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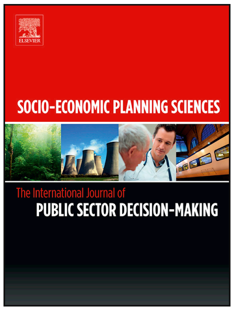

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An Experiment-Based Methodology to Understand the Dynamics of Group Decision Making

1. Introduction

In this paper, we present an experiment-based design to examine the dynamics of group decision making. The experiment-based design on group decision making that we put forth provides a path for understanding collective decision making. Understanding more about the dynamics of collective decision making will benefit public policy making and design of roundtable discussions, which can enhance communication and cooperation on important issues such as the design and placement of transportation infrastructure, hospitals facilities, and housing for the homeless, and many others.

It is easy to make a list of those things that influence individual decisions. Economists narrow in on self-interest and psychologists have taken them a step further. For example, in the Prisoners' Dilemma game two "prisoners" are given two alternatives, to confess or not confess to a crime in which both participated. The players are given one chance to make a decision and cannot consult with each other. The payoffs for confessing and not confessing can be constructed such that both players, each one pursuing his/her self-interest, will confess and thereby suffer a greater punishment than if both did not confess; thus the Prisoners' Dilemma. With repeated play though, the players learn, cooperation happens, and neither player confesses (Axelrod, 1984). In the Ultimatum Game one player is given a sum of money that is to be shared with a second player. The player with the money must decide how much to offer the second player. If the second player accepts the offer the transaction will occur. If the second player refuses the offer, the payoff to both players is zero. If self-interest is the only motivating factor, the second player should accept $1, even if the first player has $1,000 to share. Something is better than nothing. When the game is played though, the first player appears to be motivated by a sense of fairness to share more than $1 and the second player, also motivated by a sense of fairness, will reject the $1. This game has been played a number of times and it appears that "only slightly more than 6% of our subjects choose the classical (selfish) strategy." (Lucas , G., McCubbins, M.D., & Turner, M.,

2015) We discover that the players are motivated by a sense of fairness and are willing to share and expect to be offered a fair share.

When it comes to collective decisions we know that groups are not made up of individuals that have been hard-wired by their self-interest. If such were the case there would be no reason for the group to meet other than to take a vote and act accordingly. We know that when groups are challenged to make decisions, members demonstrate an understanding and appreciation of alternative values and a willingness to compromise. We know they can be influenced by others and "nudged" (Thaler, 2015).[i] Much like the Ultimatum Game, they do compromise and expect others to do so as well. We know that when groups deliberate, individual group members can be affected by kinship and friendship (Southwell, 2013). There are also other factors of influence such as persons with greater socioeconomic standing, education, perceived understanding of an issue, or even a charismatic personality. Additionally, shyness, and cultural differences (Southwell, 2013) can reduce one's influence while, at the same time, increasing the influence of others. Consequently, when individuals come together in groups and are affected by the aforementioned influences , the decision-making process becomes very complex and opaque.

To study the process one could follow a comparative statics approach where the position of the group is compared to some preceding position. Samuelson succinctly describes comparative statics as "the investigation of changes in a system from one position of equilibrium to another without regard to the transitional process involved in the adjustment" (Samuelson, p.8, 1969). A decision has not been made, but conditions have changed and the group finds itself in a different position than before. The comparative statics approach compares the differences between the two positions and the attributes that are the cause of the change in the environment. This is an important contribution but it says nothing about the process or path (i.e., incremental steps or choices in the decision making activity) followed from the first to the second decision. The description of the path is an exercise in dynamics.

The literature on group decisions makes reference to crucial decision points where the path the group is following changes direction (Poole & Baldwin, 1996). It might be similar to a point of maximum or minimum when the group changes direction from "up" to "down," or more interestingly and more subtly it might be a point of inflection that first signals the group is beginning to change direction. Using an expression common in the study of business cycles, the crucial decision point can be understood as a "leading indicator," that a change in direction is about to occur. In any case, if our objective is to develop a dynamic explanation of group decision making, that is, to describe and explain the time path from the beginning to the final decision, we must be able to identify the crucial decision points and the influences that caused them to occur. We propose a way of monitoring the decision making activity of the group and a way of collecting information that will identify these crucial decision points and those influences that lead to them. Our intent is to show how the decision-making process can be explained, beginning to end.

Community planning and development problems are inherently "wicked" because they are difficult to define and therefore difficult to solve (Rittel & Webber, 1973). Rittel and Webber contend every attempt to solve a "wicked" problem is consequential to a community as it leaves "traces" that are intractable or their reversal leads to a new set of societal problems (e.g., large-scale public works projects, such as the interstate highway system). Additionally, sharing information and applying technology to planning problems and discussions has entered a mainstream approach through social media and easy-to-access technology. Planners and developers can help lead the discussion but since these professionals are no longer the only ones with access to information, then communication, collaboration, and consensus within a larger public becomes ever more important for making sound community decisions. The study's main theoretical contribution is derived from its ability to explore the dynamics of group decisions. We create an experiment-based method to examine group decision making with real-time data. We demonstrate the viability of the method by convening two groups tasked to make decisions about a multi-purpose stadium; providing the group with data on the costs and benefits of alternative choices; creating an environment in which they can interact and deliberate; and allowing researchers to observe and collect data on the entire process.

In the experiment-based methodology our attention is devoted to the process that a group follows to arrive at a decision. We use tools available in Social Network Analysis (SNA), a domain of science often used in the analysis of case studies, and a data collection and visualization software framework (Redacted for Review, 2013) that we developed to collect and visualize data in real-time. Using these tools we identify the crucial decision points mentioned above and the events and conditions within the group that cause them. Consequently we are able to describe the dynamics of the decision making process. Our research demonstrates how the experiment-based method can help explain the dynamics of group decisions, even on large-scale public projects. The ability to examine and explain the dynamics of group decision making results in the capacity to identify potential problems, e.g. bottlenecks, and develop strategies to work through them. Understanding how group decisions provide an opportunity to develop strategies to improve public sector decisions on planning issues such as the design and placement of transportation infrastructure, health care, and housing. Combining "demographic" data on each participant, the various design outcomes of the participants, their personal explanations of why they did or did not change their designs after reviewing other models and having group discussions about the various designs, and by using SNA tools, results in a dynamic description of the process the group followed in arriving at the decision. We are able to show that individual attitudes/opinions changed over time, what caused these changes, and when and under what conditions a crucial decision point was reached.

This manuscript begins with a review of the literature from the key areas of community development, communications, cooperation, and decision making. We then discuss: (1) why using SNA tools are appropriate for identifying crucial decision points, (2) the research design; and lastly, (3) a description of the pilot study and its results.

2. Literature Review

The existing literature on cooperation, communication, discursive participation, decision making and network power theory combined, point to the need for understanding the dynamics of group decision making. The research on cooperation suggests that in the absence of institutions (i.e., formalized power, organization, or rules) cooperation works best when the group is small and homogeneous (Coase, 1960; Ostrom, 1990; Singleton, 1998). Democratic actions and planning matters are decision arenas that rely heavily on the public's input. The groups involved can be large and distinctly non-homogeneous and, without coordination or strategic support, are the types of groups that will likely struggle to find cooperative solutions. Nonetheless, there are great benefits when a community successfully arrives at a cooperative solution: enhanced democracy, successful economic development, healthy and sustainable communities, to name just a few (Innes, 1996; Innes & Booher, 1999; Corburn, 2009; Godschalk et al. 2006). This literature though does not explain the group's internal process in arriving at a decision.

We examined the communication literature where interaction theory describes in-group processes that shape group discussions and decisions (Frey, 1996; Poole & Baldwin, 1996; Honeycutt & Poole, 1994; Fisher & Stutman, 1987). This literature indicates there are important points for understanding the in-group process. They write of "milestones" and "turning points," we call them crucial decision points. Specifically, the structural model of developmental processes suggests that interaction mediates the relationships and may play an important role in the decision development. Differences among groups are then ascribed to the patterns that each group develops by considering the intersection of the group's action and the context in which the decision is being made. One drawback to this approach is that although small group dynamics can be studied, these dynamics may be discounting the value of external factors that affect the group's decision (Poole & Baldwin, 1996). As such, the decision making process, described by their "milestones," could be based on benefits being significantly large but not necessarily proportionately large relative to the cost (Rezaei & Kirley, 2009). Or it could be that a decision is triggered as individual participants develop a sense of fairness or an appreciation of another perspective (Baumeister et al. 2001; Kahneman, Knetsch, & Thaler, 1991; Tversky & Kahneman, 1991).

The communication literature indicates there are several factors in arriving at a group solution. Functional theory suggests that effective communication for group problem solving relies on appropriate member interaction (Gouran & Hirokawa, 1996) but does not reveal what that interaction looks like. Cost-benefit analysis is also recognized as an essential element (Bazerman & Neale, 1992). However, for cost-benefit analysis to be effective, accurate data on both the costs and the benefits of each alternative solution are needed but not always available (Goruman and Hirokawa, 1996). This is especially true when there is no objective market evaluation and the participants must rely on subjective measures of value. Finally, communication theory provides very little information on the way computerized group meetings alter communication and group decision making (Frey, 1996) though DeSanctis and Poole (1994) demonstrate how advanced technology does aid social and institutional structures in group decisions.

Booher and Innes' (2002) network power theory in collaborative planning allows us to understand the nuances of the way a network of people can come to a decision on a complex matter. We anticipate that the negotiation of a cooperative decision is characterized not by one crucial decision point but by a series of such points, as the communications literature suggests. This begs the question: What are the factors that trigger the crucial decision points?

Following the work by Kahneman and Tversky (1991), economists and psychologists have begun to investigate those factors that motivate individual decisions, other than adherence to a narrowly defined view of self-interest. If we share Kahneman's view that "… I feel pity for my suffering self but not more than I would feel for a stranger in pain." (Kahneman, 2011, p. 390), we can be motivated to action by a desire to alleviate someone else's pain as much as we are to alleviate our own. Additionally, we know now that an individual's decision can be disproportionately affected by a fear of loss, a desire to not harm someone else, and the quality and quantity of information (Kahneman et.al. 1986; Akerlof, 1970).

Literature reviewed by Mendelberg (2002, p.55) finds there is a "social dilemma" where there are times that rationally pursuing one's own interest is not rational for the group and may harm them. Additionally, Mendelberg's review of the social psychology research on small group deliberation finds that discursive participation allows connections between individual and group interests to be acknowledged and to be a cause of action (Dawes et. al, 1990). Furthermore, group consensus that emerges through talking leads to a higher quality of cooperation (i.e., in action not just words) (Bouas & Komorita, 1996).

The communication literature suggests that research that can identify the outcomes produced by various decision paths and their dependency on contextual variables is important in developing better theoretical frameworks. This is needed for understanding communication and group decision making and identifying a true contingency model (Poole & Baldwin, 1996). Fishkin (1995, p.41) notes:

> When arguments offered by some participants go unanswered by others, when information that would be required to understand the force of a claim is absent or when some citizens are unwilling to weigh some of the arguments in the debate, then the process is *less deliberative* because it is incomplete in the manner specified. In practical contexts a great deal of incompleteness must be tolerated. Hence, when we talk of improving deliberation, it is a matter of improving the completeness of the debate and public's engagement in it….[ii]

Part of effective decision making is the ability to have robust conversations. To understand and explain the process we must have data on the information and biases and relationships that each participant brings to the group. We must know how this information and these biases and relationships change during the group's decision making. With this we can explain the evolution of individuals and groups as they move to a decision. To do this requires software that can collect and store data to create more complete information for understanding the crucial decision points, and the participant's deliberation.

3. Methods of Analysis for Examining Collaboration

There are several methods and tools available to analyze outcomes and attribute specific effects to those outcomes. Some of these methods and tools require assumptions that are inadequate in explaining the group decision making process. We examine regression, event history, and content analysis, all of which are plausible methods. We describe the drawbacks of these tools and the benefits of SNA tools and conclude that SNA tools are better suited to describe the dynamics of group decision making.

3.1 Methods of analysis

A widely used method of analysis in social sciences is Ordinary Least Squares Regression. One of regression's many variants includes logistic or multinomial regression if the dependent variable is binary or categorical. As with all statistical methods, assumptions about the independence of variables are made. One required assumption is that the variables in the models are independent of each other (Berry, 1993). Yet when studying a phenomenon such as group decision making in which each successive step is a function of the preceding one, the assumption of independence from each observation and variable is counter intuitive.

Other variations of regression, Generalized Linear Models and Hierarchical Linear Modeling (HLM) that are sometimes called multi-level modeling, permit analyses that reflect the clustering effects of variables, which can demonstrate some interdependence between individuals and groups but not between individuals in groups. In HLM models, for example, the classic illustration is that student outcomes are in part dependent on the particular school the student attends. Analysis can even include a third hierarchical element such as the school district or city where the school is located while controlling for race, median household income, and age. Although this clearly is an advance, it is a method that still assumes the attributes of each individual, school, and school district are independent of each other while recognizing the nesting or cluster-level impact of a particular school and/or school district or city on student outcomes.

Event History Analysis is another method whose use may seem logical. It allows for forward censoring when we have no data for subjects prior to the event such as the first decision in a focus group. However, event modeling presumes the event is the same for the entire group and does not account for those who do not experience the event (Teele, 2008). It may be possible to fashion an Event History model for every possible combination of options to predict outcomes but our goal is less about predicting a particular outcome and more about revealing the steps and transactions and factors that lead to an outcome.

Anticipating the design of our study which will be explained in Section 4,participants use a software that provides visualizations of model designs and collects data on the models make independent choices, discuss the pros and cons of their various models with each other, and then ultimately make a collective decision. To understand the interdependencies of interactions between subjects and attributes on processes and outcomes, social scientists have often turned to less statistically laden methods and conducted case studies and other qualitative types of analyses such as Content Analysis. These methods are laudable and serve a need by bringing forward more specific knowledge about a process or context than regression or HLM methods, however qualitative methods do not allow us to identify cause and effect relationships.

Behavioral scientists have long understood the complexity of ascribing behavior and outcomes to any one event. Regardless of how much we have in common we know each other well enough that we know there are differences, maybe as Turner (2013) writes, “10,001 differences”.

> Human beings are geared to think about the social, communicative situation, and this silent and usually unconscious thinking influences their behavior pervasively. Other difficulties with assessing behavioral experiments include assuming that human behavior is the result of simple linear manipulatory causation that can be represented as variables to be measured, even to be located through regression analysis. (Turner, 2013).

The benefit of SNA tools is that they avoid assumptions of independence and explicitly allow the examination of interdependencies. SNA tools allow us to account for individual differences (i.e., race, gender, etc.) as well as community level factors (e.g., other network associations such as employer or position in an organization). It is for these reasons we choose SNA tools to understand the process and factors of collaborative or cooperative outcomes in group decision making.

The domain of SNA assumes interdependence between actors, which is in contrast to traditional statistical techniques, as discussed above. This interdependence is what distinguishes network statistics from traditional statistics. Furthermore, although the Event History model also assumes interdependencies it assumes they are the same across a group and does not permit an examination of the unique network relationships within a group as SNA tools do. Ultimately, when it comes to learning about collaboration in groups, as in this case, SNA tools are more appropriate than traditional statistical methods.

3.2 Social network analysis applications for examining collaboration

SNA tools allow us to reveal the relationships “between individuals, groups, and organizations and the changing, overlapping, and multiple roles that actors within them may play” (Wedel et al. 2005,

p. 40). SNA also links these structures to collective processes (Laumann, Marsden & Prensky, 1989; Wedel et al. 2005). Data and findings collected through SNA applications can be tracked and, when overlaid in graphs, illustrate how the points of influence change for a single participant. The participants' graphs can be compared to see how the factors of influence (e.g., economic status, education, knowledge, etc.), influence the decision and how they cause convergence to a point of collaboration. SNA tools permit us to document what happens before and after crucial decision points and illustrate whether certain position or flows of information are driving the outcome.

The ability to examine factors of influence is critical in understanding the group's decision. For example, it is possible that all participants agree on a particular value for one characteristic in one round only to see half of them change their response in the second round after a reconsideration of costs and/or benefits. Although we may lack the data capture to go to that level of conclusive detail in our pilot study, we demonstrate the ability of SNA tools to do so.

4. The Research Design and Future Enhancements

The key contribution of this paper is the development of an experiment-based methodology to study the dynamics of decision making in groups. In this section we describe the basic design of our experiment-based methodology followed by suggested enhancements to the original design.

4.1 The Original Experiment-Based Design

Here we explain the design of this experiment-based method and provide a description of its elements and data that could be generated for analysis. The experiment-based design includes a number of subjects and attributes to examine in the course of building a recreational stadium facility. The experiment requires, among other things, decisions on factors such as location and size of facility. The experiment could include any number of participants or design elements. For our description we include a) four participants; b) one design characteristic (i.e., covered seating for a stadium); and c) four options for the covered seating design characteristic. The participants would be chosen because their expertise and/or interest in the project. To begin, each participant would complete a questionnaire identifying personal demographic data (e.g., age, income, level of education, etc.) and a separate questionnaire identifying their relationship(s) with other participants. Each participant would then be given a detailed description of all possible design characteristics and all options (e.g., size, location, costs), and, without any discussion, construct a simulation of their preferred design by identifying his/her preferred combination of design characteristics. Each participant would then view the proposed designs of every other participant and an intensive discussion could follow where participants would be able to challenge each other, ask for clarification, etc. During the discussion participants would see: a) designs of the other participants they may not have considered; and b) how far the participants are from coming to a decision. After an in-depth discussion, another round could begin where each participant revises his or her design. Again, comparisons could be made, discussion would likely occur, and the individuals could make a second revision. The rounds would continue until the group comes to a majority agreement.

During the process observers collect and report data on the progress of deliberations. For example, Table 1 shows hypothetical responses of four participants after four rounds of choices and three rounds of deliberation. The table describes an example of participants moving from total disagreement to unanimity on one design characteristic: number of seats in the stadium. In Table 1 there are four participants, P_i, i = 1,…,4 ; one design characteristic, j = 1; and four possible values for the characteristic k = 1, … ,4. Specifically, one characteristic may be seating with the four possible values of 10,000, 7,500, 5,000, and 2,500 number of seats in the stadium. In round 1, the intersection of P_1 and C_{11} shows that 10,000 seats are chosen by P_1. The intersection of P_2 and C_{12} shows that 7,500 seats are chosen by P_2. The intersection of P_3 and, C_{13} shows that 5,000 seats are chosen by P_3. The intersection of P_4 and C_{14} shows that 2,500 seats are chosen by P_4. In the first round each participant has chosen a different value for the number of seats, i.e. there is no agreement. In the second round participants 1 and 2 agree on

10,000 seats while participants 3 and 4 agree on 2,500 number of seats. In the final round there is unanimous agreement on a total number of 10,000 seats.

Table 1
Participant Choices of Number of Seats by Round

	Round 1				Round 2				Round 3				Final Round			
	C_{11}	C_{12}	C_{13}	C_{14}	C_{11}	C_{12}	C_{13}	C_{14}	C_{11}	C_{12}	C_{13}	C_{14}	C_{11}	C_{12}	C_{13}	C_{14}
P_1	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0
P_2	0	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0
P_3	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0
P_4	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0
Total	1	1	1	1	2	0	0	2	3	0	0	1	4	0	0	0

Note: P_i= Participant i =1, 2, 3, 4
C_{jk} = Design Characteristic j = 1,2,3,4 and the value assigned to characteristic j is k = 1,2,3,4

After each round the results would be collected and tabulated as described above. Finally, after the entire experiment the individuals would be interviewed in a private setting and asked to recall what factors influenced their decisions, e.g. when they were tempted to change their response and whether they did or did not change. Using these matrices, with the information gathered during the deliberations and in the exit interviews it is possible to trace, over time, the process of the “collective decision.” This would not provide enough detailed information to identify the cause and effect process but, at the very least, it would show the path that reveals the crucial decision points.

4.2 Future Design Enhancements

In order for the study to demonstrate the depth of intricacies in the decision making process the following additions would be necessary. First, after each round, the participants should be asked to respond to a detailed questionnaire designed to discover the reasons that caused each participant to change/not change their design. These questionnaires explore those items that could cause design change, e.g. compromise, better information, influence of other participants (individually or collectively). The objective of the questionnaires is to investigate a) the evolving relationships among members of the panel; and b) the evolving relationships between each panel member and the set of design characteristics. The end goal is to couple the crucial decision points with these changing relationships and aid in identifying causes. After each round, the participants would be asked a list of questions concerning whether a) he/she was positively influenced (+1), b) not influenced (0), or c) negatively influenced (-1) by some person or concept. The questions would be the same for each participant but chosen at random and therefore would not be in the same order for each participant. In Table 2 the rows identify the person exercising the influence and the columns represent the participants as those being influenced. Reading the table row-by-row the table shows that in the discussion for that round, Participant 1 (P_1) had no influence on any of the others; Participant 2 had a favorable impact on Participants 1 and 4; Participant 3 had a favorable impact on Participant 2; and Participant 4 had a negative impact on Participant 1. Reading across the columns the table shows that Participant 1 was favorably impressed with the comments of Participant 2 and negatively impressed with those of Participant 4, and so on for each column. Participant 3 was not swayed by anyone's arguments.

Table 2
Example Matrix of Who is Influenced by Whom

	P_1	P_2	P_3	P_4
P_1	0	0	0	0
P_2	+1	0	0	+1
P_3	0	+1	0	0
P_4	-1	0	0	0

Because the debriefing would occur after each round rather than after the final decision has been made, memories would not have faded (as much) and a clearer picture of the decision making process will emerge. Additional information regarding the participants and the design characteristics requires asking the participants, after each discussion, whether or not they decided to compromise their position on a particular design characteristic in order to help move the group to a decision. The results can be seen in Table 3 where Participant 1 compromised on nothing while Participant 2 compromised on the first design characteristic, Participant 3 compromised on the fourth, and Participant 4 on the second.

Table 3
Example Matrix of Who Compromises

	C_1	C_2	C_3	C_4
P_1	0	0	0	0
P_2	+1	0	0	0
P_3	0	0	0	+1
P_4	0	+1	0	0

Note: Yes = +1 No = 0

These are only two examples. The actual list of questions could be quite large. We anticipate having data on a) individual preferences in the first round; b) the influence of different kinds of leaders (e.g., the insistent ideologue versus the more accommodating type), c) the willingness to compromise at each different round, d) the impact of new information and perhaps the sources of that information, and e) a description of how individual preferences changed during the process.

In the end these enhancements to the design yield several sets of matrices, each one corresponding to a specific round and the separate, influencing factors. Knowing the final result we can start at the beginning and observe graphically, round by round, the evolution of the decision and the influential factors. This creates the crucial decision points and provides information to identify the probable cause.

5. The Pilot Study

In order to validate our research design and the use of SNA tools for understanding the dynamics of group decision making we conducted a pilot study using the original experiment design described in Section 4.1. Our pilot demonstrates our experiment-based design and is intentionally kept simple during its testing of the visualization and data collecting software (created for this project) and to enable the identification of specific moments or data that enhance our understanding of the decision making process. The subject of the pilot is the design of a multi-purpose stadium located close to the downtown core.

In our pilot study we convened two focus groups. In each focus group we invited four participants interested in the development of the stadium: an economic development specialist, a city planner, a private sector developer, and a concerned citizen. The first focus group, Group A, had two women and two men and the second, Group B, was comprised of three women and one man. Each focus group engaged in a series of rounds during which the stadium design evolves to its final form.

Prior to the opening of the first round, the participants completed a survey covering demographics, participation and interest in local economic development, and some general background information as Step 1. In Step 2, using a software program developed for this research project, each participant made a design of the proposed stadium. These designs included the stadium size in terms of the number of seats, covered seating, parking, and the type of events that could be anticipated. In this design phase participants were made aware of effects of traffic and noise pollution caused by different types of events they selected. They were also given information on the economic impacts, specifically income employment, and costs of the facility on the community including the impact the stadium would have on their own property taxes. These designs were recorded and stored for future reference. In Step 3, the participants were able to view the designs of the other participants and then engage in conversations about the alternative designs and their benefits and costs. That completed Round 1. Round 2 was a repeat of Round 1. After the discussion in Round 1, each participant redesigned the stadium and all new designs were again made available to all the participants. Another discussion followed and then Round 3 began in which each participant submitted yet another redesign and discussion.

In Step 4, the participants examined the “most preferred design” which was an “average” based on all of the participants’ designs for the number of seats, and the amount of parking, and the economic impact in terms of property taxes calculated from their final models. The participants were asked which model they preferred, the “average” provided by the software, their own, or one offered by one of the other participants.

In Step 5, in a private setting, each of the participants was individually asked several debriefing interview questions by one researcher assisted by one graduate student (see Table 4).

Table 4
Debriefing Interview Questions

Questions
Whose opinion did you value the most? Why?
On a scale of 1 to 10 how strongly did this person influence your outcomes?
Who else could be or was influenced by whom?
At what times were you tempted to change your response but didn't and why?
At what times did you change your response and why?
What factors contributed to you reaching consensus or not with the rest of the group?
Identify two ways others influenced your actions/outcomes (position, knowledge etc.)?
Do you have social ties or organizational ties to any of the members on the session?
Who and what are they (social, organizational)?
Was the technology you used today an effective tool to make decisions on economic development projects? If so, how so?

5.1 A demonstration of our data with SNA tools for understanding crucial decision points

We use a repeated measures design, the dependent variable being the decision outcome of each individual. The independent variables are the emergence of factors (e.g., reported expressive leader, costs and benefits displayed, sense of fairness, financial revenue) that caused a change in someone's perception that, in turn, caused the group to move away from or toward a particular option. Using SNA graphs drawn with NetDraw we create visuals of the data to demonstrate the dynamics of the group decision making process. Ultimately, the visualization techniques and SNA graphs provide a road map to identify the crucial decision points and allow for the examination of "a systematic correlation between network position or attributes and influence," and then to identify "if there [are] specific actors or actor combinations whose network position[s]" significantly influence the groups' decision (Schiffer &Hauck, 2010, p. 241). Additionally we gauge the impact that data on cost and benefits has on the group decision. In combination, real-time data from the individual decisions in the scenario, participant observations discovered in debriefing interviews, network analysis graphs, and survey methods produce an encompassing data set leading to a rich understanding of the patterns of interaction in this collective decision making experiment.

Using the qualitative data from the debriefing interviews three of the researchers coded the responses to the four questions in Table 5. The scores of Inter Rater Reliability (IRR[iii]) for consensus of agreement on the responses to the questions are noted in parens.

Table 5:
Coded Debriefing Questions with IRR in parens[iv]

Questions
Why did this group participant have an impact on your decision? (.919)
What factors contributed to you not reaching consensus with the rest of the group? (.256)
Who and what are the social ties with any other participants in the focus group? (.722)
If the technology you used today was an effective tool to make decisions on economic development projects, in what way was it helpful? (.232)

First, we identify ties that are connections between participants and any reciprocity that exists among the ties. Using *NetDraw* we show the ties of ego (i.e., the person) to alter (i.e., another person). Second, we examine the several decision outcomes for the stadium including, parking, number of seats, and number of covered seats for the proposed stadium.

We model an ego-centric network and compare individual roles but not the network. The actor position can determine, in part, the constraints and the approach to the relationships. Using actor-by-actor data of equal dimension we stack conformable matrices to create a matrix for each actor. Specifically we stack our matrices by the social roles of "economic development specialist," "developer," "planner," and "concerned citizen." We also examine whether by Round 3 the information or choices converge among the participants or if one participant remains an isolate with his/her choice.

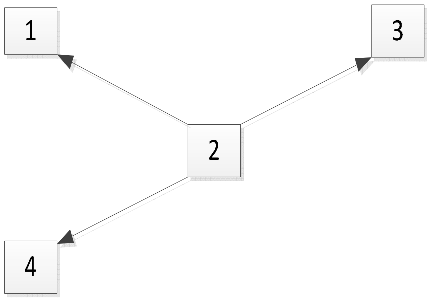
As previously mentioned, our goal is to understand the process of decision making. What factors led to the crucial decision points? The independent variables included: who were the participants; who they knew; their social ties; gender; and whether they agreed that the technology was effective. To identify the potential factors that contribute to a decision point we examine the following: a) what is the influence that the technology brought to the process; b) if information about costs, benefits, taxes, and traffic play a role; c) what is the role of fairness or the desire to cooperate; and d) who is/are the influential person(s).

We ultimately want to understand the dynamics of the interpersonal relations and the outcomes of the interactions. Our boundary is the event that is the individual focus group and we study the ideas, information and reported influence of the personal interactions during the experiment. We recognize our study is limited. It does not account for ties or relationships other than the roles represented by the four participants and our study examines only the data, activity, and information extracted from the participants during the pilot.

6. Findings

There are several ways SNA graphs can be used to examine group dynamics and explain the emergence of agreement. In this section we will identify a few of them. Specifically, we examine the differences among two groups composed of participants from the same four sectors (economic development, residential/commercial development, planning, and concerned citizen). Within each group we can explore the influence of participant attributes such as knowledge of the subject and gender, exogenous influences such as the visualization software and data on costs and benefits, and the results of repeated rounds of deliberation on stadium design characteristics. Using the following SNA graphs we illustrate some of the dynamics of the group decision making processes. The SNA graphs reveal the changes within groups and between groups.

Given that we are evaluating our experimental design and exploring the use of SNA graphs, we initially compare individuals on the factors of influence, social ties, and feelings about the visualization software as they contribute to consensus. In succeeding rounds, we compare the data stacked by participant. Figure 1 illustrates that within Group A Participant 2 was particularly influential as shown by the directed ties from Participant 2 to Participants 1, 3, and 4. Univariate statistics reveal this participant sent ties of influence to all other participants. When the participants were asked why this person was influential, they responded that it was his knowledge of the local sports market and one participant added that the two were friends. Group B shows a different pattern (see Figure 2) where only one participant, Participant 6, was influenced by one other participant, Participant 5, with a directed tie from Participant 5 to 6. The reason noted for the influence is again the person's apparent knowledge.



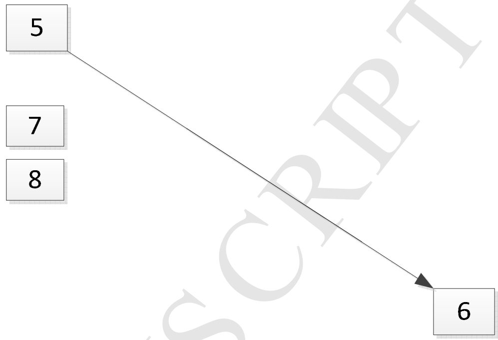


Fig. 1. Group A - Who Influences Whom **Fig. 2**. Group B - Who Influences Whom

Univariate statistics, as calculated using the software UCINET 6, indicate that Participant 5 had 33 percent more ties of influence than the other participants. This demonstrates that there is more inequality among the participants in Group B (Participants 5, 6, 7, 8) in terms of the ties of influence than with Group A (Participants 1, 2, 3, 4). This is striking as the participants in the second group show more social reciprocal ties (see Figure 3 and 4) than participants in Group A. In Group A, Participants 2 and 3 each have 33% connectivity and participant 1 is an isolate while participant 4 appears to have the most connectivity (67% more social ties than the other three participants). The fact that Participant 4 has such great connectivity does not necessarily make him/her more influential. This is illustrated in Figures 1 and 3 where Participant 4 had social ties with both 2 and 3 but had no influence on any participant. In Group B, Participants 6 and 7 share similar levels of connectivity with one other participant. Participant 6 has a directed tie to 7 and Participant 7 has a directed tie to 5. Participants 5 and 6 are the only one with a reciprocating relationship. Participant 8 is an isolate. Regardless of the increased number of social ties in Group B there was far less influence among members than in Group A. Only Participant 6 indicates being subject to any influence, in this instance from Participant 5. In short, the dynamics in each focus group are markedly different with the second focus group having two participants with 67% more ties than the other participant with ties and one participant with 33% more ties than the one participant with no social ties.

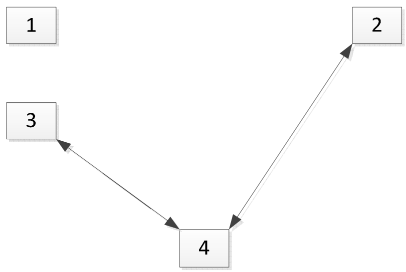


Fig. 3. Group A- Social Ties

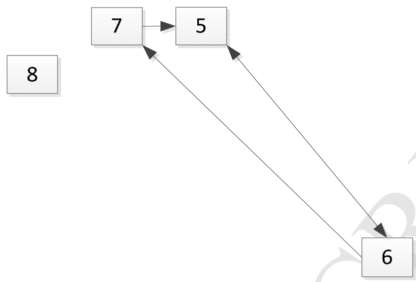
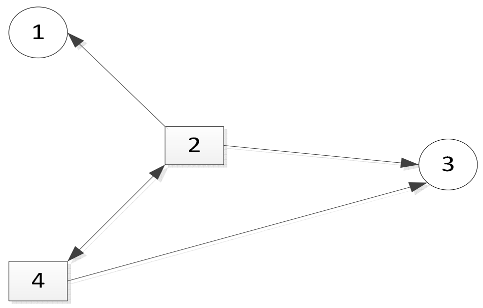


Fig. 4. Group B - Social Ties

Prior to examining the flow and forces round by round, we stack the actor matrices and compare them by their social roles in the group. We use multiplex network examination because with

> …face-to-face groups of persons, the actors may have emotional connections, exchange relations, kinship ties, and other connections all at the same time…. Sociologists tend to assume, until proven otherwise, that [an] actor[']s behavior is strongly shaped by the complex interaction of many simultaneous constraints and opportunities arising from how the individual is embedded in multiple kinds of relationships (Hanneman & Riddle, 2005, Chp. 16).

So when considering both the influence and the social ties within a group, that is to say, having one and/or the other, focus group A has five ties as seen in Figure 5. The focus group B has the same number of ties (when considering both influence and social ties) yet there is also an isolate and the structures of the two groups look completely different. The compositions of the groups are also different in terms of gender (see Figures 5 and 6), and belief in the effectiveness of the visualization software (see Figures 7 and 8).



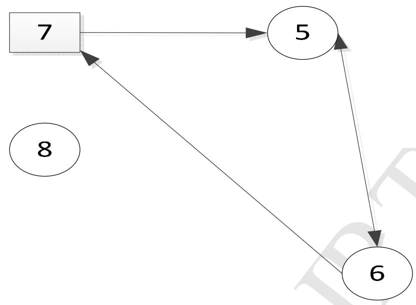


Fig. 5. Group A - Number of Ties and Gender **Fig. 6.** Group B - Number of Ties and Gender

Figures 5 and 6 also show gender where males are identified by the rectangles and females by the circles. This type of information is valuable when looking for the explanations for crucial decision points as women are thought to be more cooperative. If this is true a group predominately comprised of women is more likely to come to a crucial decision point, and a majority consensus, and do it more quickly than a group of males and research such as our pilot would manifest the result. This would also be the case with other factors of influence when comparing results of Group A to Group B.

The figures show the relations and ties among the participants have very different structures. Figures 7 and 8 illustrate one item each group has in common is the dominant belief that the visualization software is helpful to the decision making process. In Group A, the most influential actor, the economic development specialist (2), indicates it helps with the discussion while the developer (3) and the planner (4) see its benefit as providing cost and benefit information. The concerned citizen (1) indicates the software helps with the process of making the decision but expresses no reason for that conclusion (see Figure 7). Group B demonstrates a slightly different pattern where the developer (5) sees the effectiveness of the software in helping the discussion while the planner (6) and economic development specialist (7) see its value in providing a better understanding of the costs and benefits of the project as seen in Figure 8. There are no data for the citizen on this question in the second group, although the citizen does indicate she thinks that the tool was effective but does not say how.

In comparing the focus groups, the dissimilarities in the patterns suggest the outcomes are not attenuated by the person's role in the process, but that something else is going on. One outcome to note is that the people reported as most influential in each group (Participants 2 and 5), as seen in Figures 7 and 8, both cited the software as more helpful to the discussion than an understanding of the costs and benefits

The debriefing interviews provided explanations as to why participants in Group A reported no consensus. Participant 1, the citizen, indicated the cost-benefit data contributed to her disagreement with the rest of the group. Participant 2 did not respond to this question as to why the group did not come to a consensus and Participants 3 (developer) and 4 (planner) indicated the intra-group discussion contributed to their disagreement with others in their group. It is noteworthy that the participants reported the contribution of the software was not a factor in whether or not they came to a consensus. There is insufficient data from Group B to explain why the group did not come to consensus.

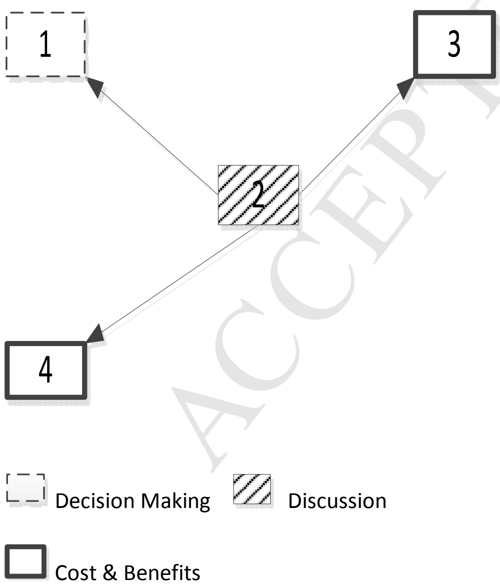


Fig. 7. Group A - Software Effective for Discussion, Cost & Benefits, and Decision Making

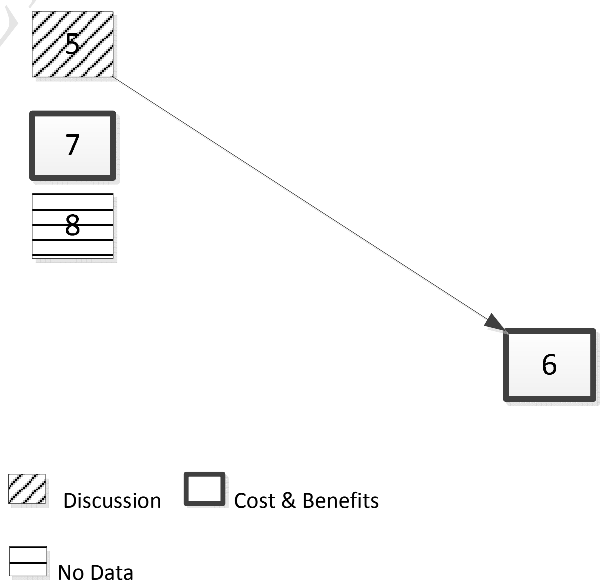


Fig. 8. Group B - Software Effective for Discussion and Cost & Benefits

One last comparison of Groups A and B is through an examination of multiplex graph matrices. When considering (in terms of their social role) the influence ties, the social ties, and the belief of the effectiveness of the software of each actor, we can see in Table 6 that Group A has some pairs of participants with no ties with scores of "0" but also an instance of a very strong ties between the roles of economic development specialist and developer, Participants 2 and 4, respectively. This contrasts with the results for Group B, as shown in Table 7, where there are ties among each pair of the participants and not a single role dominating the ties or linkages, nor is there an isolate.

Table 6.
Group A - Matrix of Summed Ties by Role on Influence, Social Ties, and Software Effectiveness

	1	2	3	4
1	1	0	0	0
2	1	2	2	3
3	0	1	1	2
4	0	2	2	1

1=Concerned Citizen 2= Economic Development Specialist, 3= Planner 4=Developer

Table 7.
Group B - Matrix of Summed Ties by Role on Influence, Social Ties, and Software Effectiveness

	5	6	7	8
5	2	2	2	1
6	2	1	2	1
7	2	2	1	1
8	1	1	1	1

5=Developer, 6=Planner,
7=Economic Development Specialist, 8= Concerned Citizen

Using *NetDraw* we illustrate the change from each round and get a glimpse of the potential factors that lead to crucial decision points. As Hanneman and Riddle (2005, Chp. 16) suggest for small networks, drawing graphs is the best way to visualize the structure. Specifically, we use these SNA graphs to examine the evolution of the decision making through Rounds 1, 2, and 3 on the topics of the number seats, parking, and percentage of covered seats. The results shown in Figures 9 and 10 for both groups after Round 1 illustrate there was no agreement on the number of seats for the facility. After Round 2 there was still no agreement but the options were narrowed to two. As seen In Figure 9 for Group A the isolate chooses the same number of seats as the person that is reported as the most influential (i.e., the economic development specialist). Both the planner and developer use cost and benefit information from the model and agree on the same number of seats. In Group B, (see Figure 10) the person with the most influence, the developer, along with the planner who reports being influenced by the developer, as well as the isolate citizen, all come to the same conclusion on the number of needed seats. Yet the way the visualization software reportedly helps is noted to be different for the developer (discussion) and planner (cost and benefits) and is unknown for the citizen due to missing data.

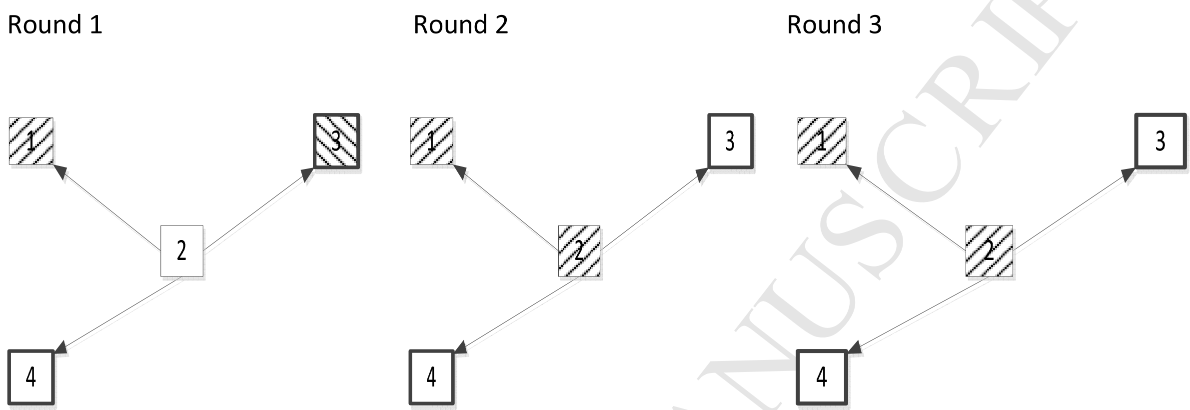


Fig. 9. Group A – Series of Choices on Number of Seats

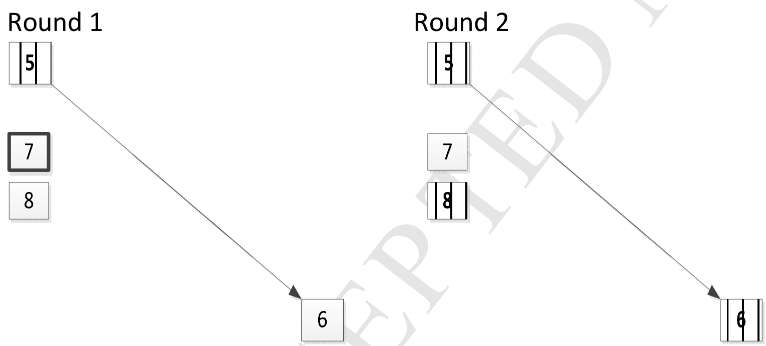


Fig. 10. Group B – Series of Choices on Number of Seats

In Figure 11, we see the most influential person and the concerned citizen are in agreement on parking after Round 1, but then the economic development specialist changes his position to that of the developer who also changes his position, which is now the same as the planner. The third round results in no changes and no majority consensus. In Figure 12 the most influential person and the person most influenced by him change their opinions to the position of the economic development specialist and she changes her position to the position of the concerned citizen and the citizen changes to the position previously held by the developer and planner. Again, there was no change after the second round and no majority consensus.

Figure 13 reveals the series of choices made on covered seats for Group A. The economic developer specialists and developer hold the same position after the first round but both change to the same option in the second round which is that of the concerned citizen in the first round and the citizen changes her opinion to the choice of the planner in first round. Again, there is no change after the second round and no majority consensus. Finally, in Figure 14, we see that the choices are varied after the first round and merge to a majority consensus on covered seats by the third round. The most influential person and the person influenced by that person do not change their positions until after the second round while the other participants change positions after each round. Ultimately, we see in both Groups A and B that the decision on the number of seats does not change after the second round for parking or covered seats, except in the case of Group B which comes to an agreement after round 3 as seen in Figure 14.

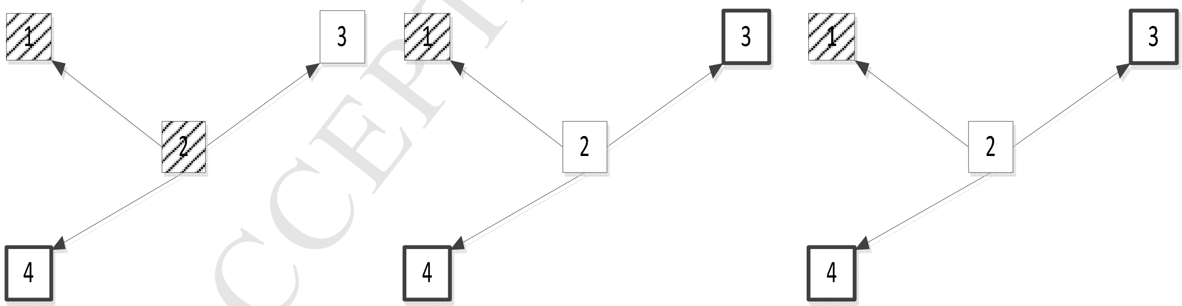


Fig. 11. Group A –Series of Choices on Number of Parking Spaces

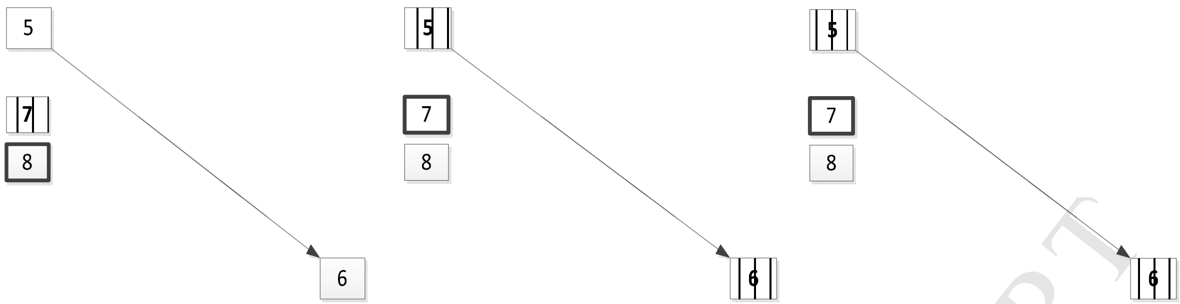


Fig. 12. Group B - Series of Choices on Number of Parking Spaces

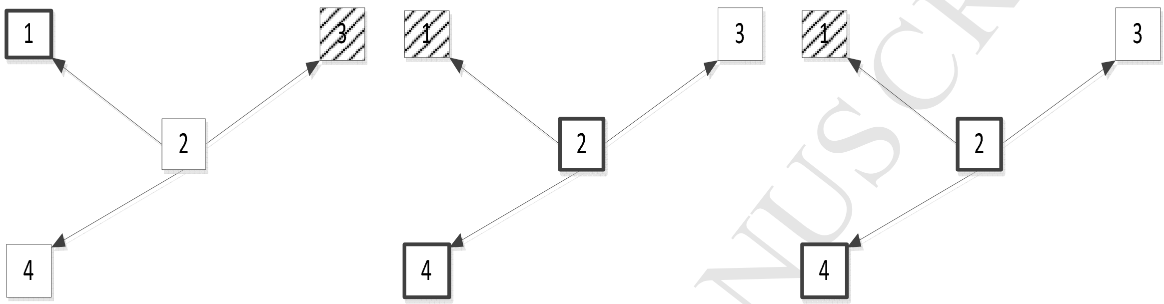


Fig. 13: Group A – Series of Choices on Number of Covered Seats

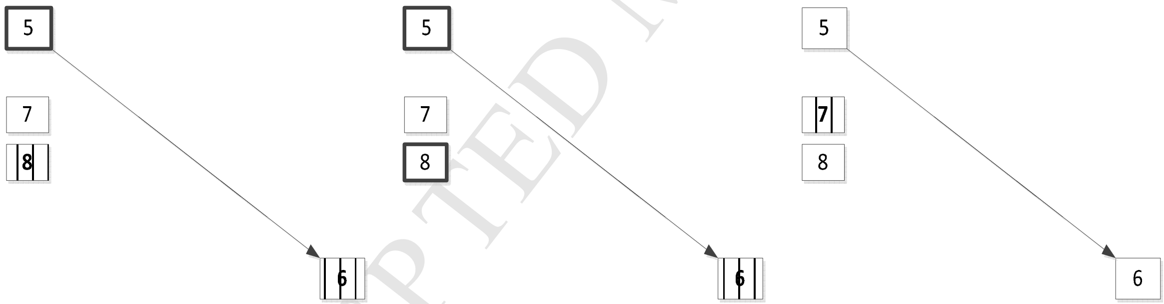


Fig. 14. Group B – Series of Choices of Number of Covered Seats

Statistical analysis on the similarity and dissimilarity of outcomes with so few data points is not possible, yet definitely warranted for future analysis with more and larger groups. Larger groups would allow us to better understand the structural equivalence of the actors and their positions in the decision making groups.

Finally, Group B, demonstrates more influence and social ties and agreement on the effectiveness of the technology and more frequently came to a majority rather than a split decision (see

Figures 11 and 13 and 13 and 14 for comparison). Admittedly, these findings are not conclusive but rather exploratory and indicative of the need for future research and the power of the combined methods of using visualization software, data, and SNA graphs together for examining group decision making.

7. Conclusions and Future Research

Crucial decision points are a key component of group decision making. That they exist may be a trivial point but there is little documented about the process of arriving at decision points. The communication researchers find that a large percentage of decision making groups follow a similar cycle with paths that loop back as the groups iterate through their decision making process. Critical decision points include breaking points where individual group members try to influence the discussion; to stay the course, to take a new direction; or to recycle new ideas (Honeycutt & Poole, 1994; Fisher & Stutman, 1987; Poole & Baldwin, 1996). Building on the DeSanctis and Poole's (1994) analytical model for understanding the relationship between technology and structural adaption theory in communications, we believe SNA graphs are helpful for examining the dynamic interactions of group members in decision making and for identifying crucial points in decision making for community development.

Our pilot research testing our experiment-based research design using our software framework, and SNA graphs reveal several things worth following up on with larger groups. This includes designs with more group members and/or with a larger number of groups. Both scenarios warrant future research and insights to decision making dynamics at the group level. This said, the visualization and data collection software developed for this research can be scaled to either scenario since it was designed for a generic number of groups and participants. For example it could be scaled from as few as 3-4 groups and/or groupings to hundreds users or more. Nonetheless, our experience with small groups raises interesting issues and presents critical findings.

First, a group with a central person of influence and multiple social ties does not necessarily come to a decisive decision even when a third factor of reported importance for the decision is identified such as the visualization software or cost and benefit information. Second, we discovered that after only two rounds, the group members had more or less come to their individual decisions on covered seating and parking spaces and kept these settings. This suggests that convergence could occur quickly and that additional attempts to influence the discourse may not be effective. Using the principle of diminishing returns, this means that additional attempts to achieve a decision might not return any measurable changes. Third, in Group B where there are more females, less influence by a single participant is observed, more social ties are found, and consensus on the value of the software, we also find a majority consensus is more quickly reached. This suggests that attributes such as gender may play a role in overcoming generally perceived obstacles such as fewer social ties. Lastly, even with limited pilot study data, the analysis reveals that combining the software framework with SNA graphs makes a positive contribution to understanding the dynamics of group decision making.

We do not want to give the impression that difficult community decisions can be resolved in an afternoon. When the issue is important to the community and the process that we have described is seen as influential, maybe even definitive, more groups will want to be involved. Participation is part of the foundation of democratic processes and often needed and sometimes required in hearings for planning and/or governance. The various opinions and values of each individual or interest group will be more difficult to sway with increasing numbers of people or groups and with, for example, limited meeting time available. There is much to be learned when the issue is real or even urgent; when there is a greater variety of opinions with respect to each option available; where the opinions of each group are well entrenched; and when more people are involved. For the purpose of our study, we used a regional example that was in discussion locally as a long term planning and investment project, and limited the rounds of discussion as well as the design characteristic options. Future research should adhere more strictly to the enhanced research design and examine the causes of change as the group moves from round to round. Proposed data collected from the computerized questionnaires following each round would provide valuable information. This enhanced method provides additional possibilities to conduct more work on the specific factors and variables that are coincident with crucial decision points such as gender, knowledge on the topic, age, and other socio-economic variables.

In sum, our experiment reveals a number of benefits. First, the software framework and SNA graphs can reveal the dynamics of group decision making. Second, the process of providing real-time data about choices, information about cost and benefits, and the opportunity to deliberate over ideas and choices has great promise to help broker collective decision making on community projects. Third, the presented software framework and SNA tools can be scaled to larger size of groups and are spatially independent from meeting rooms or town halls when including chats and other interactive channels. The presented software and methods are applicable to problems of great magnitude and large size groups.

The path forward that analysis of decision dynamics opens is crucial for dealing with the interdisciplinary and large-scale problems and policies that face communities today. Scaling up the experiment could include the adaption of dynamics we see in crowd sourcing or in big data for social science to permit screening for critical decision-making points at (almost) real time. The importance of understanding dynamics of group decision has great potential of creating a transformation in a networked society. In times where participation in planning issues is heavily supported via social media and other interactive forms provides yet another arena to explore and understand the mechanisms that are behind collective decision-making, including influences due to personal relationships and professional networks.

In the words of Innes and Booher (2007, p. 421) there is the possibility to create more “adaptive and successful collaborative planning throughout society” – in person and with technology. Here we present one successful step to study the dynamics of decision-making in groups, and raise helpful questions for future research that could lead to more successful collaborative planning

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[i] Because people are human they make predictable errors. If the errors can be anticipated then policies can be devised to reduce them. That is, they can be "nudged" away from a bad decision and in the direction of a better one (Thaler, 2015).

[ii] Italics in Original

[iii] Inter Rater Reliability is the degree of agreement among raters. It gives a score of how much consensus there is in the ratings given by the participants.

Highlights

- An experiment based methodology is proposed for understanding group decision making
- We find SNA tools are more appropriate than traditional statistical methods for understanding group dynamics
- Crucial decision points are a key component of group decision making
- The importance of understanding dynamics of group decision has great potential of creating a transformation in a networked society