizes another as a winner because the team chose his initial preference: “[Role 3] flipped us on both of these. Oh and he got us on all of his leanings, nicely done!”

Initial preferences also anchor individual evaluation in an unexpected way. Existing research highlights that initial preference biases individuals to prefer their initial preference even after they receive disconfirming information (Greitemeyer & Schulz-Hardt, 2003). I expected this to mean that individuals would simply dismiss preferences that were not their own as inferior. However, I found that initial preference does not necessarily eliminate options or hinder the discussion of them. While Team 8 was completing one of its decisions, one of the team members was actively engaged in learning about all three scenario options. After an exchange of information, this individual conveys that it appears that two options are equally appealing. To break this tie, he uses his initial preference as a tiebreaker in his decision, “yeah, I had [A] first anyways.” This demonstrates that even when an individual is willing to detach themselves from their initial preference during discussion, an initial preference still carries weight that could influence an individual's decision down the line (and is most likely harmful given the design of hidden profile tasks).

Judgmental Framing to Defuse (Responsibility and/or Conflict). A fifth theme I observed about team preferences is that teams introduced judgmental framing when individuals expressed uncertainty about which option to select or when teams encountered competing preferences. Judgmental framing is to suggest that tasks do not have a demonstrably correct answer (Laughlin, 1980; Laughlin & Ellis, 1986). Judgmental framing was introduced into discussion in one of two ways. The first was a statement about the overall nature of the task and explicitly indicating that the task had no best answers. Examples of this type of framing is below:

> "There's no right answer, we have to just choose" (Team 4, Time 3, Role 3)
>
> "The purpose of the task is discussion, and the process, and not so much the outcome" (Team 8, Time 3, Role 3)

The second judgmental framing was less overt about the task itself and focused on the options in the scenario. I describe this second type of judgmental framing as downplaying differences in the outcomes, where all options are positioned as approximately similar quality. Below are examples of judgmental framing via downplaying differences:

> "None of them are terrible" (Team 3, Time 4, Role 3)
>
> "I don't know, they all suck man." (Team 5, Time 4, Role 2)

I observed individuals introduce judgmental framing in all phases of discussion: when reporting preferences to the team, when trying to advocate for a team member to change preferences, or when the individual was abandoning their preference in favor of another one (usually preferred by a majority of the team). Judgmental framing seems to be a coping strategy to deal with the dissonance of competing options. However, framing hidden profiles as judgmental tasks is highly problematic because they are actually the opposite of judgmental; they are intellective tasks, meaning they have a demonstrably correct answer (Laughlin, 1980; Laughlin & Ellis, 1986). Further, previous work has shown that intellective tasks are associated with reduction in common information bias (Reimer et al., 2010), a stronger relationship between discussion and decision quality (Mesmer-Magnus & DeChurch, 2009), and overall higher quality decisions (Lu et al., 2012). Positioning these tasks as judgmental is detrimental to team decision making.

It should be further clarified that nowhere in the task design does it state that there is no correct answer. Rather each scenario presents a challenge that asks both the individual and the team to identify which option they think is best. Additionally, no team introduced every task as judgmental. This supports that judgmental framing is indeed a strategy to deal with uncertainty and conflict rather than a statement about the design of the task at hand.

Noisy Signals (Indicators that can be Helpful or Harmful). A sixth theme related to team preference is that of noisy signals: attributes of team decision making that can indicate both a quality decision making process or a poor one. These two attributes are team consensus and a willingness to change preferences. The determinants of consensus have already been discussed in this section. Consensus can indicate that a team preference was based on matching initial preferences or pressure to change one's preference to the dominant one (e.g., the triumvirate theme). However, consensus can also indicate that a team thoroughly reviewed the information available to them and let the information lead them to a high quality decision. For example, during Team 1's third decision making episode, they had a thorough discussion during which they reviewed everyone's information, and unanimously selected an option (the best overall) that was no one's pre-discussion preference. Conversely, Team 7 at Time 2 started with sharing preferences, established they had consensus for their top option, and spent just over 5 minutes (of 25 available minutes) discussing before submitting their preference. This means that after this team reached consensus, discussion was a mere formality of the timeline with neither the intention nor the intensity to identify new information that could inform the team's preferences.

The second is a willingness to change preferences. Logically, the willingness to change preferences is vital on tasks where one's initial preference is likely wrong and team discussion should introduce new information that identifies a better alternative. However, I observed that a willingness to change preferences can be neutralized on a team with an individual unwilling to change preferences. For example, during Team 1's final decision making task, one of the individual's stated they were "stuck" on their preference. Despite the team continuing to discuss competing options, the individual dismissed points in contrast to their own. Examples of this individual's responses to teammates' statements include "what does that matter?", "isolated incident", and "I'm not [concerned]." Ultimately, two other teammates accommodated this person's unwillingness to change, abandoning their best and middle options for the worst option.

Information Review

Information review is the second component of decision making that I identified in my thematic analysis of team decision making. This component captures all of the decision making themes I observed about how teams introduce, track, and use informational items. In total, I identified five information review themes and they are 1) separate and unequal, 2) initial preferences are given priority, 3) be careful what you ask for and when, 4) quantity and quality matter, and 5) confusing intent and process. These themes are defined and explained below.

Separate and Unequal. The first information review theme I identified is that during team discussion, individuals keep their own list running list of informational items. Figure 8 presents an example of what this looked like: four individuals and four separate lists of information. In addition to individuals keeping their own list of informational items instead of pooling a list together as a team (the separate part). The unequal piece is that there was ample evidence during the review of the data that these lists were not the same. I observed that not all individuals actively kept notes. Figure 9 shows Team 3 completing their fifth decision making task. In this image, one individual is reviewing the information they received in their individual packet. In response, some individuals are making notes pertaining to the information being discussed while one is clearly not actively updating their list.

A second indicator that individuals did not keep up with information exchanged in discussion is that they would reintroduce information into discussion that they thought had not previously been introduced. For example, during Team 8's fourth decision making task, one individual states "the one thing that [Role 3] didn't mention that I have is the low wind speed." However, this informational item had been already mentioned five minutes earlier.

The third indicator that individuals possessed unequal lists is that they were unclear or incorrect about what facts correspond with which option. For example, during Team 3's second decision making task, one of the team members (Role 2) introduces a very distinct fact about one of the options (that a particular asteroid option could cause a nuclear winter). However, a different individual (Role 4) later in the conversation conveys that she recorded that information for two of the options, “I have it for B and C.”

Hidden profiles are designed to provide each individual with a distinct set of knowledge about a particular scenario. The separate and unequal theme highlights that individuals do not compile their individual information into one team database, nor do they individually keep updated lists that accurately attend to and capture all the information introduced by their team members.

(Initial) Preferences are Given Priority. The second theme of information review highlights the prominence of preferences, particularly initial preferences, in the review of information. Prior to information being exchanged, teams first reviewed individual preferences. This was typically done in one of two ways. The first entailed the team sharing preferences prior to the start of information exchange. Here is an example of this exchange from Team 7 (Time 2):

Role 2: Are you ready? I said Ariel, Nakita, Marianna

Role 1: I said the same

Role 4: Ariel, Nakita, Marianna

Role 3: I said Ariel, Marianna, Nakita

The second approach had an individual share their preferences and then provide support for their preferences via their information. Below is an example of Team 3 (Time 1) using this type of approach:

Role 3: Do you want to go first?

Role 2: Let's see, the environmental control system should be number one priority due to the fact that we're losing O2 level. For fire suppression, O2 levels trump

> protection system and we're losing air five times faster than usual at the top of the ISS. I say that's number one priority.
>
> Role 3: Okay. Yeah, I agree with that that should be the number one priority, and then the fact that we have a crew member that's also done it before so there's a chance that at least we can leverage that experience a little.

This theme is highly problematic because it highlights that teams lack an objective exchange of information. As I discussed previously, my findings convey the prominence of individual preferences in how teams select an option. If individuals are focused on evaluating how their preferences align with others, they may be distracted from attending to all the information being introduced. Additionally, if individuals observe patterns in preferences, for example everyone choosing one option as the worst, they may tune out information pertaining to that option as not important. This theme highlights that teams focus on individual preferences and this focus not only hinders option selection, it also diminishes the quality of information exchange.

Be Careful What You Ask (for) and When. A third theme of information review identifies the importance of questions and their timing to facilitate quality information exchange. The first aspect of this theme is that establishing criteria of what information to share can limit what information is shared. For example, during Team 2’s third decision task, one of the crew members asked everyone to share all their information about “mitigations.” The problem with the criteria approach to introducing information is that some information does not fit a criterion, and of teams that used the criteria approach, I observed that used criteria to solicit questions did not introduce a category of everything else, resulting in pertinent information possibly not being asked about. This criteria approach is not optimal because it requires a level of analysis prior to someone contributing information. This analysis could be preventing someone from paying attention to the information others are sharing as they determine what categories their information belongs in.

But, my observations of team decision making highlighted the importance of asking three important questions types. The first is clarifying questions about informational items. These types of questions helped to provide clarity and specificity to the information discussed, which does not always happen naturally (see next theme). Examples of good clarifying questions include:

> Is it speeding up though? (Team 1, Time 2, Role 2)
>
> So wait, 15% of humans would die on transport because of the distance from us? (Team 7, Time 3, Role 2)
>
> That's a guess, or that was written? (Team 5, Time 3, Role 3)
>
> Does it specifically say two EVA's? (Team 3, Time 1, Role 3)

A second important question is asking for additional information. This simple type of question, targeting new information to be introduced into conversation ensured that everyone's full information sets were introduced. For example, as Team 4 (Time 3) was reviewing each option one by one, before moving on to the next item, one team member asked, "did we have everything for C?"

The last important question is asking the team how to make sense of information. It is introducing sorting criteria pertaining to the data, but after all information has been presented to and by the team. This type of question facilitates the team making sense of the information they possess. For example, Team 1 (Time 2), established a key decision criterion by asking, "would you say go with the highest probability of a hit?" My observation is that few very teams asked such questions and it was more common for them to fire off the individual criteria they were using to determine their individual preference.

This theme highlights both the importance of including specific types of questions and timing of these questions in facilitating quality exchange and review of information. In summary, my findings suggest teams need to include three questions in their discussions: 1) asking for clarification about informational items, 2) asking for additional information, and 3) asking how the team wants to make sense of the information.

Quantity and Quality Matter. The fourth theme of information review introduces the importance of quality, accurate information exchange in team discussion. Quantitative research on hidden profiles, like my Study 2, focus on the numbers associated with information exchange. This type of work captures what information was (or was not) introduced into discussion and how many times was it mentioned. My analysis of team decision making found an additional level of complexity in team information exchange pertaining to the accuracy of information exchanged. I observed two types of misinformation. The first type occurs one when information was misstated, or its meaning was modified. Below are three examples of misinformation. In each, first I quote the crew member with bold text indicating the misinformation. Next I include, for comparison, the information as it was provided to the crew members.

> "Mine says the **impact point can be calculated precisely**."
>
> (Team 2, Time 2, Role 3)

[Statement omits that this calculation can only occur 7 days before impact. Actual item: “Aurora’s impact site could be calculated precisely 7 days ahead of impact”]

“I was thinking it was Mariana that **was closest to Earth**.”

(Team 5, Time 3, Role 2)

[Inaccurate statement, an alternative option was closer. Actual item: “[Nikita] is the closest to Earth of the three options”]

“He was frustrated about missing his two-year-old daughter at work when he has to stay late… **that would go away on a long-range mission**”

(Team 7, Time 5, Role 2)

[Bold not included in scenario, just speculation. Actual item: “Vittori has a 2-year-old daughter, and colleagues have noticed he is frustrated when he has to work late and cannot be home with her. There is worry that being away for so long on this mission will exponentially increase Vittori's frustration.”]

The detrimental impact of inaccurate information is amplified when completing hidden profile tasks. If an individual misstates a common piece of information, other team members can correct this inaccuracy because they are also familiar with this information. However, unique information is known by only that person introducing it, so it is not possible for others to be aware of inaccuracies or to correct them.

The second type of inaccuracies I observed involved neutral information. In the design of the tasks teams completed, each scenario contained informational items that were intended to be neutral in nature and have no influence on preferences. However, I observed that when neutral items were introduced into discussion, they were often given a valence. Examples include:

> "Rotating counterclockwise **means that it's abnormal**'
>
> (Team 3, Time 2, Role 1)
>
> [Neutral information changed to negative fact. Actual item: "The asteroid is rotating counter clockwise along a horizontal axis."]
>
> "It has a reflective surface, and I only mention it in case somebody had been saying that's **harder to target or something.**"
>
> (Team 1, Time 2, Role 1)
>
> [Neutral information changed to positive fact. Actual item: "The surface of Aurora is highly reflective so it is possible to see it in the night sky via a telescope.]
>
> "I **like Bean because** he also likes Shakespeare and the Beatles, two of my favorite things."
>
> (Team 5, Time 2, Role 2)
>
> [Neutral information changed to positive fact. Actual items: "Bean enjoys listening to the Beatles while performing work on his own," and "Bean is an avid fan of Shakespeare and often quotes his work."]

Changing the valence of a neutral piece of information to positive or negative valence would impact the net valence of the option to which it corresponds. For example, the best overall option in each scenario is designed to have a net valence score of +2 (number of positive items more than negative items). This option also contains four pieces of neutral information. If two of those pieces of neutral information are perceived as negative valence, this option would no longer likely be the best option.

I should clarify that my observation of neutral information being assigned a valence does not seem to be from poorly constructed neutral information items. Rather, teams tend to place some valence on all information introduced. In part, this could be driven by wanting all information to align with option preferences or personal biases, such as the Shakespeare example.

In summary, this theme points out that the accuracy of information introduced into team discussion is as important as how much of a scenario's information is presented. And, this nuance is likely to be missed using strictly quantitative approaches.

Confusing Intent and Process. The fifth theme of information review introduces the complexities of inferring the causes of discussion quality outcomes. In particular three aspects of discussion stood out: focus, coverage, and late information additions. Focus refers to the same concept discussed earlier in this dissertation of how many total mentions of a type of information (i.e., unique information) out of total mentions. An underlying assumption I held about information focus is that this ratio indicates how thoroughly teams examine common and unique information. Qualitative review of team decision making revealed two competing sources of this ratio. The first is that indeed a certain type of information or particular option is the focus of discussion, that a team spent more time evaluating it. The second is that information focus scores are largely influenced by the team's approach teams in sharing information. For example, Team 6 (Time 5) established an information review process where the team took turns and each individual shared all the information they received. Team 4 (Time 2) on the other hand established a process in which individuals only added information yet to be introduced into discussion.

These two approaches would result in substantially different information focus scores. Team 6's approach would result in more dominance of common information because that information would be mentioned by all four team members during the initial information exchange whereas unique information can only be mentioned once. This example demonstrates a high common focus score that does not tell the full story of whether the team fairly evaluated all information. This vulnerability of information focus to be inflated in favor of common information due to process might explain why it was found to be a less meaningful predictor of decision making quality on hidden profile tasks than coverage (Lu et al., 2012).

Qualitative analysis also helped generate multiple (although not competing) explanations for team performance on information coverage. One aspect of information coverage that stood out is that one's ability to contribute is shaped by their performance during the individual portion of the decision making tasks and not all individuals maximize their efforts during the individual portion (to be discussed in detail in subsequent sections). If these individuals did not review, write down, or remember some of the information unique to them, this information cannot be introduced in discussion.

A second explanation of information coverage scores could be the results of the team's discussion process. It is possible that individuals wanted to share their unique information, but the team used a strict criteria based approach to determine what information they introduced and did not include a criteria into which this information fit. And lastly, an explanation could be motivation, whether to not share information that contradicts their personal preference or that most favored by the team.

Regardless of the cause, poor performance on information coverage diminishes the possibility of a team making a quality decision and is objectively a bad thing. However, through qualitative analysis I realized that determining causes of poor coverage performance requires careful study of each team (and even of each team's decision episodes).

A third information phenomenon that I observed which brings into question process or motivation is that of late information introduction. In these cases, individuals have all contributed their information to discussion and are starting to focus on determining which option to select and then one individual will contribute a piece of information much later than other information was introduced. It is unclear whether this was the result of the individual tracking what information they had already introduced, or this was a strategic ploy to sway preferences. An example of such an exchange is below. Team 8 (Time 3) has been in their team discussion for 15 minutes already, all team members have had a chance to share their information, and they have started trying to narrow down a team preference:

> Role 1: You guys holding that?
>
> Role 4: Yeah

Role 2: And a lot of that, just came down to some of our survival discussions. Do we have food? Do we have water? Do we have energy? Is there a way that we can find shelter? And Aerial gives us, based off of the facts given in the prompts, that gives us food, energy and water.

Role 1: Twice the gravity of Earth though.

Role 4: I didn't know that.

Role 3: Would that be a bad thing?

Role 1: It's like you carrying your body, everywhere you go.

Role 3: So, you had that for Aerial?

Role 1: Oh, I'm sorry. Did I not mention that?

Role 4: No.

Role 3: No.

Role 1: Oh, I apologize.

In summary, this theme highlights that while quantitative measures can evaluate discussion quality, they do not capture the full essence of what is happening while teams make decisions. Information focus and coverage scores can be indicative of team and individual bias toward particular information or options. But these scores are, and discussion quality more broadly, also influenced by the discussion processes established by teams, such as asking individuals to share all their information or just information not already discussed.

Roles and Functions

In addition to team preference and information review, the third component of team decision making in my analysis is that of roles and functions. This component captures the roles and functions that emerged as teams make decision making tasks. I identified two themes pertaining to roles and functions.

We Want You. The first theme related to roles and functions is that a number of valuable roles emerged during team decision making that helped teams in carrying out quality discussions and making good decisions. In total I identified five such roles 1) initiate structure/process, 2) maintain structure/process, 3) solicit information, 4) clarify information, and 5) establish decision criteria.

The “initiate structure/process” role helped teams to get started and create a process through which teams would review information and make decisions. For example, this is how Role 3 on Team 4 (Time 1) started this first discussion: “Well, I was wondering if we could share information first, 'cause I'm wondering if we have different information, which might explain why we choose different things?”

The “maintain structure/process” role helped maintain the established process. These individuals who redirect the conversation if getting off track or ensure one phase of discussion is complete before moving on to the next. For example, during Team 3(Time 3), Role 2 actively managed the discussion process:

> “Why don’t we read off what we have?”
>
> “I’ll go over what I have too”
>
> “So let’s go over Belinda. What’d everyone get for that”

The “solicit information” role helped ensure that all information was included in team discussion. For example, Role 3 on Team 4 (Time 2) asked a team member, “what did yours say?” After the individual finished sharing, they asked “what else did it have?”

The "clarify information" role, in contrast the solicit information role, focused on the information already introduced. This role helped to add precision to the available facts. For example, Role 3 on Team 7 (time 3) asked questions such as:

> "Oh like, chemical erosion? It's like rustic ionization or something?"
>
> "So you had said it was in the extremely inhospitable system?"
>
> "Conditions are made to sustain water. Does that mean…?"

The "establish decision criteria" role helped frame how the team would make its decision. This could be in the form of helping identify which concern or attributes seem most pressing or just the process the teams use. Referring to an earlier theme that teams used individual preferences to establish team preference applies here as well. While individuals all determined which option they thought was best, this role at least helped to have everyone use the criteria to make their decision that informed these criteria. When Team 4 (Time 4) finished sharing their information, Role 3 facilitated the next phase of their discussion, stating, "All right. How do you guys wanna do this? Shall we ... discuss the criteria?"

Two additional aspects of roles stood out to me in my analysis. One is that roles emerged during the decision making process. Roles relevant to these tasks were not included in the instructions and individuals of various titles took on these roles. For example, on one team the commander might initiate structure while on another team, one of the mission specialists fulfilled this role. And, these roles did not necessarily emerge for all teams. The second aspect is that my review of the data found that the distribution of a role across multiple team members improved the efficacy and ensured the sustention of that role's function. Teams that did not distribute roles across multiple individuals were susceptible to performance drops if the single individual filing the role did not remain diligent throughout discussion. The riskiest role configuration was having a single individual solely responsible for enacting multiple roles; my observation is that these tasks are too complex for one individual to successfully manage the responsibility of multiple roles alone.

Handle with Care. I also identified a second set of roles that seemed to produce mixed results. One is that of the jokester. This individual would make jokes during the task. In some instances, the joke would make the team laugh and seemed to help bring the group together. During Team 6's third decision task, Role 2 shares a piece of information and embeds a joke that was positively received "It has four moons, I'm not sure that's relevant. And it's in a bar-shaped galaxy, which is why I picked Mariana, because I like bars."

Alternatively, some jokesters would make offensive comments or include a joke while sharing information, blurring what is just a joke and actual discussion of information. Work on social roles in extreme and isolated environments identified jokesters as positive deviants that contributed to team culture (Johnson, Boster, & Palinkas, 2010). However, the net effect of individuals taking on jokester roles during this task was unclear. Below is an example of joking during an information an exchange between Team 1 (Time 5) which could be offensive and distracting:

> Role 4: So what are your negatives?
>
> Role 3: [He] has made offensive jokes in the past based on...
>
> Role 4: Yeah, they're chinks, who cares? Have you seen chinks?

The other role that produced mixed results is that of a preference deviant. In some instances, the deviant helped to challenge a team to think beyond their preferences or information, such as highlighted in the instance of Team 2 (Time 3), when Role 3 led the team to a higher quality decision. However, in other situations, a deviant can represent an individual not in alignment with the team, unwilling to change their stance, and might produce little value to the team, possibly even creating negative feelings between them and others. For example, Teams 3 and 8 both had a single individual disagree with three of the teams five decisions. It is clear that the teams were fine making decisions without these individuals' preference agreement.

Team Dynamics

The fourth component I identified as part of team decision making is team dynamics. Whereas the prior components captured how teams chose their preferences, reviewed information, and established roles, this component coded for team dynamics that directly or indirectly influenced other components. One theme emerged from my analysis of team dynamics.

Team Decisions are Subject to External Forces. My review of the data identified a number of forces external to the actual decision making tasks that likely impacted the teams how the teams completed the task. One such force was part of the context: sleep deprivation. Numerous teams visually displayed signs of fatigue while working on the task. See Figure 10 of an example of an individual sleeping while they are supposed to be working on the task. A second observed issue was a response to a conflict with HERA's mission control. The actual incident did not occur during the task, but the comments, which were made as the team was getting ready to start the task, indicate a sense of frustration that likely impacted that individual's performance. Below is a short exchange between Team 1 (Time 4):

Role 2: Mission control...

Role 3: You don't like them so much anymore

Role 1: Looks like

Role 2: Not in the last hour

Role 3: Because they said bad things abouts about you?

Role 2: No they're being paternalistic

A third external force was simply considering the rest of the day's schedule. The team was deciding whether to spend more time on their decision or move onto the next task, and this decision was based on whether they would have free time once the tasks are complete. Here is an exchange between Team 3 (Time 5):

Role 3: Okay, moving right along?

Role 2: You got ten more minutes before we shut you off.

Role 3: Or we could skip ahead and have free time after?

Role 2: Free time? We got stupid interactions after this.

Role 3: Well, a break between this and interaction.

These findings are telling because the teams included in my dissertation are being studied as part of broader work on teaming in isolated and confined environments. However, my findings show that even in these environments, decisions are influenced by external forces having nothing to do with the task itself. And the number of these external forces increases infinitely for real world teams, ranging from both personal and professional life. Accounting for such forces could help explain the contextual carryover that affects performance in team decision making.

Strategy

I have now reviewed four components of team decision making identified in my qualitative analysis of the data: team preference, information review, roles and functions, and team dynamics. The fifth component that emerged in my thematic analysis is that of strategy. Strategy consists of all my observations and codes on teams formulating plans or approaches to team decision making. I identified two themes within the strategy component.

Jump In and Go. The first theme is that teams start these tasks with very little discussion of how to approach them. For example, the following are instructions that teams expressed when starting the task for the first time, with no familiarity with the task or established process. Below is the exchange between Team 8 as they initiated their first discussion:

Role 1: We ready?

Role 3: Are we ready?

Role 4: All ready.

Role 1: All right, what did you do?

This lack of strategic discussion exists throughout decision making episodes. In only one decision making episode (Team 5, Time 2) did someone suggest that the team should take a moment to process all the information they just exchanged: "So, let's take a brief pause here. How do you guys want to resolve this difference?" The approach to these tasks is more of high speed checkers than strategic stress.

Wrong or Different? The second strategy pertinent theme is that during initial decision making episodes, teams clash about whether individuals received different information or they are incorrectly sharing information. For example, here is a brief exchange of Team 3 (Time 1):

Role 4: I think we may have all read different things.

Role 3: Oh, we all have a different understanding of the same…

Role 4: I don't know, but I would …

Role 2: I'm pretty sure we all had the same thing.

What is also concerning is that even when teams establish that they have different information, they continue their discussion in much the same way as it was, without incorporating strategies that could best leverage the unique information to identify a correct solution. Both strategy themes convey a troubling lack of quality strategic consideration by teams as they completed their decision making.

Pre-Discussion

The previous five components that I identified in this study focus on what happens during team discussion. The sixth crucial component team decision making that I identified is pre-discussion. This component encapsulates my observations and codes of what take place during a hidden profile decision making episode before a team comes together for discussion; focuses on the individual performance phase that builds to the team phase. In my analysis of the pre-discussion component, I identified one prominent theme.

Individuals Do Not Maximize Their Time. I found that individuals failed to make the most of their time while completing the individual portion of the decision making task. This is the time during which individuals are supposed to become familiar with the scenario and learn key facts that will help them identify the best option. One way I found individuals do not maximize their time is via behavior that is harmful to their own performance. I observed individuals taking naps (Figure 10) and leaving their workstation to fix food and get coffee (See Figure 11). I also observed behavior that negatively impacts others' performance during this phase: talking to others before everyone has completed the individual phase. At minimum, these side-bar conversations can make it more difficult to concentrate for individuals still working on the task (Figure 12). But, in other instances, they will actually draw those still working away from the task and into the conversation (Figure 13).

What makes this finding most concerning is that the failure to take good notes or memorize the information presented during this pre-discussion phase informs what information can be included in the team discussion. So even in the situations where an individual does not put effort into the task but not distract others, they ultimately hurt the team. If they also distract others during this time, the detriment of their behavior on their team's performance is magnified.

Post Discussion

The seventh, and last component, of my decision making analysis is post discussion. This component includes my observations of team conversations once they complete the decision making task. A major impetus for these conversations is the post decision survey teams must complete after finishing the task. This survey is intended to be completed individually, but most teams talk through it. In fact, the survey takes on a role as a type of feedback artifact that informs my theme pertaining to post discussion.

Mixed Reactions to Evaluation. The survey individuals complete provides them with a list of informational items. This list consists of unique informational items that were included in the scenario, as well as distractors. The reactions to this survey were quite mixed. Some teams responded to the survey as containing information that was included in the scenario and they need to do a better job of sharing information: "I feel like a lesson learned is we probably should just have gone over all the information we had anyway, even though we weren't the same, because there could have been something that you had that made me worried" (Team 7, Time 1). Others dismissed the survey as filled with pointless information or detail: "extraneous data" (Team 6, Time1).

More broadly, the survey served as a reassurance to some and a source of doubt for others about the accuracy of their selection. For example, after reviewing the survey, Role 3 on Team 5 (Time 2) responded with "propulsion was the one!" This is surprising because the survey provides no actual feedback about what information is real or a distractor, nor does it provide any insights about which options were best. Further, I am hesitant to dismiss the survey as an artifact unique to research studies. It is tenable that teams in the real world use some proxy of performance that has nothing to do with the actual quality of their performance. This proxy could include something as simple as a meeting agenda that someone made prior to a meeting. There is no assurance that the items on the agenda contain all the meaningful pieces of information that needed to be addressed nor that all of them were relevant to a decision made during the meeting.

Themes in Team Decision Making over Time

The second point of focus in my thematic analysis of team decision making was analyzing the role of time in decision making and the ways in which multiple decision making episodes affected teams. My analysis focused on two elements. One was to capture differences that emerged as teams worked together over time. The second was to note any temporally oriented conversations that attended to the fact that teams have worked together previously or would continue to work together. In total, I identified nine themes relevant to team decision making. I describe them below (see Table 52 for summary). Next to the title of the theme are parentheses that indicate which component of decision making this theme most closely aligns.

Consideration of Past and Future (***Team Preference***)

One theme that emerged in my analysis of team decision making over time is that teams are aware that they will complete and or have completed more than one decision and this influences their decision at the current time. One such example is evident in Team 1 (Time 1). In this situation, an individual is concerned about the team selecting his preferred option because if it is not deemed incorrect, he fears they will not listen to him in the future:

> Role 3: I mean, here's the worst case scenario if he's wrong, right? We're going to be like, ugh idiot...
>
> Role 4: Never listen to me again, right? That will be the [inaudible] and I will be gladly willing to...

A second example of teams considering future or past performances is demonstrated in an exchange involving Team 4. In this situation, the team recognizes that one individual's preferences have yet to be selected as the team preference, so they choose that individual's choice. The specific exchange is provided below:

> Role 2: Let's go with [Role 4] this time
>
> Role 1: Let's go with [Role 4]
>
> Role 4: No, we don't have to go with me
>
> Role 2: No, we're gonna go with you this time. They're all the same. A. We'll go with yours, so.
>
> Role 3: Done.

The third example demonstrates that teams possess some evaluation of previous performances. For instance, during Team 1's fourth decision task, one individual responds to another's preference by asking, "why are you always wrong?" The team member dismisses the preference of another teammate by expressing this individual is always wrong. A second demonstration of preference tracking is the recognizing preference patterns. In response to two individuals having opposing preferences, which occurred multiple times and each decision prior involved one of the two disagreeing with the team preference, Role 2 states, "I'm always between you guys" (Team 5, Time 3).

These examples show that teams consider previous and future performances in their selecting of preferences. What is also interesting about the first example and third set of examples is they include some evaluation of decision quality; however, the design of the tasks in this study do not provide performance feedback. Not only are teams tracking past preferences and considering future performance, but they are also using some subjective measure of quality to categorize these performances. This demonstrates that a team decision is not an independent performance episode but rather is subject to the influence of past and future episodes.

Preference Stickiness (Team Preference)

A second theme that emerged as I analyzed team decision making over time what I describe as preference stickiness. I define this term as instances in which an individual conveys to the team that they have a preference from which they are unwilling to shift. No such statements were made during teams' initial decision making tasks but occurred as teams worked together over time. Examples of such statements are included below:

"I'm still stuck on C" (Team 1, Time 5, Role 2)

"I'm still stayin' with mine" (Team 3, Time 4, Role 2)

"I'm sticking with A… but majority rules" (Team 8, Time 2, Role 1)

The emergence of this theme as teams work together over time suggests that some individuals become less willing to change their perspective as they collaborate with others who hold competing views. This observation suggests working that long term teamwork could result in the emergence of individual tendencies detrimental to quality decision making.

Conflict Avoidance through Silent Dissent (Team Preference)

I introduced the notion of silent dissent as one of the responses to situations in which three other team members preference the same option. In instances of silent dissent, individuals convey they support a preference but actually prefer a different preference, based on their post discussion preference submission. My analysis of team decision making over time found a peculiar trend pertaining to silent dissent. Sometimes, teams had more than one individual silently oppose their team's preference. This means that at least half of the team did not prefer the option the team selected. Further, all instances of multiple silent dissenters occurred at Time 3 or after, so this is a unique behavior that only emerged in teams who had worked together over multiple periods.

It is worth considering whether preference stickiness and silent dissent represent similar mental states (i.e., an unwillingness to change preferences) but manifest in different behaviors with the former vocal and the latter silent. They could both be equally harmful to a team, but the potential harm is likely higher for silent dissent because there is less opportunity to engage in dialogue about the differences.

Apex at Time 3 (Information Review)

The fourth theme that emerged in my analysis of team decision making over time is that team discussion peaked at Time 3. This observation did not rely on counts of what information was actually exchanged. It was informed by how information was shared and requested. Time 3 (Mission Day 14) was the performance episode during which teams were most diligent in prompting others to share all of their individual information, ensuring everyone spoke, asking questions about information to make sure it is fully understood, and individuals explaining their information objectively. Some examples that demonstrate quality discussion at Time 3 are shared below and in brackets I identify how these examples represent quality decision making:

> "Let's just go with facts" (Team 1, Role 3)
>
> [objective review of information]
>
> "Let's look over Belinda. What did everyone get for that?" (Team 3, Role 2)
>
> [systematically review of information]
>
> "Do we have anything else for b?" (Team 4, Role 1)
>
> [creating opportunities for additional information sharing]
>
> "I'll just start vomiting facts" (Team 6, Role 4)
>
> [comfortable disclosing all personal information]

Time 3 also corresponds with the period in time where all teams seem to have figured out the task. During the first two decision making episodes, some teams are still debating whether they indeed possess different information. At Time 3 and beyond, there is no conflict about the nature of the activity. For example, as Team 3 was preparing to start the individual phase of the activity, Role 3 reminded everyone "we have different info" to encourage them to pay attention to information presented in their report. I want to clarify that teams understanding of the activity does not necessarily mean they have the correct understanding of the activity. Some teams are striving to share information so they can improve their performance on the post discussion questionnaire.

Established Early, Changed Informally (Strategy)

A fifth theme pertaining to team decision making over time is that strategies are established early. If teams have formal discussion about how they want to complete the tasks, they do that during Times 1 and 2. For example, Team 5 discussed whether they want to use a majority rule approach to handling disagreements at Time 2. Most teams did not have such conversations and came up with their approach informally. After Time 2, teams let established norms guide them. For example, Team 8 at Time 3 had no discussion about how to approach the task and Role 2 simply asked Role 3, "Want to go ahead?"

I observed that changes in approach in later periods, if they occur, happen informally, with an individual changing their behavior. For example, Team 1 started their discussions with each individual introducing their information and only after everyone had a chance to share did they disclose their preferences. However, at Time 5, Role 3 started the discussion with "who do you want?" and the team began with first discussing preferences before introducing informational items. This episode also results in the team's poorest performance in terms of decision quality of all five tasks.

Through at Time 5 (Team Preference)

A sixth theme that emerged from my review of decision making over time was that many of the flaws and biases identified in this document emerged during Time 5, resulting in the poorest team preferences of all the decision making episodes. In addition to the example about Team 1 stated above, the last decision making episode was also the episode during which one team member conveyed an unwillingness to change preferences (preference stickiness). During Team 3's final decision making task, the team member who had previously solicited information about each option did not engage in this function (i.e., abandoning a crucial role). And, the last decision episode of Team 5 is when a three to one initial preference distribution (i.e., a triumvirate) resulted in the minority preference abandoning their initial preference before the team exchanging any new information.

My analysis suggests that Time 5 represents a period in team's life cycle during which teams are most susceptible to the potential shortcomings that befall teams when completing decision tasks requiring teams to leverage distributed knowledge. However, the last decision (Time 5) took place on the 34th day of a 45 day simulation. Thus, the data prevent a clear understanding of whether Time 5 represents what happens simply when teams complete numerous decisions together or is a dip in performance from which teams recover.

Clash of Opposing Forces (Pre-Discussion)

Theme seventh of team decision making over time revisits the pre-discussion theme that individuals do not maximize their pre-discussion time. Initially, individuals appear to be fully engaged during the pre-discussion periods. The detrimental behaviors highlighted in the previous pre-discussion emerge in subsequent teaming episodes. However, while individuals demonstrate behavior that interferes with optimal pre-discussion performance, teams are becoming more familiar with the task and likely becoming more efficient. Prior to the start of an activity some teams made comments to guide focus as they review the information. For example, Team 2 (Time 2) reminded everyone "we're all going to have different information about the task."

Additionally, during the team discussion statements such as "I wrote mine verbatim (Team 3, Time 4, Role 2)" suggest improved efficiency.

My study did not include any measure of pre-discussion performance. My observations indicate the emergence of factors that could both improve and hinder performance as teams work together over time. Future studies could explore which of these forces is more powerful.

The Excitement Wears Off (Team Dynamics)

An eighth theme I observed related to teams making decisions over time is a change in attitude about the task. During the initial teaming episodes, teams seem generally happy about completing the tasks. Team 5 vocalized this sentiment after finishing their first task, saying "that was a fun one, I like that one a lot." However, as teams worked together, they started expressing more negative attitudes about completing the tasks. The comments made by team members conveyed a criticism of the scenario, a lack of desire to complete the task, or an indifference to a decision's outcome. While an explanation for these negative comments could be that teams did not find the tasks engaging, the fact these comments were made only during later decision making episodes suggests are more influenced by time than the tasks themselves. Below are examples of the comments made by teams:

> "I'll go with whatever, it's not like this is a real situation" (Team 3, Time 5)
>
> "This is going to suck" (Team 1, Time 4)
>
> "We're deciding the fate of the human race in 15 minutes [in sarcastic tone]" (Team 5, Time 4)
>
> "I don't care enough that it matters" (Team 6, Time 5)

Teams Evolve at Different rates

The ninth and final theme that emerged from my analysis of team decision making over time is not specific to one component of decision making but applied to team decision making at large. This theme recognizes the differences in teams making decisions as compared to individuals. Some teams established effective norms early on but struggled later on. Team 1 would be a good example of this. As I previously highlighted, they had an effective discussion process that they abandoned during their last decision making episode. Other teams took longer to find an effective process. For example, Team 7 cemented a process during their third decision making tasks that they continued throughout the rest of their decision making episode. Some teams sustained performance over multiple decision episodes. Teams like 4 and 6 used a steady approach through their decision making episodes. Others tended to fluctuate, like Team 3 which constantly modified its approach.

Discussion

This chapter produced a thorough qualitative analysis of team decision making via thematic analysis. My initial review of decision making evaluated each complete decision making episode as an independent teaming activity without consideration of team and time. I used an inductive approach to identify 36 coding categories and subsequently mapped Hinsz et al.'s (1997) group information modeling process to these codes; I found that all the processes identified in Hinsz et al.'s model were represented in the codes I identified (see Figure 6). Through review of the codes, I identified seven components of team decision making including: 1) team preference, 2) information review, 3) roles and functions, 4) team dynamics, 5) strategy, 6) pre-discussion, and 7) post discussion. Across these seven components, I generated 18 themes that influence team decision making. Table 51 presents a summary of these 18 themes.

My second analysis incorporated a case study thematic approach that evaluated how team decision making evolves across time. This analysis used the components of decision making and codes identified in the initial phase of analysis, as well as looking for specific conversation that conveyed a consideration of time or repeated collaboration. This analysis generated nine themes pertaining to team decision making, which include 1) team preference: consideration of past and future, 2) team preference: preference stickiness, 3) team preference: conflict avoidance through silent dissent, 4) information review: apex at Time 3, 5) strategy: established early, changed informally, 6) team preference: trough at Time 5, 7) pre-discussion: clash of opposing forces, 8) team dynamics: the excitement wears off, and 9) that teams evolve at different rates.

Relationship to Existing Literature

I used an inductive approach in my thematic analysis of team decision making to generate novel insights pertaining to how teams make decisions. This entailed letting the observed data and decision making episodes drive the structure and nature of my themes, rather than using existing literature as the framework to organize my thinking and determine which factors I would focus on. I did complete the literature review of this dissertation on team decision making using the hidden profile paradigm prior to the qualitative analysis completed in this chapter. Familiarity with this literature further helped ensure that the themes identified in this chapter offered a new and richer understanding of how teams make decisions.

The themes pertaining to the temporal effects team decision making are truly novel because this dissertation is the first to study intact teams completing multiple hidden profile tasks over an extended period of time. The 18 themes generated from analyzing team decisions as stand-alone episodes also each offer distinct insights about how teams in this study made decisions. The specific insights from each of these themes were discussed in the previous sections of this chapter and the broader contributions of this work are addressed in subsequent ones. However, because there is a rich literature on single episode team decisions and team performance in general, I would like to explicate the distinctly new findings in my 18 stand-alone themes and how they map to existing research.

The novel insights of team preference themes (i.e., how teams make decisions) include that teams actively and continuously track individual preferences, individual preferences are the primary drivers of team decisions and that actual discussion and consideration information about competing is a of secondary importance, and while individuals succumb to the majority's preference, they react to the this pressure in three distinction ways (align with the majority, silent dissent, and vocal deviance). These findings align with broader work on social pressure and clash of individual preferences leading to suboptimal decisions discussed in studies of groupthink (Janis, 1972).

Additional novel team preference findings include how teams use selection and elimination tactics to identify a team preference, initial preferences as a referent beyond just an unwillingness to consider perspectives, the use of judgmental framing as a strategy to gain support for preferences, and the mixed implications of consensus and willingness to change preferences in hidden profile. These findings contribute distinct and nuanced insights related to existing literature on teams using various strategies to make decisions (e.g., Goodwin & Wright, 2001), framing of team task outcomes (e.g., Laughlin, 1980; Laughlin & Ellis, 1986), pre-discussion preference bias (e.g., Faulmüller et al., 2010), and the influences of consensus (e.g., Schwenk & Cosier) and composition (e.g., Weingart et al., 2007) on decision making.

The other primary set of themes focused on information exchange during team decision making. Novel insights from these themes included finding that team information pooling consisted of individual information sets and teams did not make a compiled team list, various ways in which teams reviewed information and how preferences influenced the order in which information was disclosed, important questions that facilitated quality discussion and that the timing of these questions alter their effectiveness, the accuracy of the information shared matters as much as what information is shared, and poor team performance on established team discussion quality outcome measures could be the result of either team process or motivation. These finds collaborate and extend existing findings on how individual information drives individual preferences before and after learning of additional information (e.g., Klocke, 2007), individual preferences influencing the intensity and bias of information exchange (e.g., Schultz-Hardt & Mojzisch), the importance of quality questions in team performance (e.g., Van Quaquebeke & Felps, 2018), the necessity of quality information in making quality decision (e.g., Hahlweg et al., 2017), and that intention is only one of a number of factors that influences behavior (e.g., Ajzen & Fishbein, 1974; Sheeran, 2011).

The third set of themes were secondary themes that were observed as part of thematic analysis on team preference and information review. These themes contributed new insights including key decision making roles and how they impact team decisions, the presence and types of external factors in team decisions (in controlled contexts intended to minimize external factors), minimal strategy discussion about how to pool information and conflict over whether different information represented unique or misinterpreted information, factors that influence individual phase performance, and teams created their own performance self-assessments of information exchange and discussion quality when not receiving external feedback. These findings provide further understanding of team mechanisms specific to decision making and build on existing work related to the type of roles that emerge while teaming (e.g., Bales, 1950; Mathieu et al., 2015; Driskell et al., 2017), how teamwork is impacted by external forces (e.g., West & Hirst, 2003), the tendency of teams to commit minimal time to strategy (e.g., Hackman, Brousseau, & Weiss, 1976), individuals' shortcoming in preparing for team decisions (e.g., Faulmüller et al., 2010), teams relying on various forms of feedback to evaluate their performance (e.g., Peñarroja et al., 2015) and differing in responses to performance evaluations (e.g., DeShon et al., 2004).

In summary, this review of the 18 themes focused on decision making episodes is meant to highlight that each of these themes offered a distinct insight into how teams make decisions when having to leverage distinct individual information sets yet also support and extend existing literature on teams.

Contribution to Team Decision Making Theory

The qualitative approach utilized in Study 3 provides novel contributions to the understanding of team decision making that complement the quantitative analysis of Study 2. One such contribution, and a focal point of interest in this study, is understanding how teams make decisions. The underlying premise of existing hidden profile research is that information fuels team decisions. In an ideal decision making episode, individuals introduce information in a team discussion, the team creates a pooled set of information that leverages everyone's unique perspectives, and this pooled information results in a higher quality decision better than one could be achieved by any single individual. My analysis found that individual preference, rather than information, is the primary driver behind team decisions. Hinsz et al. (1997) provide a thorough model of how teams process information through objectives, attention, encoding, storage, retrieval, processing, and response. My finding is that this model is apt for understanding team decision making. But rather than informational items being the unit of information being processed, the primary information being processed at the team level is that of each individual's preferences. Another limitation of the Hinsz et al. in the hidden profile context is that it fails to capture the interplay between individual and team processing episodes. In Figure 14 I depict team decision making as observed in this data, recognizing both the individual and team phases and the role of preferences in driving decision outcomes.

My findings do not dismiss the importance of information in these types of tasks. Informational items are the foundations of team decisions but their relationship to decision outcome is mediated through individual preference. Further, I observed that team's do not compile a pooled set of information. Rather each individual updates a personal information set from discussion to inform their preference, and my findings suggest these personal information sets are prone to inaccuracies. My findings suggest that the teams included in this study are limiting their potential synergies by having too much of their decision informed by individual level factors, not moving beyond personal information sets that inform personal preferences which then lead to team personal.

Another important conclusion from the findings in this study is that decision making episodes do not occur in isolation. They are influenced by both previous and future episodes. In general, carryover effects from previous decision making episodes could be beneficial if the teams identify effective processes or establish someone as an expert who can contribute more meaningfully to the team, both of which require some kind of feedback. Otherwise, considering previous episodes is likely to detract from team decision making by replicating previous decision episodes and not formally evaluating objectives and processes of the decision at hand.

Considering future decisions could be both beneficial and harmful. Being cognizant of the future acknowledges potential consequences for current actions. In a positive light, teams who are cognizant of future decision episodes may temper harmful behavior that would be detrimental to future collaboration, such as aggressively fighting for a preference. However, thinking about the future consequences could also result in timidness, such as not wanting to share a perspective counter to the group for fear of future alienation.

The teams in this study both benefited and suffered by allowing other episodes to influence their decisions. Performing these tasks over time increased familiarity with the tasks and some teams modified their initial approaches to improve what they discussed or how they discussed it, for example making sure to include more unique information in team discussion or ensure information is presented objectively and systematically. Conversely, working together on these tasks over the course of 45 days presented some potentially detrimental behaviors. These included diminishing an individual's contribution based on perceptions of previous performance, abandoning effective processes and roles, using previous decisions to inform current decisions, and having less excitement about completing the task.

It is also apparent that the relationship between potential benefits and detriments of performing over time fluctuates as teams work together. Initial decision making episodes represent instances when the positive benefits of completing multiple decisions is greater than the detriments. Teams refine their strategies processes to more effectively complete the tasks.

However, as time goes on, the positive benefits plateau and the detriments continue to rise. Additionally, performing well on these types of tasks requires a high level of vigilance, and my observations suggest that remaining vigilant over time is taxing. Even though teams may have identified processes that enhance performance, towards the end of their decisions, they are not as diligent in ensuring those processes are put into practice.

It is also important to note that teams develop and decline at different rates. The title of this dissertation asks whether teams ripen or rot as they work together. My qualitative findings report that teams both ripen and decay. And, teams are like different fruits, with their own unique rate of maturation, maximum sweetness, and shelf life. General trends are apparent, but to understand the source of outcomes (and identify potential interventions) requires nuanced consideration of similarities and differences. Continuing this research with different teams will further help to understand what causes ripening and decay, and explain the rates at which they happen. While I proposed that each of the teams I studied is a unique fruit, perhaps they are more similar to different varieties of grapes and I fail to see their likeness until I compare them to a different representative fruit of teams (e.g., medical teams), to see the similarities between grapes and bananas.

A third conclusion from my findings is the importance of accounting for multiple variables in any given decision making episode. The primary focus of decision making research using hidden profiles have been the exchange of information and team preferences (Lu et al., 2012; Mesmer-Magnus & DeChurch, 2009; Reimer et al., 2010). These two variables were only two of the seven components identified in my analysis. Further, my analysis highlighted that all of these components are interdependent. For example, if individuals do not diligently review their personal information, that information cannot be introduced into the team discussion. If team discussion cannot introduce unique information, the team cannot identify the optimal solution. Decision making can be conceptualized as a series of links, with each component representing a link, and a team's potential to do well on these types of tasks is only as strong as the weakest link.

A fourth insight, which builds upon the need to consider all the components of team decision making, is that it is difficult to get an accurate picture of how teams perform on decision making tasks using existing quantitative measures commonly used to evaluate team decision making. Decision quality reports whether indeed a team identified the best option or not. But this could occur through chance or a sound process. Alternatively, my findings showed that teams might select a suboptimal preference not because of a fundamentally poor process, but because of a small strategic decision, such as selecting the least bad option. In fact, my observations suggest that choosing the worst option is more indicative of poor team decision making than choosing the best is of good. Selecting the worst option is an indication of a multitude of shortcomings in team discussion or decision and is a greater source of alarm than choosing the best option assures excellence. However, neither tells the story of how a team reached its decision.

Measures of information exchange, especially using coverage and focus scores are also murky in evaluating discussion quality. Focus scores are particularly susceptible to various team approaches that have no influence on the quality of information processing, like whether teams encourage individuals to repeat already introduced information or only add unique information that was not yet discussed. Coverage scores are more meaningful than focus because they represent the potential pieces of information from which teams can build their decision. But these scores are limited as well. Scoring indicates only what information was introduced. It says nothing about whether others attended to this information or incorporated it in their information. My introduction of consideration scores in Study 2 helps clear up some of this ambiguity. My review of team decisions suggests that unique information consideration coverage in particular provides a meaningful insight into team discussion. But even this measure does not capture the full picture. For example, how should incorrectly shared information be assessed? A team could score high on information coverage, but that team could have also shared an inaccurate counterfactual piece of information for each accurate informational item that was introduced.

This leads me to my final conclusion from Study 3. This conclusion consists of two parts. The first is that the rich findings from my thematic analysis that help explain the how’s, what’s, and why’s of team decision making demonstrate the importance of coupling qualitative analysis with that of traditional quantitative methods to not only understand a phenomenon. The second supports the sentiment of Study 2 that longitudinal study provides novel insights about team decision making and teamwork more broadly. Further, that performance does not take unidirectional growth trajectory and it is important to capture team performance over an extended period of time. For example, this study would suggest that teams improve as they work together (that the gains of repeated teaming offset and detriments) if only studied at Times 1 through 3. However, taking the full five decision making episodes into consideration shows that the emergence of negative long term consequences could overshadow the gains of long term teaming.

Contributions to Practice

This study extends the practical contributions of Study 2. Study 2 points out the biases tendencies that diminish the quality of team decision making for both space and traditional teams. This study explains the mechanisms that cause these concerning outcomes and they can be summed by one general theme: teams let factors other than the information available to them drive their decisions. This chapter supports the need for teams to incorporate a multi-step protocol to ensure an effective decision making process. I propose a 10 step protocol below that can apply to all teams involved in decisions requiring them to incorporate differing perspectives, as is the case with hidden profile tasks (. In fact, it may be worth considering creating a formal checklist from this protocol, as checklists have been found to promote information exchange (Lingard et al, 2005) and reduce communication error (Lingard et al., 2008) among medical teams and are a well-established tool in the space context (e.g., Degani & Wiener, 1991; Segal, 1994).

I propose the following protocol: 1) teams must suspend any discussion of individual preferences until the end of the discussion; 2) teams must capture all the information available to them on a shared list visible to all members; 3) each team member must be given an opportunity to share their information without interruption; 4) information must be shared objectively without any interpretation; 5) after information is shared, others can ask clarifying questions or bring up any inaccuracies they perceive in the information; 6) before moving on to the next phase of discussion, teams should pause for a moment to allow individuals to review the pooled information and their personal information to ensure all available information has been presented to the team; 7) organize the information (in the case of the tasks in this dissertation, organizing positive and negative information per each option is likely most effective); 8) Based on the information available and the details of the scenario, teams can identify the criteria by which they can evaluate competing options; 9) Only after all of this should teams start to consider which option they should choose; And 10) all discussion of preference has to be supported by information and only information introduced during the discussion.

A second practical implication of this study is that teams appear to experience decision fatigue. Towards the end of their time together, teams manifest negative behaviors, such as less willingness to change preferences or less thorough review of information pre discussion, that offset any positive gains from multiple decision episodes. This suggests two possible courses of action. One is to restrict how many decisions teams make together. This dissertation found that after three decisions, teams show a decline in performance. After three decisions, maybe the team should be disbanded and members shuffled with those from other teams to create new teams, in hopes of preventing the negative behaviors. The alternative, for teams who cannot disband, is providing some kind of decision making reprieve in hopes that decision making performance can return or be maintained near peak levels if enough time passes between decisions. One such example could be restricting the number of decisions a medical team or judicial team makes on a given day.

A third practical implication from these findings is to consider social motives when composing teams. The qualitative analysis suggested that it may be especially problematic to have individuals with differing motives on the team. Individuals with high agreeableness or pro-social motivation were more likely to accommodate teammates' preferences, whereas those who were uncompromising or pro-self motivated tended to hold to their preferences. Mixing the two may harm team decision effectiveness if the unique information from prosocial team members is not fully considered. This suggests that when creating decision making teams, it may be better to compose them of similarly-motivated individuals, either socially (or self) motivated, rather than having teams of mixed motivations.

These courses of actions may not be feasible in all organizations or contexts (such as a space mission). In such circumstances, it is worth examining whether the full team is needed for decisions and a subset of members are capable of making informed decisions. This could possibly elevate some decision fatigue But, the optimal outcome is to identify a process that can improve and sustain quality decision making over the lifetime of the team.

Limitations

A limitation of this study is that I was the sole individual in conducting the thematic analysis. And, I conducted the thematic analysis after completing a literature review of hidden profiles research. While I did my best to take an inductive, unbiased approach to the data I analyzed, it is possible that I was influenced by previous work without my awareness. A different rater may generate different themes, based on the lens through which they evaluate team decision making. However, due to the purely qualitative nature of thematic analysis, qualitative scholars have argued that inclusion of a second coder does not result in a higher quality or more objective evaluation of the data, and single coder thematic analysis is considered a best-practice (Loffe & Yardley, 2004; Vaismoradi, Turunen, & Bondas, 2013).

Another limitation of this study is that the analysis relies entirely on archival video. My findings are strictly observational, based on conversation and behavior that occurred during the decision making tasks. Relying on archival video prevents the inclusion of intent and perception in analysis. For example, it is unclear whether the changes I observed in team decision making over time were intentional or even whether teammates noticed these changes. At one extreme, individuals could interject a process change to manipulate the team outcome and others feel powerless to resist. On the other hand, a team member may have forgotten to solicit everyone's information and no one else realized. The addition of more interactive data collection, through methods such as interviews and open-ended survey questions, will facilitate insights into causes of observed behavior. This study identified behaviors that caused the trends observed in Study 2, but this study lacks the data to speak to the cause intentions and motivations of these behaviors.

Future Directions

One future direction inspired by this research is to examine how feedback informs changes in team decision making. This study found that the post discussion survey served as a sort of countermeasure for some teams that encouraged diligence in accurately taking notes on information during the individual phase of the task and introducing this information during the task. This brings into question whether the presence of the survey explains the increase in decision making processes and outcomes observed at Time 3. Perhaps without the survey and exchange during this, teams would have maintained a steady level of performance similar to their initial decision episode throughout their work together. Alternatively, the survey could have served as a buffer from the observed negative influences of decision making over time and teams would have suffered earlier or greater performance declines.

Future research feedback could examine how the types and timing of feedback influences decision making. For example, some team decisions can result in instant performance feedback, such as a medical team deciding what kind of medication to a patient undergoing cardiac arrest. Other performance feedback may take months or years, such as an executive board choosing whom to hire as an executive director. Further, the tasks designed in this study can provide both team and individual level feedback. How would the team respond if they learned the dissenter on the team had actually identified the correct answer? Would this individual's preferences or information be more valued in future discussions?

A second future research direction worth examining is how the number of individuals on a team influences the evolution of team decision making. Larger teams may offset some of the negative tendencies observed in this study. The teams in this study indicated some tracking of individual preference over the performance episodes, and this tracking detracted from teams' performance. The difficulty of recalling individual preferences from previous decision episodes would increase as team size increased, possibly reducing this previous performance bias. An increase in team size may also reduce the possibility of roles (or their functions) being abandoned over time; each additional individual increases the potential for someone to observe that no one asked for information about a particular option. Conversely, increases in team size may hinder improvement in decision quality over time. Individuals may be more wary to introduce alternative approaches to tasks, such as the ones that resulted in performance improvement at Time 3. Existing research shows that increasing team size exacerbates the common information bias and reduces decision quality of teams completing hidden profile tasks (Lu et al., 2012); however, the effects of team size on how team decision making evolves over time is a new research direction yet to be explored.

A third future direction is leveraging the themes identified in this study for quantitative analysis. These themes could be converted to codes and the frequencies, prevalence, trends, and relationships of these codes could be objectively scored through multi-party content coding

(Cavanagh, 1997). In this study, I identified themes that explain deficiencies in how teams prepare for discussion, how they manage discussion, and how they select a preference. I expect that quantitative representations of these themes will serve as statistically meaningful predictors of discussion quality and mediators of the relationship between discussion and decision quality.

A fourth future direction of this research is to gain the perspective of participants completing the decision making episodes. The findings in this chapter were generated by an outsider reviewing the decision making process, thus all findings are based on an outsider's interpretation of events. Future work should include participants reviewing recordings and transcriptions of their team decision making with a researcher and asking them to explain the motivation and rationale behind the various processes and interactions taking place during the decision. Adding this approach will help further understand the causes and intentions of the behaviors observed in team decision making. Participants' responses and perspectives from this exercise could also identify additional mechanisms that influence decision making process and outcomes.

CHAPTER 5

Conclusion

Each of the previous chapters contains a detailed conclusion section pertinent to its study. This chapter provides general concluding remarks on this dissertation as a whole. The aim of this dissertation was to make contributions to the decision making literature through two paths. First, I advanced understanding of the components and mechanisms that influence how teams make decisions and the quality of those decisions. Second, I provided novel insights into how the approach to and outcomes of decision making evolve as teams work together over multiple teaming episodes. My study of team decision making utilized the hidden profile paradigm, which allowed for the analysis of how teams leverage distinct individual knowledge to shape team preferences. The setting for this research allowed for skilled, educated, and experienced professionals, allowing for findings that are more applicable to real life teams than that of traditional lab student studies used for team decision making research (e.g., Nijstad & De Dreu, 2012). Lastly, this dissertation's use of a mixed-methods approach leveraging both quantitative and qualitative methods, a first of its kind based on my review of hidden profile literature, allowed for both the identification and analysis of key phenomena not possible using strictly one method or the other.

In Chapter 1, I reviewed the existing literature on team decision making using hidden profiles. This is a rich literature stemming from 1985 that has repeatedly identified a team bias in favor of common information over that of unique information. My review of the hidden profile literature found extensive theoretical and empirical work that explains the source of discussion bias in favor of common information and its relationship to discussion quality. However, my review in the literature identified three deficiencies. First, the literature has succumbed to the jingle-jangle fallacy (Kelly, 1927; Thorndike, 1904), where the terms “shared information” and “information sharing” represents numerous and distinct conceptualizations relevant to either a team’s discussion or the nature of the decision making task. The second deficiency is a lack of empirical research on how teams use information in reaching their conclusion. Existing literature highlights a significant relationship between information exchanged and decision quality and theoretical explanations for these relationships, but it falls short in the study of the mechanisms that translate information into decision. The third deficiency in the hidden profile literature is a lack of longitudinal studies. The existing knowledge of team decision making is based on one shot teams, failing to inform how team decision making evolves as teams complete multiple decision making episodes. All three of these deficiencies were addressed in this dissertation.

Chapter 2 developed five parallel hidden profile tasks that could be used to study decision making over time. These tasks were developed using a thorough five phase process and that included over 3000 participants. While using an overarching space theme, these topics were independent of one another in the decision at hand and the information that informed this decision. This independence allows for the tasks to be administered in any sequence and to simulate a meaning decision making episode regardless of how many of tasks the team completes. Chapter 2 not only generated the tasks used for this dissertation but also created scenarios that can be used to inform the decision making literature through subsequent research.

Chapter 3 examined team decision making using quantitative methods. This chapter contained two sets of research questions. The first emphasized evaluating the components of team decisions. This chapter found that established biases of teams favoring common information over that of unique information held true even in my unique population. Further it identified novel insights about how teams use information valence (positive and negative informational items about options). Teams favor positive common information over that of negative common information and the opposite is true in the cause of unique information, with teams favoring negative over positive, suggesting that team discussion favors the dominant preference over that of competing preferences. This study also showed that teams compare the differences between positive to negative information for each option in their selection of a preference. Teams use a net valence score in choosing an option, but teams differ on whether that score is based on what information was introduced, how much information was discussed, or whether multiple individuals mentioned it. In summary, the findings from this research question indicate troubling biases that limit a team's ability to make quality decisions when needed to leverage individuals' distinct knowledge.

The second research question quantitatively evaluated how team discussion and discussion quality changes over time. Both discussion and decision quality showed a general trend with performance peaking the third time the team completed the tasks. The two measures were distinct before and after the third episode. Discussion quality showed a slight decrease on the second decision episode from the initial and the last two decision episodes returned to slightly above the initial performance. Discussion quality peaked at Time 3, dropped to its lowest during the last decision episode, and remained equal at the other three time periods. As part of analyzing change over time, I also evaluated changes in general team processes. I found that three of these processes also showed a peak at time 3, but more followed the trends of discussion quality than that of discussion quality. The conclusion that can be derived from this research question is that teams are able to mitigate some of the biases that hinder team performance on hidden profile tasks, but ultimately succumb to them.

Study 3 (Chapter 4) utilized qualitative analysis to compliment the findings of Study 2. Like Study 2, Study 3 segmented into two parts. The first focused on identifying key aspects that inform team decision making by reviewing each team decision as an independent teaming episode. I used a thematic analysis approach to identify seven components that encapsulate the various aspects of team decision making and identified 18 themes across these seven components, which are presented in Table 51. This analysis produced two major findings about team decision making. The first was that individual preferences, rather than information available in a scenario, serve the main drivers for teams' preferences. The second major contribution was the identification of additional novel factors that influence team decision making not addressed in existing hidden profile literature, such as the type of questions posed by the team during discussion and the accuracy of information presented to the team.

The second part of Study 3 combined thematic analysis with a case study approach to identify the emergence or development of themes as teams worked together over multiple decision making episodes. This generated 8 time related themes to the role of time in how teams select preferences, share information, adapt their strategies, prepare for discussion, and perceive the tasks at hand. The major conclusion drawn from these themes is that team decision making episodes do not occur in isolation. Previous and future episodes influence how individuals approach a given task. Overall, the influence of multiple decision making episodes is initially beneficial to the team, but these benefits are not maintained, and some negative tendencies emerge as teams continue to make decisions. The findings of Study 3 both compliment and provide explanation for the trends observed in Study 2.

It is also worth noting that Study 2 and Study 3 are intended to serve as parallel and complementary studies. Study 3, the qualitative analysis of team decision making, was completed prior to my review of the quantitative results. The motivation behind this approach was to avoid the results of quantitative findings biasing the thematic analysis. Familiarity with the trends identified in Study 2 prior to completing the analysis of Study 3 could have resulted in unintentionally focusing on particular teams and aspects of team decision making that correspond with the results identified in Study 2. The approach used in this dissertation helped identify meaningful themes in team decision making independent of quantitative findings. Further, for mixed-method research on the same teams, it is advisable to conduct the qualitative analysis first in order to maximize the objectivity of the qualitative analysis. In situations where two separate data sets are used for a mixed method design, the qualitative findings could also inform the measures or hypotheses included in the quantitative study, to enhance the richness of study.

Combining Studies to Further Understanding of Team Decision Making

As discussed in the previous section, the quantitative sections of this dissertation were analyzed independently of one another. After completing both studies, reviewing both studies in tandem provides an opportunity to identify holistic insights pertaining to team decision making. I include three such evaluations in this section. First, I identify practices of the best performing teams, when evaluating performance as quality of team decision. Second, I identify practices of the best performing teams, when discussion quality is the measure of performance. And, third, I discuss what aspect of team decision making is most important in determining the quality of a team's decision.

Best Practices of Best Decision Quality Teams

Two teams tied as the top decision making teams: Team 1 and Team 6. Both of these teams selected the best option in 60% of their decision making episodes. In reviewing these teams' performance, I focused on the decision making episodes during which they chose the correct answer. This review identified a number of interesting attributes that both teams shared. For one, both teams thoroughly analyzed the information presented to the team. They asked clarifying questions when teammates shared information and were able to establish a clear understanding of the facts that were introduced during discussion.

A second shared attribute by these two teams is they let the information introduced into discussion (i.e., coverage) drive their decisions. Rather than succumbing to pre-discussion preferences, who shared what information, or how much time is spent on particular information, they focused on the information available to them as the way to determine the best option. In fact, Team 1 was the only team of the eight studied for this dissertation that introduced their information prior to disclosing their individual preferences.

A third commonality between the two teams is a commitment to selecting the best option. As discussed in Chapter 3, some teams made statements that conveyed the decision making tasks were judgmental in design, with no correct or best answer. Team 1 and Team 6 never expressed a sentiment that all the options were equal or that the team's choice did not matter; their team discussions focused on the team identifying the best of the three options they were presented.

In summary, I identified three practices of the best decision making teams: (1) clarification of information presented, (2) team preference determined by information introduced in discussion, and (3) framing of tasks as intellective, with a best answer. It is likely that these three practices are interrelated. For example, if taking an approach where a preference is determined by the information introduced, rather than pre-discussion preference, it would make sense for teams to ensure facts are accurately understood and ask clarifying questions. Additionally, if teams believe a best answer exists, a logical approach suggests this answer should be determined by the information introduced into discussion. Further, evaluating a casual relationship between the three points to intellective framing as the key to these best practices: thinking a best answer exists results in letting information determine the best option, and allowing information to determine the best option requires clarity about that information to ensure the information is accurately understood to increase the likelihood of identifying the best option.

Best Practices of Best Discussion Quality Teams

For a second perspective on best practices, I also reviewed teams who scored highest in discussion quality to identify what aspects of their approach facilitated high quality information exchange. In this dissertation I discussed four distinct measures of discussion quality, but for this analysis I focused on coverage measures to identify teams with the best discussion quality, since coverage determines what information teams can discuss during their decision. This dissertation also identified the importance of consideration coverage in team decision making. Thus, I determined Teams 4 and 5 as those with the best discussion quality; they were the only teams to both exceed an 85% coverage rate and 75% consideration coverage rate.

In reviewing these teams' discussions, two common attributes stood out. The first is that both had systematic and consistent approaches to introducing information about the task at hand, where they discussed one option at a time. For example, a team member would suggest they start by reviewing option A and each individual would take a turn disclosing information about that option. This is in contrast to other teams that either asked each individual to share all their information (about all three options) at once or lacked a broader systematic process by which to introduce information. The second attribute shared by both of these teams is that they actively solicited additional information, asking individuals whether they had any additional information that had not yet been mentioned.

My observations suggest that teams that excel at discussing information implemented a two phase process to ensure the introduction and capture of all information. They systematically and thoroughly review each of the options that they could choose from, and they account for potential process shortcomings by having a secondary information solicitation phase in case any information was missed during the initial disclosure of information.

Predicting Quality Team Decision Making

The combination of quantitative and qualitative analyses in this dissertation reviews three types of predictors that can explain the quality of a team’s decision: (1) team discussion quality (reviewed in the quantitative study), (2) team decision making process (reviewed in the qualitative study), and (3) the timing of decision making episode (evaluated in both studies). Team discussion, coverage in particular, determines whether teams introduce the necessary information to identify the best option. However, my findings suggest coverage is more a measure of potential to identify the best option rather than the actual determinant of decision quality. The review of the teams with best discussion and decision performances serves as evidence of this. The top two teams in terms of discussion quality were in the middle of the pack in terms of identifying the best option, relative to the other teams in this study. Further, my qualitative analysis found that individual preferences, rather than information exchanged, are the primary drivers behind team decisions. Again, information can influence these individual preferences, but the team decision depends on how individuals process this information, including whether they pay attention to others' information or are willing to change their preference.

Qualitative analysis of team decision making over time found that teams change processes as they work together over time, with processes peaking at the midpoint of the team decision making episodes. While team decision making processes determine how teams utilize information, time influences what decision making processes teams utilize. Thus, I propose the timing of team decision making episodes should be the first consideration in predicting team decision making.

As further support for this conclusion, I evaluated the role of pre-discussion preferences, as a post-hoc analysis. These are the preferences of each individual team member prior to their team discussion. Extant research has found that pre-discussion preference informs team preferences, with teams likely preferring the dominant individual pre-discussion preference as the team's post discussion preference (Gigone & Hastie, 1993). Out of 39 decision making episodes, I found 36 instances of a dominant pre-discussion preference (where one option is preferred by more individuals than any other), and teams chose the dominant pre-discussion preference as their team preference in 19 (53%) of those instances. However, examining the relationship between pre-discussion individual preferences and post discussion team preferences, highlighted temporal effects. At Time 5, the worst decision making episode, teams selected the dominant pre-discussion preference at the highest rate, a rate of 83%. Conversely, at Time 3, the best decision making episode, teams chose the dominant pre-discussion preference at the lowest rate, at a rate of 13%. This pattern supports that timing of decision making episodes influences how teams make decisions.

In summary, the findings of this dissertation suggest that a construction analogy could be used to describe team decision making. If the best decision represents building the tallest standing structure, the information exchanged during discussion represents the building blocks available to build the structure. The team decision making process is the design of the structure and determines how effectively the building blocks are utilized. And, time influences whether teams optimize the design they use in this construction.

Generalizability

The context in which the teams in this dissertation completed decision making tasks is a unique one. These teams lived and worked together in an analog space habitat and individuals who made up these teams had to meet the requirements of eligibility to be an astronaut. These distinguishing characteristics evoke the question of whether the findings from this dissertation would generalize to traditional work teams, and I believe the best way to assuage this concern is to highlight that the findings of this dissertation correspond and replicate previous findings using traditional teams.

The findings of common information bias (Hypothesis 1) in the quantitative study were direct replication of extant research on how teams discussion information on task in which individuals possess both unique and common information (Mesmer-Magnus & DeChurch, 2009; Lu et al., 2012). The findings of negative information bias (Hypothesis 2) and the use of valence to identify preference (Hypothesis 3), clarified and extended previous work identifying tendencies to focus on negative information (e.g., Dose, 2003; Stewart, 1998) and the importance of information valence in determining team decisions (Hoffman, 1961).

While the 18 team decision making themes identified in the qualitative study of this dissertation each provide new insights into how teams make decisions, they corroborate and align with previous work on how teams make decisions (Schultz-Hardt & Mojizsch, 2012), how attributes of team discussion can influence the quality of team decisions (Van Quaquebeke & Felps, 2018), and other factors that could impact team decision making, such as team roles (Driskell et al., 2017). A more detailed discussion of the novel contributions of these 18 themes and how they correspond to existing literature was reviewed in Chapter 4.

A dearth of research on how team decision making evolves over time results in lack of traditional team findings to which both the quantitative and qualitative temporal findings of this dissertation can be compared. However, the results discussed above demonstrating that the teams in this dissertation behave similarly to traditional teams making one-off decisions suggest that the teams in this dissertation and traditional teams will likely behave in similar ways when performing over time. Without question there are distinct aspects of team decision making observed in these space analogue teams, such as resting during the individual phase. I do not think this specific behavior is likely to emerge in traditional teams, but other distractors in real life teams, such as multitasking or interruption, could present equal performance deterrents. I observed no evidence to preclude the assumption that the temporal findings of this dissertation generalize to traditional teams.

Boundary Conditions

The previous section outlines support for why the findings of this dissertation will generalize to traditional teams, despite the teams in this study operating in a unique environment. However, there are two boundary conditions to the findings introduced in this research project. The first is that tasks completed by these teams vary in topic and are totally independent of one another; there is no knowledge that can be transferred from one task to the next that might help a team identify the best option. Thus, the findings in this dissertation are likely to apply to generalist teams that encounter a broad range of decision types. Executive boards or task forces would be examples of these types of teams, where the individuals represent a diversity of skills and functions, and decisions range from developing strategic initiatives to hiring to responding to legal and public relations issues.

In contrast to generalist teams are specialist teams whose decisions all focus on a similar subject matter. For example, a marketing team makes multiple decisions about how to best brand a product and promote it to consumers. On specialist teams, previous decisions may help inform future decisions. They may identify a specific criteria that is helpful in choosing the best option (e.g., return on investment) or refer to a previous outcome as an insight into what they should choose during the current decision (e.g., replicate success).

I suspect that generalists teams do a better job of discussing information because the team knows that everyone on the team represents a unique perspective and insight into the issue. In every decision, they have to build a case for the decision from scratch, which will facilitate more thorough discussion. Additionally, I suspect that individuals on generalists teams are more willing to change their initial preference due to the need to consider differing perspectives. Conversely, specialist teams may feel more comfortable with the task and skip over key processes. It is also tenable that individuals on specialist teams will be more resistant to adjust their initial preference because doing so could signal a shortcoming in an area in which they are perceived as an expert. Thus, I propose the decision making issues identified in this dissertation may be even prominent on specialist teams.

A second boundary condition of the teams in this dissertation is that they did not receive feedback after their decision making episodes. Whereas some teams may receive direct feedback on their performance, such as a medical team and the well-being of the patient after receiving treatment, the teams in this dissertation represent teams where there is no objective answer or the outcome of a decision is not known until much later in time and other decisions are made before that result is known. I suspect that teams not receiving feedback (like in this study) are more likely to continue making the same mistakes as they move from decision making episode to the next compared to teams receiving feedback. However, given that the teams in study were generalist teams, as discussed previously, performance feedback is likely less influential than for specialized teams where teams can build on previous decisions. Further, it is worth questioning how often real life decisions can be determined as correct or incorrect. For example, if choosing to launch a product or hire an employee, it would be difficult to assess how the decision compares to the alternative choices, since the other product was not launched nor the other individual hired. Even if the decision results in failure, that does not indicate that the alternative was better. This study cannot speak to the trends of teams receiving performance feedback, but teams receiving feedback on whether they make the correct choice or not may be more the exception than the rule outside of laboratory studies.

Contribution to Theory

As a whole, this dissertation provides five contributions to the team decision making literature. The first is that it applies the hidden profile paradigm to the unique context of space teams. Existing work on teams in isolated and confined environments cautions about generalizing findings from traditional teams to those in such unique working conditions (Bell et al., 2018). This dissertation finds that teams of highly able, skilled, educated, and motivated individuals in such unique environments succumb to similar shortcomings as more traditional teams and this is a setting that can be utilized to contribute to further study of team decision making.

A second contribution of this work is presenting some of the first research on understanding how team decision making evolves over the lifetime of a team. This dissertation captures that working together over time introduces both positive and negative forces pertaining to teamwork. Initially, these positive forces improve team performance over an initial baseline measure, but these positive gains diminish and are offset by negative forces introduced from repeated teaming that reduce team performance to measures at or below baseline.

The third contribution of this dissertation is emphasizing the numerous, interconnected factors that influence team decision making. Hidden profile research has relied on evaluation of what information is introduced in discussion, how often that information is mentioned during discussion, and whether teams identified the correct option as the main focus of research. This dissertation stresses the importance of accounting for additional factors such as pre-discussion performance, discussion structure, individuals' consideration of others' information, and strategies to determine the best option as vital to understanding team decision making outcomes.

The fourth contribution of this dissertation is demonstrating the value of using a mixed-methods approach in teaming research. The quantitative study of this dissertation provided insights into trends of decision making variables and differences between the trends of those variables (e.g., common information coverage compared to unique information coverage). By coupling the quantitative study with a qualitative one, I was able to speak to the causes of observed trends, as well as generate novel insights into mechanisms that influence team decision making. Both quantitative and qualitative studies produced findings the other could not and combining the two resulted in a rich multi-perspective understanding of the subject matter at hand that enriches existing literature and informs future research.

The fifth contribution of this dissertation is the development of five quality high fidelity hidden profile tasks. These tasks can be applied to future studies of team decision making, as well as serve as activities to facilitate the study of broader attributes of teamwork. Further, the process outlined in this dissertation on how these tasks were developed can be used as a template to create and validate future team tasks in an effective, timely, and affordable manner.

Contributions to Practice

All the teams observed in this dissertation were part of NASA's HERA simulations intended to develop understanding of long-term space flight, necessary for endeavors such as the mission to Mars. My findings about team decision making over time advance this aim, addressing "team risk" (Landon, Vessey, & Barrett, 2016). The findings provide insights into how team decision making evolves as teams live and work together and causes for some of these trends. These findings should serve as an alarm for NASA and other space agencies that extended work together does not generate higher quality decision making. These findings identify tendencies and factors that lead to suboptimal decision making that need to be addressed in the training of future space teams.

However, the findings from this dissertation are not restricted to the space domain. The qualifications necessary for eligibility to participate in the HERA studies is likely a better representation of the working professionals involved in teamwork than typical student lab studies. While the cohabitation component of the HERA environment is uncommon to most work settings, I observed no aspects of team decision making in the eight teams I studied that would not translate to challenges experienced in professional teamwork. For example, even the sleep fatigue condition imposed during Campaign 4 is not likely all that different from the sleep fatigue of someone who has become a recent parent, working as an accountant during tax season, or preparing a company for an IPO. Elon Musk stated that during a busy stint at Tesla he logged workdays that were at least 17 hours a day (Bueck, 2018).

These findings offer three pieces of guidance to work teams of any kind that are involved in multiple decision making episodes. The first is to develop training that can inform teams of potential shortcomings that can arise when teams make decisions and the unique challenges of making multiple decisions. In order to translate the findings of this dissertation into practice, I have included a team decision support document in Appendix A. The second is to evaluate team decision making processes to identify if teams succumbing to biases identified in this dissertation. This could include allowing individuals to complete anonymous surveys after decision making episodes to measure whether they feel their perspective is encouraged and well received. Alternatively, teams could complete hidden profile tasks and use them as proxies for how well teams are performing on decisions making tasks. Lastly, organizations that are able could regularly restructure teams to limit the amount of decision making episodes of any one team, until alternative interventions are identified.

Limitations

In drawing conclusions from this dissertation, certain limitations should be kept in mind. The first limitation is the setting, the teams studied in this were all participating in a NASA simulation. They were composed of individuals selected from a pool of applicants and required to meet certain requirements such as work experience, education, physical fitness, and psychological well-being. Additionally, all teams were the same size, were composed of the same four roles, and knew exactly how long they would be working together. In the previous section I propose that the findings from this sample may be more generalizable than findings from traditional lab teams, but only further study using similar tasks will confirm this. For example, it is possible that these teams had a reduced power differential relative to other work teams, such as one where an intern and vice-president might be part of the same decision making committee.

A second limitation is the time duration of 45 days. This study’s central question is how decision making is affected over time. The current findings need to be considered in light of the relatively short duration of 45 days. Furthermore, decision tasks were generally evenly spaced and predictable. In crisis or health care teams, decisions may need to be made in “bursty” intervals, with much longer periods between bursts. It is tenable if teams completed 20 decision making tasks over a 100 day period, the trends would differ from the ones observed in my findings. For example, a longer duration might capture a cyclical pattern or a severe drop below the baseline measure in decision making performance. The rhythms and predictability of team decisions needs to be considered when generalizing findings.

A third limitation is the use of contrived tasks. Though participants were being evaluated, heightening their desire to perform well, there were no real consequences to their decisions. Additionally, the tasks were highly structured. Teams were provided a specific amount of time to individually prepare for the task and as well as set amount of time for team discussion and decision. Team decisions “in the wild” are unlikely to face such constraints, allowing additional time or multiple meetings to make decisions. Further, the tasks required teams to choose a preference. Applied settings allow teams to determine they lack sufficient information or quality options and postpone a decision until more information or additional alternatives are available.

A fourth limitation is the use of a hidden profile task. It is the most effective means through which to evaluate synergy in team decisions (Schultz-Hardt & Mojizsch, 2012; Sohrab et al., 2015), but the paradigm does not fully simulate the real world. For example, hidden profiles have a limited set of informational items and corresponding options that frame the team’s decision and discussion quality involves evaluating how many of those pieces of information are introduced into discussion. Such boundaries do not always exist in decisions. For example, if a hotel developer was determining where they should develop their next hotel, they have endless options to consider. Additionally, they have countless factors to consider corresponding to each option, from contractors, to taxes to expected tourism trends. There is no objective way to establish how much total information is available for consideration. And even if the locations are limited to three options and the team identifies eight factors that will determine their decision, these are decisions in themselves.

A fifth limitation of this dissertation is a lack of clarity of whether teams perceived the tasks to have a correct answer. Prior work highlights that when tasks are perceived as intellective (have a correct answer), teams more thoroughly review the information available to them and use this information to inform their preference (Laughlin, 1980; Lu et al., 2012; Mesmer-Magnus & DeChurch, 2009). In the qualitative review of this dissertation, I found evidence of teams framing tasks as judgmental, meaning they do not have a correct answer (Laughlin, 1980), but I observed this framing occurring in instances during which individuals were unsure of their preference or realized that their preference clashed with that of others on the team. It is unclear whether teams truly believed the tasks were a judgmental design or framed them as such as a strategy to get others to shift their preference or to reconcile abandoning their own. Further, only some of the teams discussed the tasks as judgmental, while none of them explicitly stated there is a correct answer that they had to identify. At best, it can be inferred that teams conceptualized these tasks differently, with some perceiving them as judgmental while others intellective, but there is a lack of data to confirm how teams actually perceived the tasks and if this thinking varied within teams across teams.

Future Directions

This dissertation and its findings provide a number of future directions in the study of team decision making over time. One such direction is the inclusion of team properties in the longitudinal study of teams. Previous work on hidden profiles have identified constructs such as motivation (De Dreu et al., 2008; Nijstad & De Dreu, 2012), task understanding (Van Ginkel &

Van Knippenberg, 2012), and shared mental models (DeChurch & Mesmer-Magnus, 2010) as meaningful predictors of decision quality (Nijstad & De Dreu, 2012). Future study of team decision making should consider how these dynamics evolve as teams make decisions and how the relationship between these variables and outcomes measures change over time. It is tenable that the initial increase in decision making performance was due to increased understanding of the task and the subsequent decline was the result of decrease in epistemic motivation or a shift more pro-self motivation. Variables such as psychological safety (Edmondson, 1999), trust (De Jong, Dirks, & Gillespie, 2016), and self-efficacy (Bandura, 1982) should also be included in future work, as they would likely influence the extent to which individuals are willing to introduce, solicit, and consider information.

Future research should also more thoroughly consider the individual and team components of team decision making using the hidden profile task. An individual might not share their information because the team did not utilize a process that asked everyone to contribute their information. Alternatively, a team could use a thorough systematic process for reviewing information, but an individual doesn't feel enough psychological safety to disclose a piece of information that runs counter to the dominant preference. The result is the same in both of these situations, but the cause of the result is very different. Focusing on both individual and team level components will help identify this difference.

The focus on both the individual and team should also be applied in recognizing the individual and team phases of team decision making. Hidden profile being with an individual performance phase where the individual attends to the information and stores and encodes it. This phase determines what information individuals contribute to a discussion. An individual may not introduce a piece of information into discussion because of a poor team discussion process, an unwillingness to share the information, or simply that they missed it in their individual review of the information. Existing models of group information processing fail to account for these two phases of performance. Hinsz et al.'s (1997) model of groups as information processors strictly focuses on the team as the processor, without clear consideration of how the individual fits into this model. The more recent Motivated Information Processing in Groups Model (De Dreu et al., 2008; Nijstad and De Dreu, 2012) includes both individual and team level influences on team decision making, but only at the team phase. As future research includes more studies of how teams make decisions over time, it is vital to also capture how individual phase performance changes and how these changes influence the team phase.

A third area of future research should be interventions. Numerous studies have examined interventions to improve team decision making on hidden profile-like tasks. The issue with existing intervention studies is that the findings are confined to one-off studies of team decision making. Galinsky and Kray (2004) propose that their intervention of counterfactual thinking will be sustained over time, but this proposition was not tested using multiple hidden profile tasks. Future work on interventions could explore which of the existing interventions do in fact persist over time and which have the most lasting effect. Additionally, future work could identify micro interventions that could serve as minimally intrusive primers to remind teams of prior more extensive interventions and training.

This dissertation, while providing novel contributions to components of decision making and understanding of how decision making evolves over time, hopefully serves as a jumping off point for future studies on how teams leverage distributed knowledge to optimize decision making. The hidden profile literature consists of 35 years of meaningful research and yet there is much to still understand about the mechanisms of team decision making and how they can be improved.

Table 1

Disambiguating Terms Used to Characterize Team Decision Processes: Previous Terms

Previously Used Group Process Terms	**Usage Examples**
Sharing	**Usage 1 -** "... the act of mentioning aloud an information cue during group discussion" (Devine, 1999, p. 619) **Usage 2** - "...discuss and incorporate into their decisions…" (Wittenbaum et al., 2004, p. 2004) **Usage 3** - "Encompassing team communication related to goals, progress, coordination, and the like…" (Mesmer-Magnus & DeChurch, 2009, p. 535)
Exchanging	**Usage 1 -** "Members must first decide to contribute the information and then have the opportunity to contribute to it." (Dennis, 1996, p. 534) **Usage 2 -** "...group members often fail to exchange information completely…" (Cruz, Boster, & Rodríguez, 1997, p. 291) **Usage 3 -** "...whether or not a piece of information was brought up, whether the statement of information was accurate, and how many times the information was repeated." (Dose, 2003, p. 245)
Pooling	**Usage 1** - "The numbers of positive and negative items recalled before and after discussion…" (Stasser & Titus, 1985, p. 1475) **Usage 2 -** "Mentioning information is only part of effective information pooling. Once unshared information is mentioned, it must be actively considered." (Stasser et al., 2000, p. 103) **Usage 3 -** "Percentage of unique information mentioned out of total available information… and the percentage of unique information out of total discussion" (Lu et al., 2012, p. 54)
Discussing	**Usage 1 -** "Discussions can be viewed as a sampling process." (Stasser & Titus, 1987, p. 84) **Usage 2 -** "...the amount of shared and unshared information that groups pool…" (Reimer et al., 2010, p. 122) **Usage 3 -** "...groups talk more about information that is shared…" (Mojzisch et al., 2010, p. 946)

Table 2

Disambiguating Terms Used to Characterize Team Decision Processes: Revised Terms

Revised Group Process Terms	**Definitions**
Discussion	General process of talking about a topic, that includes various aspects of information exchange (i.e., coverage, focus, consideration).
Information Coverage	The amount (or percentage) of available information included in group discussion.
Information Focus	The percentage of discussion addressing particular types of information (e.g., unique information) relative to total information discussed.
Information Consideration	The recognition by others of information shared during discussion.

Table 3

Summary of Hidden Profile Scenarios

Scenario Description	Factors to Consider
Gravity The ISS is experiencing three system failures. The crew must decide which of the failing systems (computer, propulsion, and environmental controls) is the most vital to repair.	Implications of malfunction Likelihood of successful repair Timing of resupply
Gravity - Updated Version[1] Three modules on the ISS have been damaged. Due to limited resources, the crew can only repair one module and must decide which one is most urgent to the success of their mission.	Ability to run studies Ensure safe work conditions Psychological well-being
Fire in the Sky Individuals are NASA NEO (Near Earth Object) analysts. Three asteroids are identified as potential threats and the team must decide which of the asteroids should be targeted.	Trajectory of asteroid Projected impact date Impact damage
Interstellar Due to climate change and overpopulation, a team of astrobiologists are tasked with selecting a planet where human colony must be established immediately, from three hypothetical planet choices.	Natural Resources Environment Distance from Earth
New World A crew is approaching Mars and due to unexpected weather patterns, the previously established landing site is no longer a viable option and the crew must choose from the alternative sites.	Weather patterns Conduciveness to rover exploration Proximity to key locations
Fast Five The Mars mission has been fast-tracked and it has been determined that a fifth member must be added to a four-person crew. The team must decide which of three eligible candidates should be the final crew member.	Training and experience Physical health Reports from previous crew members

Note. [1]Gravity was updated after additional validation data was collected. The updated task was implemented in HERA C5. HERA C4 used the original Gravity task.

Table 4

Scenario Information Distribution

Option	***Number of Good Items***	***Number of Bad Items***	***Number of Neutral Items***	***Total Number of Items***
Worst Option	4	6	4	14
Middle Option	3	3	5	11
Best Option	6	4	4	14

Note. Options were determined as best, middle, and worst based on the number of good items minus number of bad items.

Table 5

Descriptive of Items Retained for Phase 3

Scenario	**Classification**		**Importance Score**		
	Low	High	Low	High	SD
Scenario 1 (failing systems)	65%	94%	1.740	5.897	1.295[a]
Scenario 2 (asteroid diversion)	65%	94%	1.419	6.548	1.864
Scenario 3 (planet selection)	90%	100%	1.116	6.663	2.197
Scenario 4 (Mars landing site)	70%	100%	2.433	6.413	1.589
Scenario 5 (5th crew member)	68%	100%	1.709	6.581	1.949
Average	71%	97%	1.683	6.420	1.900

Note. Classification refers to the percentage of participants that selected an item in line with the intended category, for example an intended good item being selected as a good item. Importance score is 1 - 7 scoring of how important the participants perceived the item. [a]The importance score for four neutral items were not captured in Phase 1 testing of Scenario 1.

Table 6

Scenario Information Distribution Example for Scenarios 1-3 (Campaign 4)

Scenario Option	**Information Type**	***Role 1***	***Role 2***	***Role 3***	***Role 4***
Worst Option	Good	G1, G2, G3, G4	G1, G2, G3, G4	G1, G2, G3, G4	G1, G2, G3, G4
	Bad	B4	B3, B6	B1	B2, B5
	Neutral	N1, N2	N3, N4	N1, N3	N2
Middle Option	Good	G1, G2, G3	G1, G2, G3	G1, G2, G3	G1, G2, G3
	Bad	B2, B3	B1, B2, B3	B1, B2	B1, B2, B3
	Neutral	N1, N2	N3, N4	N1, N3	N2, N5
Best Option	Good	G2, G6	G1	G3, G4	G5
	Bad	B1, B2, B3. B4	B1, B2, B3, B4	B1, B2, B3, B4	B1, B2, B3, B4
	Neutral	N1, N2	N1, N2, N3	N3, N4	N2, N3, N4

Note. Letter on the table correspond with whether an item is good, bad, or neutral. Numbers represent a specific item. For example, if only one individual receives G1, it is a unique piece of information or if all four roles receive B4, it is a fully shared piece of information.

Table 7

Scenario Information Distribution Example for Scenarios 4-5 (Campaign 4)

Scenario Option	**Information Type**	***Role 1***	***Role 2***	***Role 3***	***Role 4***
Worst Option	Good	G3, G4	G1	G1- G4	G1-G4
	Bad	B1, B2, B6	B3, B4, B5, B6	B1	B4
	Neutral	N2, N3	N3, N4	N1, N3	N1, N2
Middle Option	Good	G1, G2, G3	G1, G2, G3	G1, G2, G3	G1, G2, G3
	Bad	B1	B1, B2, B3	B1, B2	B2, B3
	Neutral	N2, N3, N5, N6	N3, N4	N1, N3	N1, N2
Best Option	Good	G5	G1- G4	G3, G4	G2, G6
	Bad	B1- B4	B1	B1- B4	B1- B4
	Neutral	N2, N3, N4	N1, N2, N3	N3, N4	N1, N2

Note. Letters on the table correspond with whether an item is good, bad, or neutral. Numbers represent a specific item. For example, if only one individual receives G1, it is a unique piece of information or if all four roles receive B4, it is a fully shared piece of information.

Table 8

Final Round of Item Set Performance (Campaign 4)

Scenario	***Role 1***	***Role 2***	***Role 3***	***Role 4***	***Totals***	***Role %***	***Full Info***	***Full %***
Scenario 1								
Worst Option	13	15	14	14	56	74%	4	31%
Middle Option	1	3	2	4	10	13%	2	15%
Best Option	3	2	4	1	10	13%	7	54%
Totals	**17**	**20**	**20**	**19**	**76**		**13**	
Scenario 2								
Worst Option	14	15	18	11	58	72%	5	29%
Middle Option	5	3	2	2	12	15%	1	6%
Best Option	2	2	1	6	11	14%	11	65%
Totals	**21**	**20**	**21**	**19**	**81**		**17**	
Scenario 3								
Worst Option	16	14	12	17	59	70%	3	17%
Middle Option	3	5	3	1	12	14%	2	11%
Best Option	1	5	5	2	13	15%	13	72%
Totals	**20**	**24**	**20**	**20**	**84**		**18**	
Scenario 4								
Worst Option	0	0	15	15	30	36%	2	10%
Middle Option	18	2	4	3	27	33%	2	10%
Best Option	2	19	2	3	26	31%	16	80%
Totals	**20**	**21**	**21**	**21**	**83**		**20**	
Scenario 5								
Worst Option	16	0	11	0	27	35%	4	19%
Middle Option	2	4	5	18	29	38%	5	24%
Best Option	1	15	4	1	21	27%	12	57%
Totals	**19**	**19**	**20**	**19**	**77**		**21**	

Note. The values indicate number of respondents participating in final round of testing.

Table 9

General Team Process Measure Administration for Campaign 4

Decision Making Task Administration	Preceding Team Process Administration	Number of Days of Measure Prior to Decision Making
MD -4	N/A	N/A
MD 6	MD 5	- 1
MD 14	MD 10	- 4
MD 20	MD 15	- 5
MD 34	MD 33	-1

Note. General team process measures are not administered on the same day as the decision making so the most proximate administration prior to the decision making episode will be considered. MD: Mission Day.

Table 10

General Team Process Measure Administration for Campaign 5

Decision Making Task Administration	Preceding Team Process Administration	Number of Days of Measure Prior to Decision Making
MD -4	N/A	N/A
MD 6	MD 4	- 2
MD 14	MD 10	- 4
MD 20	MD 18	- 2
MD 34	MD 31	- 3

Note. General team process measures are not administered on the same day as the decision making so the most proximate administration prior to the decision making episode will be considered. MD: Mission Day.

Table 11

Aggregation Metrics for Team Processes at Each Time Point

Measure	Time	Alpha	Rwg Mean	Rwg Median	ICC1
Team Identity	2	-	0.84	0.83	0.49
	3	-	0.86	0.90	0.68
	4	-	0.77	0.89	0.44
	5	-	0.80	0.91	0.63
Team Action Process	2	0.86	0.88	0.92	0.30
	3	0.88	0.90	0.95	0.65
	4	0.88	0.90	0.94	0.23
	5	0.95	0.75	0.84	0.52
Team Viability	2	0.82	0.60	0.69	0.59
	3	0.92	0.83	0.95	0.69
	4	0.86	0.68	0.88	0.44
	5	0.91	0.91	0.95	0.67
Implicit Coordination	2	0.84	0.88	0.96	0.56
	3	0.82	0.87	0.91	0.37
	4	0.88	0.83	0.91	0.53
	5	0.93	0.70	0.93	0.60
Team Status Conflict	2	0.91	0.26	0.00	0.09
	3	0.79	0.47	0.50	0.40
	4	0.87	0.15	0.00	-0.05
	5	0.88	0.43	0.41	0.21

Note. Team Identity does not include an alpha score because it was a single item scale.

Table 12

ICC(1) of Team Process Metrics

Measure	ICC(1)	ICC(2)
Identity	0.89	0.97
Team Action Process	0.80	0.93
Team Viability	0.93	0.98
Team Implicit Coordination	0.85	0.96
Team Status Conflict	0.63	0.87

Table 13

Hypotheses and Corresponding Analyses

Hypothesis	Variables	Analysis	Sample Size
1.Common information is more likely to be discussed than unique information	IV: categorical DV: continuous	Wilcoxon signed test	N = 8
2. Negative information is more likely to be discussed than positive information	IV: categorical DV: continuous	Wilcoxon signed test	N = 8
3. Highest option net valence is related to team option preference	IV: categorical DV: categorical	Chi-square goodness-of-fit	N = 39
4. Discussion quality fluctuates across time	IV: categorical DV: continuous	Skillings-Mack (Friedman)	N = 8
5. Decision quality fluctuates across time	IV: categorical DV: ordinal	Skillings-Mack (Friedman)	N = 8

Table 14

Comparison of Common and Unique Information Coverage

Team	Common Coverage	Common Total	Unique Coverage	Unique Total	Common Coverage %	Unique Coverage %	Difference
1	49	51	35	48	96.08%	72.92%	23.16%
2	43	43	30	42	100.00%	71.43%	28.57%
3	49	51	33	48	96.08%	68.75%	27.33%
4	49	51	35	48	96.08%	72.92%	23.16%
5	50	51	42	48	98.04%	87.50%	10.54%
6	55	60	40	60	91.67%	66.67%	25.00%
7	56	60	38	60	93.33%	63.33%	30.00%
8	57	60	44	54	95.00%	81.48%	13.52%
Mean					**95.55%**	**72.79%**	**22.76%**
SD					**2.58%**	**7.89%**	**7.04%**

Note. Coverage counts if a piece of information was introduced into discussion. The total columns represent the number of items included in the scenario. Neutral items were excluded from these counts.

Table 15

Comparison of Common and Unique Information Focus

Team	Common Mentions	Unique Mentions	Total Info Mentions	% Common Focus	% Unique Focus	Difference
1	257	223	480	53.54%	46.46%	7.08%
2	200	158	358	55.87%	44.13%	11.73%
3	282	174	456	61.84%	38.16%	23.68%
4	388	219	607	63.92%	36.08%	27.84%
5	356	255	611	58.27%	41.73%	16.53%
6	236	176	412	57.28%	42.72%	14.56%
7	171	147	318	53.77%	46.23%	7.55%
8	294	239	533	55.16%	44.84%	10.32%
Mean				**57.46%**	**42.54%**	**14.91%**
SD						**7.50%**

Note. Mentions count any time a piece of information was introduced or repeated by an individual. Neutral items were excluded from these counts.

Table 16

Comparison of Common and Unique Information Consideration Coverage

Team	Common Cons. Coverage	Common Total	Unique Cons. Coverage	Unique Total	Common Cons. Coverage %	Unique Cons. Coverage %	Difference
1	35	51	26	48	68.63%	54.17%	14.46%
2	32	43	19	42	74.42%	45.24%	29.18%
3	43	51	21	48	84.31%	43.75%	40.56%
4	45	51	28	48	88.24%	58.33%	29.90%
5	44	51	34	48	86.27%	70.83%	15.44%
6	47	60	22	60	78.33%	36.67%	41.67%
7	34	60	25	60	56.67%	41.67%	15.00%
8	46	60	27	54	76.67%	50.00%	26.67%
Mean					**76.69%**	**50.08%**	**26.61%**
SD					**10.40%**	**10.89%**	**10.99%**

Note. Consideration coverage evaluates whether a piece of information was mentioned by an individual other than who introduced the information into discussion. The total columns represent the number of information items included in the scenario. Neutral items were excluded from these counts.

Table 17

Comparison of Common and Unique Information Consideration Focus

Team	Common Cons. Mentions	Unique Cons. Mentions	Total Cons. Mentions	% Common Cons. Focus	% Unique Cons. Focus	Difference
1	160	116	276	57.97%	42.03%	15.94%
2	120	91	211	56.87%	43.13%	13.74%
3	156	73	229	68.12%	31.88%	36.24%
4	253	131	384	65.89%	34.11%	31.77%
5	231	146	377	61.27%	38.73%	22.55%
6	155	84	239	64.85%	35.15%	29.71%
7	81	65	146	55.48%	44.52%	10.96%
8	191	135	326	58.59%	41.41%	17.18%
Mean				**61.13%**	**38.87%**	**22.26%**
SD						**9.32%**

Note. A consideration mention counts any time a piece of information was introduced or repeated by an individual other than who introduced the information into discussion. Neutral items were excluded from these counts.

Table 18

Comparison of Unique Negative and Positive Information Coverage

Team	Unique Neg. Coverage	Unique Neg. Total	Unique Pos. Coverage	Unique Pos. Total	Unique Neg. Coverage %	Unique Pos. Coverage %	Difference
1	21	24	14	24	87.50%	58.33%	29.17%
2	20	21	10	21	95.24%	47.62%	47.62%
3	19	24	14	24	79.17%	58.33%	20.83%
4	18	24	17	24	75.00%	70.83%	4.17%
5	21	24	21	24	87.50%	87.50%	0.00%
6	18	30	22	30	60.00%	73.33%	-13.33%
7	18	30	20	30	60.00%	66.67%	-6.67%
8	23	27	21	27	85.19%	77.78%	7.41%
Mean					**78.70%**	**67.55%**	**11.15%**
SD					**13.00%**	**12.62%**	**20.19%**

Note. Coverage counts if a piece of information was introduced into discussion. The total columns represent the number of items included in the scenario. Neutral items were excluded from these counts.

Table 19

Comparison of Unique Negative and Positive Information Focus

Team	Unique Neg. Mentions	Unique Pos. Mentions	Total Unique Mentions	% Unique Neg. Focus	% Unique Pos. Focus	Difference
1	142	81	223	63.68%	36.32%	27.35%
2	76	82	158	48.10%	51.90%	-3.80%
3	71	103	174	40.80%	59.20%	-18.39%
4	147	72	219	67.12%	32.88%	34.25%
5	154	101	255	60.39%	39.61%	20.78%
6	104	72	176	59.09%	40.91%	18.18%
7	89	58	147	60.54%	39.46%	21.09%
8	143	96	239	59.83%	40.17%	19.67%
Mean				**57.45%**	**42.55%**	**14.89%**
SD						**17.29%**

Note. Mentions count any time a piece of information was introduced or repeated by an individual. Neutral items were excluded from these counts.

Table 20

Comparison of Unique Negative and Positive Information Consideration Coverage

Team	Unique Neg. Cons. Coverage	Unique Neg. Total	Unique Pos. Cons. Coverage	Unique Good Total	Unique Neg. Cons. Coverage %	Unique Pos. Cons. Coverage %	Difference
1	15	24	11	24	62.50%	45.83%	16.67%
2	9	21	10	21	42.86%	47.62%	-4.76%
3	11	24	10	24	45.83%	41.67%	4.17%
4	17	24	11	24	70.83%	45.83%	25.00%
5	19	24	15	24	79.17%	62.50%	16.67%
6	11	30	11	30	36.67%	36.67%	0.00%
7	12	30	13	30	40.00%	43.33%	-3.33%
8	14	27	13	27	51.85%	48.15%	3.70%
Mean					**53.71%**	**46.45%**	**7.26%**
SD					**15.49%**	**7.47%**	**10.85%**

Note. Consideration coverage evaluates whether a piece of information was mentioned by an individual other than who introduced the information into discussion. The total columns represent the number of information items included in the scenario. Neutral items were excluded from these counts.

Table 21

Comparison of Unique Negative and Positive Information Consideration Focus

Team	Unique Neg. Cons. Mentions	Unique Pos. Cons. Mentions	Total Unique Cons. Mentions	% Unique Neg. Cons. Focus	% Unique Pos. Cons. Focus	Difference
1	76	40	116	65.52%	34.48%	31.03%
2	38	53	91	41.76%	58.24%	-16.48%
3	45	28	73	61.64%	38.36%	23.29%
4	95	36	131	72.52%	27.48%	45.04%
5	93	53	146	63.70%	36.30%	27.40%
6	51	33	84	60.71%	39.29%	21.43%
7	38	27	65	58.46%	41.54%	16.92%
8	81	54	135	60.00%	40.00%	20.00%
Mean				**60.54%**	**39.46%**	**21.08%**
SD						**17.52%**

Note. A consideration mention counts any time a piece of information was introduced or repeated by an individual other than who introduced the information into discussion. Neutral items were excluded from these counts.

Table 22

Comparison of Common Negative and Positive Information Coverage

Team	Common Neg. Coverage	Common Neg. Total	Common Pos. Coverage	Common Pos. Total	Common Neg. Coverage %	Common Pos. Coverage %	Difference
1	22	23	27	28	95.65%	96.43%	-0.78%
2	19	19	24	24	100.00%	100.00%	0.00%
3	22	23	27	28	95.65%	96.43%	-0.78%
4	21	23	28	28	91.30%	100.00%	-8.70%
5	23	23	27	28	100.00%	96.43%	3.57%
6	22	25	33	35	88.00%	94.29%	-6.29%
7	23	25	33	35	92.00%	94.29%	-2.29%
8	23	25	34	35	92.00%	97.14%	-5.14%
Mean					**94.33%**	**96.88%**	**-2.55%**
SD					**4.27%**	**2.19%**	**3.94%**

Note. Coverage counts if a piece of information was introduced into discussion. The total columns represent the number of items included in the scenario. Neutral items were excluded from these counts.

Table 23

Comparison of Common Negative and Positive Information Focus

Team	Common Neg. Mentions	Common Pos. Mentions	Total Common Mentions	% Common Neg. Focus	% Common Pos. Focus	Difference
1	153	104	257	59.53%	40.47%	19.07%
2	100	100	200	50.00%	50.00%	0.00%
3	124	158	282	43.97%	56.03%	-12.06%
4	215	173	388	55.41%	44.59%	10.82%
5	192	164	356	53.93%	46.07%	7.87%
6	87	149	236	36.86%	63.14%	-26.27%
7	72	99	171	42.11%	57.89%	-15.79%
8	126	168	294	42.86%	57.14%	-14.29%
Mean				**48.08%**	**51.92%**	**-3.83%**
SD						**15.65%**

Note. Mentions count any time a piece of information was introduced or repeated by an individual. Neutral items were excluded from these counts.

Table 24

Comparison of Common Negative and Positive Information Consideration Coverage

Team	Common Neg. Cons. Coverage	Common Neg. Total	Common Pos. Cons. Coverage	Common Pos. Total	Common Neg. Cons. Coverage %	Common Pos. Cons. Coverage %	Difference
1	20	23	15	28	86.96%	53.57%	33.39%
2	17	19	15	24	89.47%	62.50%	26.97%
3	22	23	21	28	95.65%	75.00%	20.65%
4	21	23	24	28	91.30%	85.71%	5.59%
5	21	23	23	28	91.30%	82.14%	9.16%
6	20	25	27	35	80.00%	77.14%	2.86%
7	16	25	18	35	64.00%	51.43%	12.57%
8	19	25	27	35	76.00%	77.14%	-1.14%
Mean					**84.34%**	**70.58%**	**13.76%**
SD					**10.42%**	**13.04%**	

Note. Consideration coverage evaluates whether a piece of information was mentioned by an individual other than who introduced the information into discussion. The total columns represent the number of information items included in the scenario. Neutral items were excluded from these counts.

Table 25

Comparison of Common Negative and Positive Information Consideration Focus

Team	Common Neg. Cons. Mentions	Common Pos. Cons. Mentions	Total Common Cons. Mentions	% Common Neg. Cons. Focus	% Common Pos. Cons. Focus	Difference
1	100	60	160	62.50%	37.50%	25.00%
2	69	51	120	57.50%	42.50%	15.00%
3	83	73	156	53.21%	46.79%	6.41%
4	149	104	253	58.89%	41.11%	17.79%
5	122	109	231	52.81%	47.19%	5.63%
6	59	96	155	38.06%	61.94%	-23.87%
7	36	45	81	44.44%	55.56%	-11.11%
8	83	108	191	43.46%	56.54%	-13.09%
Mean				**51.36%**	**48.64%**	**2.72%**
SD						**17.09%**

Note. A consideration mention counts any time a piece of information was introduced or repeated by an individual other than who introduced the information into discussion. Neutral items were excluded from these counts.

Table 26

Net Coverage Valence Preferences

Team	Highest Value Selected (Count)	Number of Tasks Completed	% Choosing Highest Value
1	4	5	80.00%
2	3	4	75.00%
3	3	5	60.00%
4	2	5	40.00%
5	2	5	40.00%
6	3	5	60.00%
7	4	5	80.00%
8	0	5	0.00%
Mean			**54.38%**
SD			**27.18%**

Note. Coverage scores evaluated whether information was introduced in discussion. A count indicates the team chose the preference with the highest score based on this assessment of their discussion.

Table 27

Net Focus Valence Preferences

Team	Highest Value Selected (Count)	Number of Tasks Completed	% Choosing Highest Value
1	2	5	40.00%
2	1	4	25.00%
3	2	5	40.00%
4	2	5	40.00%
5	4	5	80.00%
6	4	5	80.00%
7	3	5	60.00%
8	2	5	40.00%
Mean			**50.63%**
SD			**20.43%**

Note. Focus scores include introduction and repetition of information in calculating valence. A count indicates the team chose the preference with the highest score based on this assessment of their discussion.

Table 28

Net Consideration Coverage Valence Preferences

Team	Highest Value Selected (Count)	Number of Tasks Completed	% Choosing Highest Value
1	3	5	60.00%
2	1	4	25.00%
3	4	5	80.00%
4	5	5	100.00%
5	2	5	40.00%
6	2	5	40.00%
7	5	5	100.00%
8	3	5	60.00%
Mean			**63.13%**
SD			**28.15%**

Note. Net consideration coverage evaluates what information was mentioned by an individual other than who introduced the information. A count indicates the team chose the preference with the highest score based on this assessment of their discussion.

Table 29

Net Consideration Focus Valence Preferences

Team	Highest Value Selected (Count)	Number of Tasks Completed	% Choosing Highest Value
1	1	5	20.00%
2	0	4	0.00%
3	3	5	60.00%
4	1	5	20.00%
5	4	5	80.00%
6	2	5	40.00%
7	3	5	60.00%
8	3	5	60.00%
Mean			**42.50%**
SD			**27.12%**

Note. Net consideration focus excludes information mentions by the individual who introduced the information. A count indicates the team chose the preference with the highest score based on this assessment of their discussion.

Table 30

Comparison of Highest Net Valence Selection Preference

Team	Choosing Highest Information Coverage %	Choosing Highest Information Focus %	Choosing Highest Consideration Coverage %	Choosing Highest Consideration Focus %
1	80.00%	40.00%	60.00%	20.00%
2	75.00%	25.00%	25.00%	0.00%
3	60.00%	40.00%	80.00%	60.00%
4	40.00%	40.00%	100.00%	20.00%
5	40.00%	80.00%	40.00%	80.00%
6	60.00%	80.00%	40.00%	40.00%
7	80.00%	60.00%	100.00%	60.00%
8	0.00%	40.00%	60.00%	60.00%
Mean	**54.38%**	**50.63%**	**63.13%**	**42.50%**
SD	**27.18%**	**20.43%**	**28.15%**	**27.12%**

Note. These scores convey the rate at which teams chose the highest valence option per each measure of discussion.

Table 31

Information Coverage Percentage over Time (Unique & Common)

Team	Time 1	Time 2	Time 3	Time 4	Time 5	**Mean**
1	83.33%	87.50%	91.67%	69.23%	85.71%	**83.49%**
2	91.67%	79.17%	87.50%	84.62%		**85.74%**
3	91.67%	62.50%	95.83%	84.62%	78.57%	**82.64%**
4	79.17%	85.71%	100.00%	91.67%	75.00%	**86.31%**
5	95.83%	92.86%	92.31%	95.83%	87.50%	**92.87%**
6	75.00%	45.83%	95.83%	83.33%	95.83%	**79.17%**
7	45.83%	66.67%	95.83%	91.67%	91.67%	**78.33%**
8	88.89%	87.50%	75.00%	95.83%	95.83%	**88.61%**
Mean	**81.42%**	**75.97%**	**91.75%**	**87.10%**	**87.16%**	
SD	**15.99%**	**16.18%**	**7.72%**	**8.78%**	**8.11%**	

Note. These scores convey the percentage of common and unique information items included in the scenario that were introduced in discussion. Neutral items were excluded from these scores.

Table 32

Information Coverage Rank Scores

Team	Time 1	Time 2	Time 3	Time 4	Time 5
1	2	4	5	1	3
2	4	1	3	2	2.5
3	4	1	5	3	2
4	2	3	5	4	1
5	4.5	3	2	4.5	1
6	2	1	4.5	3	4.5
7	1	2	5	3.5	3.5
8	3	2	1	4.5	4.5
Mean	**2.81**	**2.13**	**3.81**	**3.19**	**2.75**
SD	**1.25**	**1.13**	**1.60**	**1.22**	**1.39**

Table 33

Total Information Focus over Time (Counts of Unique and Common Mentions)

Team	Time 1	Time 2	Time 3	Time 4	Time 5	**Mean**
1	163	155	78	36	48	**96.00**
2	155	73	90	40		**89.50**
3	155	106	126	24	45	**91.20**
4	111	100	94	209	93	**121.40**
5	141	118	106	151	95	**122.20**
6	77	41	122	79	93	**82.40**
7	40	43	88	83	64	**63.60**
8	92	119	108	65	149	**106.60**
Mean	**116.75**	**94.38**	**101.50**	**85.88**	**83.86**	

Table 34

Unique Information Focus Percentage over Time

Team	Time 1	Time 2	Time 3	Time 4	Time 5	**Mean**
1	50.92%	45.81%	57.69%	22.22%	33.33%	**41.99%**
2	52.90%	32.88%	48.89%	20.00%		**38.67%**
3	52.90%	16.04%	44.44%	29.17%	26.67%	**33.84%**
4	30.63%	16.00%	39.36%	47.85%	34.41%	**33.65%**
5	56.74%	16.95%	38.68%	52.98%	35.79%	**40.23%**
6	18.18%	60.98%	52.46%	34.18%	49.46%	**43.05%**
7	10.00%	30.23%	57.95%	54.22%	53.13%	**41.11%**
8	27.17%	34.45%	57.41%	58.46%	48.99%	**45.30%**
Mean	**37.43%**	**31.67%**	**49.61%**	**39.88%**	**40.25%**	
SD	**18.16%**	**15.93%**	**8.07%**	**15.31%**	**10.11%**	

Note. These scores convey the ratio unique information mentions out of total information (common and unique) mentions. Neutral items were excluded from these scores.

Table 35

Unique Information Focus Percentage Rank Scores

Team	Time 1	Time 2	Time 3	Time 4	Time 5
1	4	3	5	1	2
2	4	2	3	1	2.5
3	5	1	4	3	2
4	2	1	4	5	3
5	5	1	3	4	2
6	1	5	4	2	3
7	1	2	5	4	3
8	1	2	4	5	3
Mean	**2.88**	**2.13**	**4.00**	**3.13**	**2.56**
SD	**1.81**	**1.36**	**0.76**	**1.64**	**0.50**

Table 36

Information Consideration Coverage Percentage over Time (Unique & Common)

Team	Time 1	Time 2	Time 3	Time 4	Time 5	**Mean**
1	70.83%	66.67%	58.33%	53.85%	50.00%	**59.94%**
2	66.67%	54.17%	62.50%	53.85%		**59.29%**
3	58.33%	58.33%	79.17%	61.54%	64.29%	**64.33%**
4	70.83%	71.43%	92.31%	87.50%	54.17%	**75.25%**
5	75.00%	85.71%	92.31%	75.00%	75.00%	**80.60%**
6	41.67%	37.50%	79.17%	58.33%	70.83%	**57.50%**
7	29.17%	45.83%	58.33%	62.50%	50.00%	**49.17%**
8	72.22%	66.67%	54.17%	58.33%	70.83%	**64.44%**
Mean	**60.59%**	**60.79%**	**72.04%**	**63.86%**	**62.16%**	
SD	**16.65%**	**15.21%**	**15.63%**	**11.66%**	**10.64%**	

Note. These scores convey what percentage of total information was repeated at least once by an individual other than the one who introduced it. Neutral items were excluded from these scores.

Table 37

Information Consideration Coverage Percentage Rank Scores

Team	Time 1	Time 2	Time 3	Time 4	Time 5
1	5	4	3	2	1
2	4	1.5	3	1.5	2.5
3	1.5	1.5	5	3	4
4	2.5	2.5	5	4	1
5	2	4	5	2	2
6	2	1	5	3	4
7	1	2	4	5	3
8	5	3	1	2	4
Mean	**2.88**	**2.44**	**3.88**	**2.81**	**2.69**
SD	**1.58**	**1.15**	**1.46**	**1.19**	**1.28**

Table 38

Unique Information Consideration Focus Percentage over Time

Team	Time 1	Time 2	Time 3	Time 4	Time 5	**Mean**
1	46.74%	42.45%	60.61%	4.76%	29.17%	**36.75%**
2	55.32%	24.49%	52.17%	13.64%		**36.40%**
3	53.70%	12.90%	40.28%	16.67%	17.24%	**28.16%**
4	25.33%	12.00%	37.93%	44.52%	34.55%	**30.87%**
5	55.29%	16.46%	33.78%	52.44%	31.58%	**37.91%**
6	2.17%	62.50%	46.15%	25.00%	44.68%	**36.10%**
7	5.00%	30.43%	56.10%	64.71%	42.86%	**39.82%**
8	20.00%	32.53%	59.09%	54.84%	43.75%	**42.04%**
Mean	**32.95%**	**29.22%**	**48.26%**	**34.57%**	**34.83%**	
SD	**22.60%**	**17.08%**	**10.22%**	**22.28%**	**9.94%**	

Note. These scores represent how many mentions unique information received over common information, when excluding mentions of the person who introduced the information.

Table 39

Unique Information Consideration Focus Percentage Rank Scores

Team	Time 1	Time 2	Time 3	Time 4	Time 5
1	4	3	5	1	2
2	4	2	3	1	2.5
3	5	1	4	2.5	2.5
4	2	1	4	5	3
5	5	1	3	4	2
6	1	5	4	2	3
7	1	2	4	5	3
8	1	2	5	4	3
Mean	**2.88**	**2.13**	**4.00**	**3.06**	**2.63**
SD	**1.81**	**1.36**	**0.76**	**1.66**	**0.44**

Table 40

Selection of Best Answer over Time

Team	Time 1	Time 2	Time 3	Time 4	Time 5	**Total**
1	1	1	1	0	0	**3**
2	0	0	0	0		**0**
3	0	0	1	0	0	**1**
4	0	0	1	0	0	**1**
5	1	0	0	1	0	**2**
6	0	1	1	0	1	**3**
7	0	0	1	1	0	**2**
8	0	0	0	0	0	**0**
Total	**2**	**2**	**5**	**2**	**1**	**12**
	25%	**25%**	**63%**	**25%**	**14%**	**31%**

Note. A (1) indicates the team selected the best overall option as their team preference.

Table 41

Selection of Best Answer Ranks Scores

Team	Time 1	Time 2	Time 3	Time 4	Time 5
1	4	4	4	1.5	1.5
2	2.5	2.5	2.5	2.5	2.5
3	2.5	2.5	5	2.5	2.5
4	2.5	2.5	5	2.5	2.5
5	4.5	2	2	4.5	2
6	1.5	4	4	1.5	4
7	2	2	4.5	4.5	2
8	3	3	3	3	3
Mean	**2.81**	**2.81**	**3.75**	**2.81**	**2.50**
SD	**1.00**	**0.80**	**1.13**	**1.16**	**0.76**

Note. Rankings based on whether the team selected the best overall option.

Table 42

Performance as Avoidance of Worst Option over Time

Team	Time 1	Time 2	Time 3	Time 4	Time 5	**Total**
1	1	1	1	1	0	**4**
2	0	1	1	1		**3**
3	1	0	1	0	0	**2**
4	1	1	1	1	0	**4**
5	1	1	1	1	0	**4**
6	1	1	1	0	1	**4**
7	0	0	1	1	1	**3**
8	0	0	0	0	1	**1**
Total	**5**	**5**	**7**	**5**	**3**	**25**
	63%	**63%**	**88%**	**63%**	**43%**	**64%**

Note. A score of 1 indicates the team chose an option other than the worst one.

Table 43

Preference Quality over Time

Team	Time 1	Time 2	Time 3	Time 4	Time 5	**Mean**
1	2	2	2	1	0	**1.40**
2	0	1	1	1		**0.75**
3	1	0	2	0	0	**0.60**
4	1	1	2	1	0	**1.00**
5	2	1	1	2	0	**1.20**
6	1	2	2	0	2	**1.40**
7	0	0	2	2	1	**1.00**
8	0	0	0	0	1	**0.20**
Mean	**0.88**	**0.88**	**1.50**	**0.88**	**0.57**	
SD	**0.83**	**0.83**	**0.76**	**0.83**	**0.79**	

Note. A score of 2 indicates the team chose the best option, a 1 indicates a middle option, and 0 indicates the worst option.

Table 44

Selected Option over Time

Option Selected	Time 1	Time 2	Time 3	Time 4	Time 5	**Total**
Best	2	2	5	2	1	**12**
Middle	3	3	2	3	2	**13**
Worst	3	3	1	3	4	**14**

Table 45

Team Identity over Time

Team	Time 2	Time 3	Time 4	Time 5
1	4.00	4.00	4.25	4.25
2	4.00	4.50	4.75	
3	2.75	2.25	2.67	2.25
4	5.00	5.25	5.00	5.25
5	4.75	4.00	4.50	4.50
6	4.75	5.25	5.50	5.50
7	4.33	3.75	3.50	4.25
8	5.00	5.00	4.75	4.50
Mean	**4.32**	**4.25**	**4.36**	**4.36**
SD	**0.75**	**1.00**	**0.90**	**1.05**

Table 46

Team Action Process over Time

Team	Time 2	Time 3	Time 4	Time 5
1	6.50	6.75	6.30	6.40
2	5.50	6.35	6.45	
3	5.20	4.80	5.20	4.25
4	6.70	6.80	6.60	6.40
5	5.85	5.60	5.85	5.05
6	6.30	6.55	6.50	6.35
7	6.47	6.65	6.60	6.40
8	6.15	6.65	6.35	6.70
Mean	**6.08**	**6.27**	**6.23**	**5.94**
SD	**0.52**	**0.71**	**0.48**	**0.92**

Table 47

Team Viability over Time

Team	Time 2	Time 3	Time 4	Time 5
1	6.81	7.00	7.00	7.00
2	6.13	6.53	6.25	
3	5.47	5.16	5.42	4.72
4	6.97	7.00	6.50	6.63
5	5.16	5.38	5.25	4.78
6	6.50	6.63	6.47	6.59
7	6.63	6.84	6.69	6.59
8	6.84	6.81	6.81	6.72
Mean	**6.31**	**6.42**	**6.30**	**6.15**
SD	**0.67**	**0.73**	**0.64**	**0.96**

Table 48

Team Implicit Coordination over Time

Team	Time 2	Time 3	Time 4	Time 5
1	6.88	6.94	6.75	6.94
2	6.06	6.69	6.75	
3	4.81	5.25	4.33	4.06
4	6.63	6.63	6.19	6.50
5	5.81	5.94	5.94	5.00
6	6.69	6.50	6.75	6.44
7	6.50	6.31	6.50	6.19
8	6.44	6.50	6.38	6.69
Mean	**6.23**	**6.34**	**6.20**	**5.97**
SD	**0.67**	**0.53**	**0.81**	**1.05**

Table 49

Correlation Matrix of Discussion, Decision, and Team Process Measures (Spearman's Rho)

Measure	1	2	3	4	5	6	7	8	9	10	11	12
1. Coverage	(.82)											
2. Focus	-.10	(.82)										
3. Cons. Cov.	**.88***	-.31	(.82)									
4. Cons. Focus	.24	.67	-.05	(.82)								
5. Best Option	-.44	.29	-.29	-.05	-							
6. Avoid Worst	.10	-.15	.14	-.28	.65	-						
7. Decision Quality	-.23	.18	-.19	-.08	**.91***	**.88***	-					
8. Identity	.36	.26	.24	.00	.05	.44	.27	-				
9. Action Process	-.14	.10	-.17	.24	.15	.20	.21	.26	(.89)			
10. Viability	-.07	.43	-.14	.31	.10	-.01	.08	.17	**.79***	(.88)		
11. Coordination	-.10	.59	-.35	.17	.30	.33	.44	.43	.38	.67	(.86)	
12. Status Conflict	.48	-.19	.68	-.30	-.30	-.20	-.38	.11	-.67	-.53	-.53	(.86)

Note. *Correlation is significant at the 0.05 level. Values in parentheses on the diagonal for discussion quality represent rate agreement when coding discussion; this score was for all code rather than for a specific measure of discussion quality. Values in parentheses for team processes represent the mean alpha coefficient of the four time points team processes were measured.

Table 50

Crew Decision Making Episodes Transcription Data (Video Footage Duration and Word Count)

Crew	Time 1	Time 2	Time 3	Time 4	Time 5
1	VF: 25 WC: 4655	VF: 21 WC: 3036	VF: 12 WC: 1519	VF: 14 WC: 1274	VF: 18 WC: 1725
2	VF: 25 WC: 3697	VF: 15 WC: 1911	VF: 11 WC: 2485	VF: 12 WC: 1627	Did Not Complete
3	VF: 19 WC: 3172	VF: 14 WC:1928	VF: 17 WC: 2223	VF: 14 WC: 1797	VF: 15 WC: 2253
4	VF: 26 WC: 3938	VF: 24 WC: 3912	VF: 25 WC: 3830	VF: 23 WC: 3159	VF:12 WC: 1487
5	VF: 24 WC: 4331	VF: 22 WC: 3530	VF: 22 WC: 3539	VF: 24 WC: 2937	VF: 14 WC: 1920
6	VF: 24 WC: 3734	VF: 16 WC: 2292	VF: 17 WC: 2547	VF: 16 WC: 1785	VF:18 WC: 2473
7	VF: 08 WC: 1243	VF: 06 WC: 824	VF: 12 WC: 1618	VF: 09 WC: 1247	VF:14 WC: 1622
8	VF: 20 WC: 3056	VF: 22 WC: 2990	VF: 20 WC: 2821	VF: 19 WC: 1892	VF: 26 WC: 4202

Note. VF: Video Footage in minutes. WC: Word Count. Crew 2 did not complete the final task due to inclement weather.

Table 51

Summary of Decision Making Components and Themes

Components	Themes
Team Preference	Individual Preference as Decision Driver
	Triumvirate as Threshold
	Team Preference as Selection and/or Elimination
	Initial Preference as Referent
	Judgmental Framing to Defuse (Responsibility or Conflict)
	Noisy Signals (Indicators that can be Helpful or Harmful)
Information Review	Separate and Unequal (Tracking of Information)
	Initial Preferences Given Priority
	Be Careful What You Ask and When
	Quantity and Quality Matter
	Confusing Intent and Process
Roles and Functions	We Want You (Key Roles)
	Handle with Care (Roles that can Help or Hurt)
Team Dynamics	Team Decisions are Subject to External Factors
Strategy	Jump In and Go (Lack of Thoughtful Strategy)
	Wrong or Different (Conflict over Unique Information)
Pre-discussion	Individuals Do Not Maximize Their Time
Post Discussion	Mixed Reaction to Evaluation

Table 52

Temporal Decision Making Themes

Themes (Components)
Consideration of Past and Future (Team Preference)
Preference Stickiness (Team Preference)
Conflict Avoidance through Silent Dissent (Team Preference)
Apex at Time 3 (Information Review)
Established Early, Changed Informally (Strategy)
Trough at Time 5 (Team Preference)
Clash of Opposing Forces (Pre-Discussion)
The Excitement Wears Off (Team Dynamics)
Teams Evolve at Different Rates

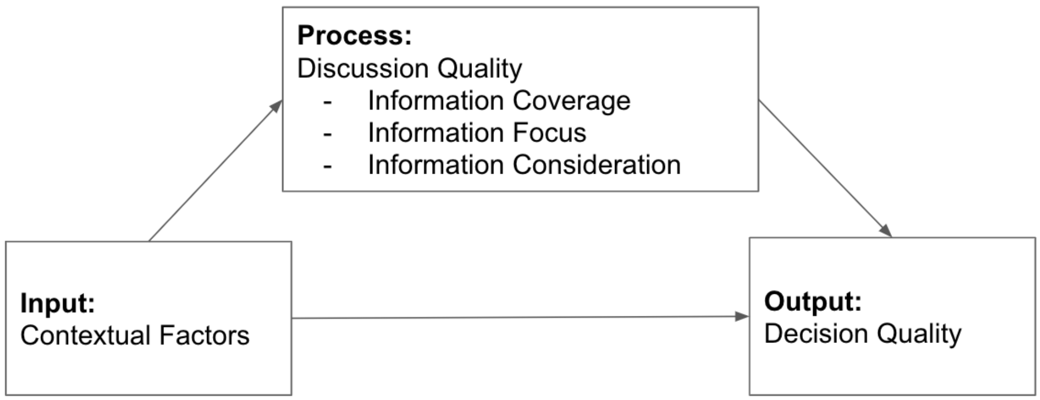


Figure 1. IPO model of team decision making

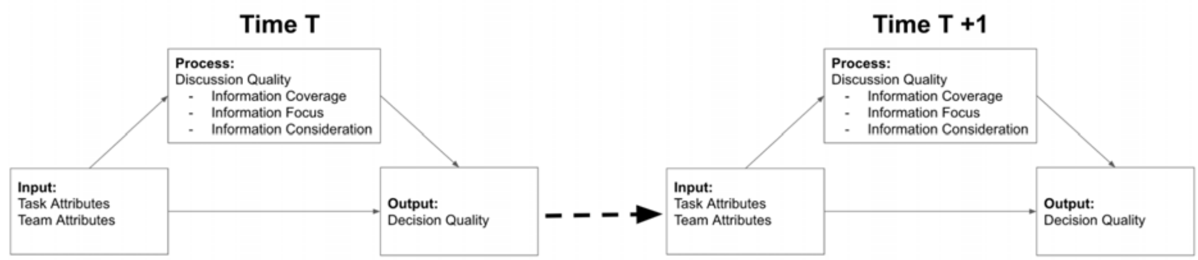


Figure 2. Recurring Phase Model of decision making

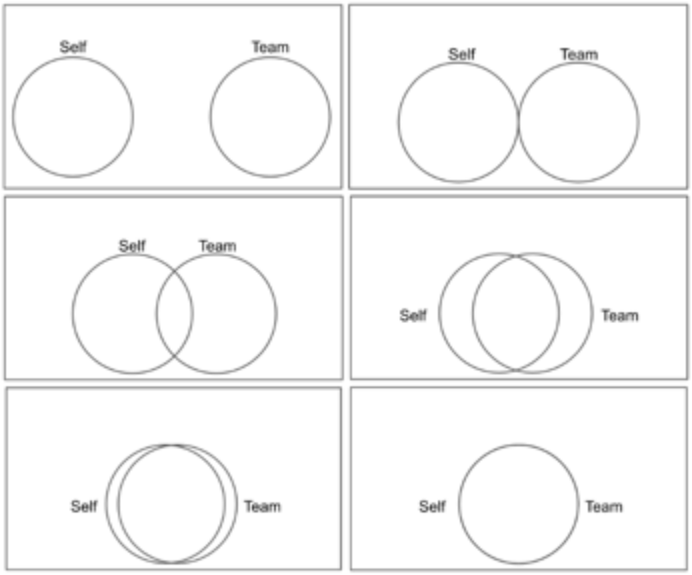


Figure 3. Team Identity Scale

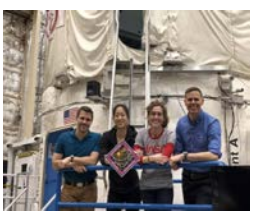
Crew	Background	Crew Patch
 Crew 1 (May 6 – June 18, 2017)	Occupational background: Physicist, Doctor, Geneticist, and Botanist 4 Males Age Range: 34-49 (M=43.75)	
 Crew 2 (Aug.5 – 27, 2017)	Occupational backgrounds: Electrical Engineer, Spacecraft Operator, Research Scientist, and Psychology Professor 1 Female, 3 Males Age Range: 29-40 (M=35.25)	
 Crew 3 (Oct. 28 – Dec. 11, 2017)	Occupational backgrounds: Physician's Assistant, Material Science Engineer, Legal Engineer, and Aviator 2 Females, 2 Males Age Range: 32-56 (M=43.5)	
 Crew 4 (Feb. 3 – Mar. 19, 2018)	Occupational backgrounds: Engineering Manager, Investor, Electrical Engineer, and Materials Engineer 2 Females, 2 Males Age Range: 32-40 (M=35)	
 Crew 5 (May 4 – June 18, 2018)	Occupational backgrounds: Geoscientist, Marketing Manager, Radiobiologist/Space Biologist, and Air Force Pilot 2 Females, 2 Males Age Range: 29-49 (M=36.25)	

Figure 4. Campaign 4 crew information

Crew	Background	Crew Patch
 Crew 1 (Feb. 16 – April 1, 2019)	Occupational backgrounds: Healthcare, Pilot Physician, Physician, and Engineer 1 Female, 3 Males Age Range: 36-41 (M=40.25)	
 Crew 2 (May 25 – July 8, 2019)	Occupational backgrounds: Astrophysicist, Engineering Manager, Geobiologist, Rocket, and Propulsion Engineer, 2 Females, 2 Males Age Range: 29-41 (M=32.75)	
 Crew 3 (Aug. 17 – Oct. 2, 2019)	Occupational backgrounds: Aerospace Engineer, Petroleum Engineer, Physician, and Research Engineer 4 Males Age Range: 34-44 (M=38.25)	

Figure 5. Campaign 5 Crew Information

Components	Categories/Superordinate Codes	Process (Hinsz et al., 1997)
Team Preference	Consensus	Response
	Elimination	Response
	Initial preference reference	Processing
	Perception of outcome	Processing/Objective
	Preference tracking	Attention/Storage/Retrieval
	Rule of Three	Response
	Selection	Response
	Vote	Response
	Willingness to change	Processing
Post Discussion	Information	Feedback
	Performance	Feedback
Pre-Discussion	Distraction	Attention/Storage
	Not maximizing individual time	Attention/Storage
	Note taking/capturing	Attention/Storage
Information Review	Capturing	Storage/Retrieval
	Information Coverage	Retrieval/Storage
	Presentation	Retrieval
	Quantity of Data	Retrieval
	Review info by individual	Retrieval
	Review info by option	Retrieval
	Timing of Sharing	Retrieval
Roles and Functions	Clarify information	Processing
	Establish decision criteria	Processing
	Initiate structure/process	Processing
	Jokester	Processing
	Solicit information	Processing
Strategy	Discussion of Voting/Majority Rules	Processing/Response
	Everyone share preferences first, then info	Processing
	Identification of unique info	Objective/Processing
	Mentions of previous tasks	Feedback/Learning
	Need for consensus	Processing/Response
	One by one share preference then info	Processing
	Share info first, then discuss preferences	Processing
Team Dynamics	Attitude towards task	Processing
	External Factors	
	Time	Processing

Figure 6. Thematic analysis component and code results

Figure 7. Team tracking preferences

Figure 8. Individual information lists

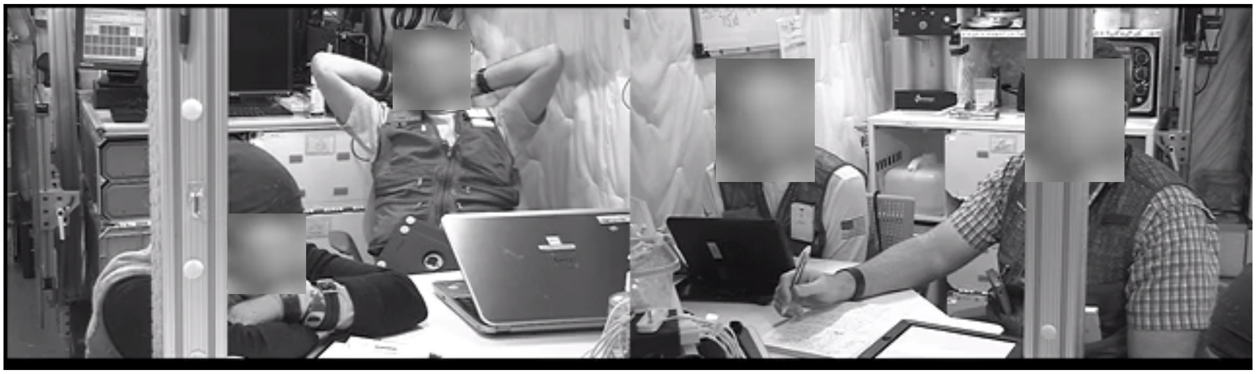


Figure 9. Individuals not taking notes

Figure 10. Individuals sleeping during task (individuals to the far left on both images)

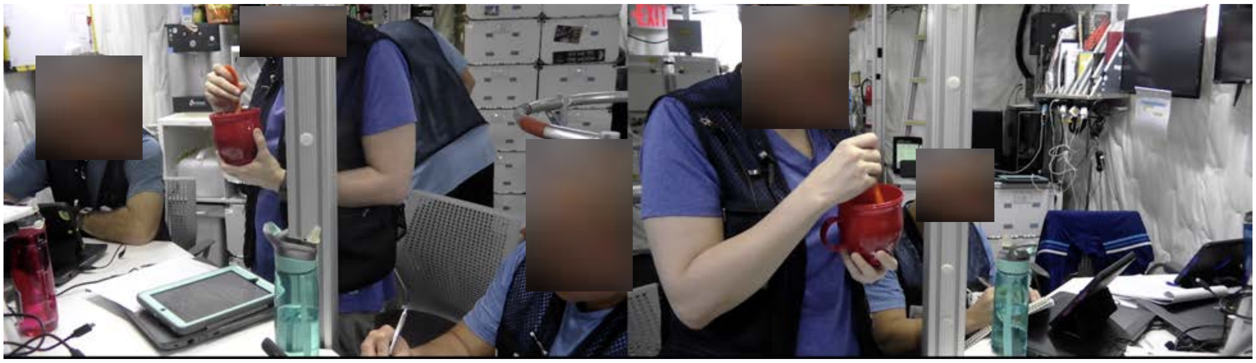


Figure 11. Preparing food and coffee during task

Figure 12. Talking while others still working

Figure 13. Interrupting other’s work (individual in green shirt)

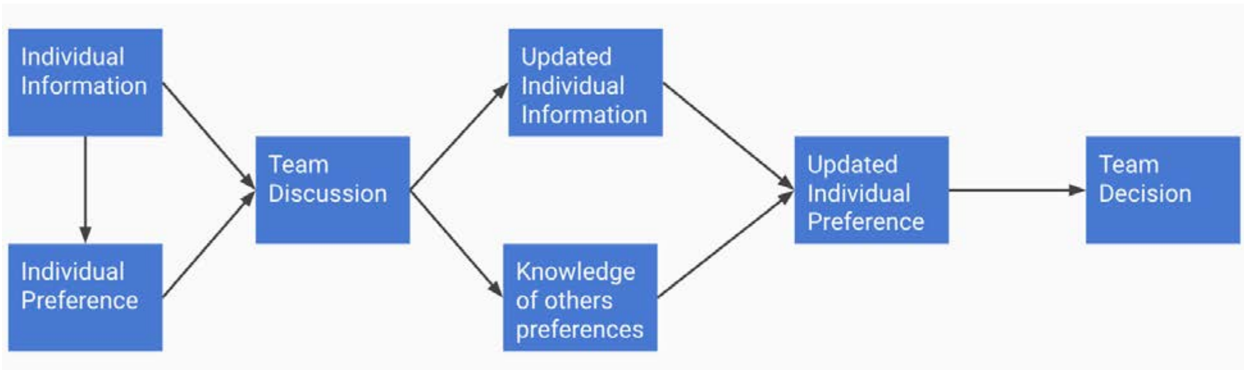


Figure 14. Observed process of decision making

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Appendix A

Suggested Protocol for Leveraging Unique Information during Decision Making

1. Suspend any discussion of individual preferences until the end of the discussion
2. Capture all available information on shared list visible to all members
3. Allow each team member to share their information without interruption
4. Establish norms that information be shared objectively and without interruption
5. Encourage asking questions of information once everyone has shared
6. Pause for a moment to allow individuals to review the pooled information and their personal information to ensure all available information has been presented to the team
7. Organize the information by relevant criteria
8. Identify criteria by which competing options will be evaluated
9. Discuss preferences based only on information introduced in previous steps; if new information is presented, delay decision until it has been appropriately processed
10. In making decision, encourage disagreement