Evolution of Social Networks Among American Female Adolescents

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This study delves into the evolution of social networks incorporating both elements of Rational Choice Theory and Feminist Theory inside a Social Network analysis. Simulated data was generated by modeling American female adolescents as an instantiation of a more general set of theoretical ideas about the formation of gendered relational patterns. This study uses the methodology of Computer Simulation to explore micro to macro mechanisms and account for how individual social actions aggregate to generate macro-level network structures. This research examines generative mechanisms and explores under what conditions some characteristics of gendered network structures emerge and are maintained through time. Three AVI files (movies of simulation demos) and a JAR (Java ARchive) of the JAVA code are also included.

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Chapter I: Introduction

The intellectual foundation of my study draws from the three sociological fields of Feminist Theory, Social Network Analysis, and Computational Sociology. It is unusual to combine quantitative-oriented fields of Social Network Analysis and Computational Sociology with Feminist Theory where the majority of research is qualitatively oriented. Most feminist researchers who engage in qualitative research refrain from employing traditional research methods that take deductive approach and use objective procedures because they fail to obtain information about women's lived experiences and true consciousness. Instead of using positivist's quantitative methods that are characterized by decontexualization, feminist qualitative researchers have produced distinctive feminist methods that can retain concrete circumstances by taking an inductive approach, which allow them to examine processes by generating concepts and theory in the research field.

However, there do exist feminist researchers who conduct structural analyses of gender inequality using quantitative methods. These feminist scholars (e.g., Chafetz, 1980, 1990; Curtis 1986; Friedman & Diem 1993; Chafetz & Hagan 1996; Ridgeway 1993; 1997; 1999; Smith-Lovin & McPherson 1993) employ traditional social science techniques and assumptions in their explanation of gender inequality and provide compelling evidence of gendered social organizations.

1.1 Macrostructural Theories

Dunn et al (1993) advocate Macrostructural Theory to explain systems of gender stratification[1] and gender inequality by identifying macro level structural causal variables such as ideological systems, family structure, sex ratio, economic and political factors. Rather than addressing the situation of individual women, Macrostrucural feminist scholars use general categories of the 'status of women' to

[1] This study uses Chafetz's (1999) definition of gender stratification as "the degree to which men and women, who are otherwise social equals, are unequal in their access to the scarce and valued resources and opportunities of their society" (p.10).

understand patterns of covariation of the system of gender inequality[2]. Macrostructural Theories would be helpful in structurally explaining the givens at which the other quantitative feminist researchers who employ Microstructural Theories such as Social Exchange Theory, Rational Choice Theory, Network Theory, Expectation States Theory, and Affect Control Theory start to explain gender inequality. These Microstructural Theories are not actually "feminist" in its espousing the construction of abstract, logically formal theories and even the use of laboratory experiments to test them (i.e. Expectation States Theory), but when theoretical schemes of these theories are applied to gender, they are quite useful for explaining gender inequality.

1.2 Microstructural Theories

Feminist scholars who use Microstructural Theories usually theorize from macro to micro direction to explain how individual choices, behaviors, and interaction patterns are gendered as outcomes of gendered inequality at the macro-level (Chafetz 1999). In the following section, my review will introduce basic ideas of each theory.

1.2.1 Social Exchange Theory

Feminist scholars (Chafetz 1980, 1990; Curtis 1986) who use Social Exchange Theory explain gender inequalities between spouses by attributing macro-level social structural arrangements that provide husbands greater access than their wives to material resources required by a family, to spousal inequality of social exchange where the debtor (wife) will fulfill some diffuse, unspecified obligation in exchange of gifts and favors provided by her husband. Chafetz (1990) argues that these micro-level spousal inequalities handicap women in the labor force, and hence reinforce macro-level gender inequality.

1.2.2 Rational Choice Theory

Friedman and Diem (1993) argue that feminists' rejection of Rational Choice Theory (RCT) as a sexist theory due to its separative model of the self, rather than the connective model, has impeded general theoretical progress. They assert that RCT can explain perpetuation of gender inequality at the micro level by examining mechanisms of choice within existing structural constraints, and they

[2] Dunn et al (1993) points out that there is the problem of "general paucity of systematic, macrostructural research designed to test these theories"(p.87), and that more refinement of theories is required.

demonstrate some feminist empirical work that implicitly use RCT to explain differences in the choices made by men and women (this will be discussed in theory section in detail later).

Chafetz and Hagan (1996) used a modified RCT proposed by Marini (1992) to understand how women increasingly try to balance preferences for individual achievement and or romantic relationships and children. They assume that women in industrial nations tend to hold values that reflect those prevalent in their society. According to them, those women assess their perceived opportunities to achieve what they value and the reward and lost entailed, and act in goal-oriented ways to achieve their value ends. However, in contradiction to most RCT, Chafetz and Hagan argue that these women do not necessarily act in an effort to maximize the achievement of one set of goals. Instead, they argue that contemporary women increasingly behave economically rational actors to achieve the value of individual fulfillment and success in the "public sphere," yet are unwilling to abandon the value of successful familial relationships and domestic life. They assume that women will increasingly opt for a "satisficing" (Collin 1992) mode[3] by "reaching a reasonably high level of both rather than attempting to maximize one to the substantial exclusion of the other" (p.201). At the macro level, their theory provides explanations of a set of family changes experienced by all industrial nations (such as increased ages at first marriage and first birth, increased divorce and cohabitation rates, etc) as the result of changes in women's rational choices as they confront a new opportunities as well as constraints.

1.2.3 Social Network Theory

Smith-Lovin and McPherson (1993) advocate the structural analysis of gender inequality by examining the types of networks and ties that differ enough to explain gender differences in preference, opportunities, information, and behaviors by searching for *regularities* in relational structures. For example, McPherson and Smith-Lovin (1982) found that "a system of organizations divided into large, male-dominated, economically oriented organizations and small, female-dominated, domestically oriented organizations" (p.900) by examining the relationship between sex and organization size in voluntary sections. In addition, McPherson and Smith-Lovin (1986) report the inverse relationship

[3] Chafetz and Hagan (1996) recognize that the degree to which women act in a "satisficing" mode will vary depending on the opportunities they perceive, which are substantially affected by their age and social class (p.201).

between organization size in voluntary organizations and female homogeneity. They found that women were more likely to belong to sexually-homogeneous groups than men, resulting in men having more numerous and sexually-homogeneous contact than women. Although they report compelling evidence of gendered social organizations by employing social network analysis, their research is limited to *static* description of gender differences in social networks.

1.2.4 Expectation States Theory

An Expectation States Theory (EST) employs the social psychology of expectations and the concept of status characteristics to explain systematically the interactional inequalities of power and influence produced by gender in goal-oriented groups (Berger, Conner, and Fisek 1974; Berger & Zelditch 1985; Ridgeway 1993). Ridgeway and Smith-Lovin (1999) describes expectation states as being "not a theory of gender, *per se*, but a theory of the way characteristics of people that carry status value in the surrounding society shape the power and prestige hierarchies that emerge when they interact" (p.252). EST views gender as external status characteristic and it argues that women are disadvantaged in interaction because women have lower status value in our society than men (Lockheed & Hall 1976; Wagner 1988). EST explains how these gender status beliefs affect peoples' behaviors and reactions in a way that becomes self-fulfilling prophecies[4] that result in a reduction of women's self-confidence, prestige, and power and shaping the resulting power and prestige order through a series of interaction processes without any assumption about the individual abilities of men and women. Thus, EST is a situational specific account of women's disadvantages in interactional power and influence by combining social structural systems of beliefs with interactional processes in goal-oriented groups. The strength of EST is that it uses mediating interactional process[5] in its account of how gender affects interactional inequalities of power and influence in mixed-sex task oriented groups, given that men enjoy higher social status than women. Therefore, theory provides possible strategies that the impact of gender as status

[4] The EST begins with the observation that when interaction is goal oriented, participants form performance expectations, looking for a way to anticipate the likely usefulness of their own and their fellow interactants' suggestions. This self-other performance expectations guides the way not only one act in relation to another but also the other's reactions to you, leading to becoming self-fulfilling (Ridgeway 1993).

[5] Ridgeway (1993) argues that "no theory of gender stratification will succeed unless it incorporates an account of mediating interactional processes" (p.193)

characteristics in specific situations can be altered in several ways (see Lockheed & Hall 1976; Wagner, Ford, and Ford 1986; Meeker & Weitzel-O'Neill 1977; Ridgeway 1982). However, as Ridgeway (1993) acknowledged, the weakness of EST is that an account of gender inequality in same-sex groups remain a weakness in the theory's account of gender, interaction, and status.

1.2.5 Identity Control Theory

Identity Control Theory (ICT) assumes that people learn a set of meanings, which serve as an identity standard and guide their behavior in situations when that identity is evoked. When ICT is applied to gender identities, it assumes that people learn gender meanings from societal definition of masculinity and femininity (Burke, 1991, Ridgeway & Smith-Lovin 1999), and both men and women act out master gender meanings; a set of meanings that applies to the self across situations. ICT is different from older gender role socialization theory in its conceptualization of identity-driven behavior as control systems (Burke, 1991; Burke & Reitzes, 1981; Heise, 1979; Smith-Lovin & Heise1988). This control-system formulations of identity theory posits that a control process leads to both stability and change in identity-driven behavior. Both men and women refer gender meanings to interpret the implications of interaction and modify their behavior to control the perceptions of self-relevant meanings (Ridgeway & Smith-Lovin 1999). As a variant of ICT, Smith-Lovin and Robinson (1992) use Affect Control Theory (Heise 1979; Smith-Lovin & Heise 1988) to examine the way gender identities are maintained in group conversation. Their argument is that both socialization and peer-group interaction lead boys and girl to develop gender identities, which then affect cross-sex interaction. Ridgeway and Smith-Lovin (1999) argue that the strength of ICT is that it integrates the view that interactions are based on what we learn about societies' definitions of maleness and femaleness, with situation-specific natures of these gendered behaviors in such a way that "gender is displayed and maintained in different ways in different situations[6]" (p.255).

1.2.6 Summary

[6] The another strength of IC theory is that it allows specification of the conditions under which gender meanings are likely to change, as a result of life events (ex. Burke and Cast 1997) or societal change (Ridgeway & Smith-Lovin 1999).

Microstructural Theories provide feminist researchers the powerful theoretical and methodological tools to explain gender inequality by its construction of abstract, logically formal theories. Utilitarian theories of Social Exchange and Rational Choice Theory provide mechanism of exchange and choice mechanisms to account for gender inequality at the micro level. Social Network Theory offers structural analysis of gender inequality by examining *regularities* in relational structures to explain gender differences in preference, opportunities, information, and behaviors. Expectation States Theory provides a situational specific account of gender inequality in interactional processes in goal-oriented groups by combining social structural systems of beliefs. Identity Control Theory accounts for gendered behavior in interaction by a control process of gender identity. What these Microstructural Theoretical approaches imply is the important effect of gender differences in resources, opportunities and societal definitions at the macro-level on individuals' choice, relational behavior, and pattern of interaction, which in turn reproduce gender inequality at the societal level. However, these theories are not powerful enough to explain how interaction processes produce or reproduce social institutions characterized by gender inequality from micro to macro direction due to its limited attention to individual agency.

From a feminist perspective, Chafetz (1990) proposes the importance of a 'micro-level' analysis that examines voluntaristic aspects of gender systems in order to understand the powerful mechanisms that maintain and reproduce systems of gender inequality. At the micro level, Chafetz proposes the concept of 'engenderment,' to indicate the process by which both genders internalize gender-normative way of behaving, and therefore come to be gender-differentiated. The interesting point is that Chafetz introduces the concept of 'micro-definitional power' to describe the situation in which actors orient themselves to 'proper' behavior by "intrapsychic phenomena as they (women) are affected by social and cultural factors" (p.14). Interactionist Theory is concerned with people's everyday, routine behaviors that define situations (usually to the advantage of males), which affects the construction of their sense of social reality in such a way that it sustains systems of gender stratification.

1.3 Interactionist Theory

Qualitative feminist scholars who use Interactionist theory such as Ethnomethodology or Symbolic Interaction Theory (ex. Ferguson 1980; West & Fenstermaker 1993; Gerson 1985b) theorize the perpetuation of gender inequality by examining how people constantly construct a sense of a gendered self and attribute gender to others in their interactive process at the micro level. Thus, Feminist Interactionists view macro-level social structure as "definitional property that is constantly being created and recreated in the interactive process by the meanings people attitude to their own and to other's behaviors" (Chafetz 1988, p.17). The strength of Interactionist Theory is that it provides the view of gender as an emergent property by regarding gender as "an ongoing accomplishment that emerges during virtually all interactions, both within- and between-sex" (Gerson 1985). People are constantly re-creating their own and other interactants' sense of gender as West and Zimmerman (1987) call it "doing gender" (Chafetz 1999). Qualitative feminist works that take in this approach will be introduced in great detail in the next chapter of literature review.

1.4 Call for Integrated Theory of Gender Inequality

Both Interactionist Theories and Microstructural approaches attempt to explain how people's everyday choice, behaviors, and interactions are gendered (Chafetz 1999), for the former the focus is more agency-oriented and for the latter is more structurally-oriented. Each theoretical framework contributes partially to understanding gender inequality, and as some feminists have already embarked upon (e.g., Chafetz 1990; Lorber 1994), the work of theoretical synthesis is necessary to provide mechanisms of how gendered institutions are generated and maintained in our society. The question is *how can we combine Microstructural Theory with Interactionist Theory?* My answer to this question is to shift our attention away from structure to process in Microstructural analysis of gender inequality by addressing how gender inequalities structurally originate and maintained. In so doing, a single perspective or level of static structural analysis may not be enough to get the satisfactory understanding of gender inequality. Recently, Network theorists have begun studies on the evolutionary nature of network

structures to explore the driving forces behind network evolutions, which will be introduced in the next section.

1.4.1 Studies on Network Evolution

Network analysts (Doreian & Stokman 1996; Stokman & Doreian 1996; Doreian et al 1996; Leenders 1996a; 1996b; Flache & Macy 1996; Zeggelink et al 1996; Snijders 1996; Hummon & Doreian 2003; Doreian & Krackhardt 2001) have shifted their attention from description of network structures to *explanation* of network change through time by delving into some of the driving forces behind network evolutions. Now, descriptive analysis of network structures is "mature enough to go deep and to turn to more difficult questions of dynamics and evolution" (Stokman & Doreian 1996 p.233-34). In order to understand social network *process*, we must examine through-time mechanisms by specifying rules that govern a series of structural changes of creating, maintaining and dissolving network structures through time.

The dynamic nature of network structures has been empirically examined by describing changes in network structure. In the study of friendship formation, Hallinan (1978) examined stability and change in children's friendship dyads over time by using a continuous time Markov model. Her findings concerning dynamic process of friendship formation showed that mutual best friend dyads were more stable than asymmetric dyads which tended to change to null dyads over time. The important point is that Hallinan viewed friendship formation as a dynamic and interactive process by describing structural changes in dyadic ties over time. Although Hallinan has not directly examined the underlying mechanisms of friendship formation, her through-time description of dynamic nature of friendship relations paved the way to examining the through-time mechanism of network formation.

It is worth noting that Doreian and Stokman (1996) distinguish network *dynamics* from the *evolution* of a network by studying the *processes* of network change that require the use of time-based descriptions of network structures. According to them, *dynamics* is the more general statement of changes through time that are purely descriptive. On the other hand, *evolution* has a stricter meaning that requires explanations of dynamics by specifying underlying processes or mechanisms for network

change. By using this classification, we can regard Hallinan's (1978) work that describes changes in friendship formation through time as dynamic. However, richer investigation of process for network change can be achieved by examining evolution of networks. In the studies on evolution of networks, mainly three generative mechanisms of (1) network properties, (2) goal-orientated actors, and (3) individual characteristics, have been specified as the through-time mechanism for network change.

1.4.1.1 Network Properties

Doreian et al (1996) examined balance mechanisms through time by focusing on structural tendencies toward reciprocity, transitivity and group balance. At the micro level, Doreian et al traced the process toward reciprocity and transitivity as the groups evolved by developing tools that measure these structural characteristics. At the group level, they traced the process towards balance through time of a signed network and measured the amount of imbalance using "line index of balance." Their results showed early stability in reciprocity and later stability for transitivity and much later stability for group balance. What is important in Doreian et al's study is their finding of the involvement of different time scales[7] in balance mechanisms through time. More specifically, the knowledge of distinct time scales of each structural property under which underlying balance processes operate is essential in network evolution studies.

Doreian and Krackhardt's (2001) study of signed transitivity also examined through time mechanism by examining pre-transitive conditions to see how signed networks change through time. More specifically, they studied a transitivity model that incorporates negative side of affect relations by combining transitivity with signed relations as the variant of transitivity model. They proposed 'signed transitivity' that was based on Fundamental Structural Balance Hypothesis (FSBH) by hypothesizing that balanced triads are present at all times and become more frequent through time while the imbalanced triads become less frequent. By using the 'Newcomb data', they reported the conditions under which the balance mechanism could or could not account for the frequencies of triad types. Doreian and

[7] Hummon and Doreian (2003) point out that some inconsistent empirical findings concerning reciprocity might be due to the differing time scales.

Krackhardt's idea of 'signed transitivity' provides us with new insights into the nature of a triad, including the transitive triad, in their descriptive and dynamic analyses of singed transitivity.

As Doreian and Krackhardt's findings showed, when we consider negative relations in transitivity model along with positive relations, we can discover another mechanism operating in the frequencies of triad types. In this sense, collecting signed affect relational data is essential to investigate the conditions under which balance mechanism can account for the frequencies of triad types, depending on the sign of relations among threesomes. These results imply that simulation may help us to consider what we should look for and when to look when we collect empirical data, which would provide us with through time distribution of network (Doreian & Stokman 1996).

1.4.1.2 Goal-oriented Actors

Some network researchers, from the perspective of methodological individualism, interpret network characteristics as goals pursued by social actors who choose their behavior under structural constraints (Zeggelink et al 1996; Flache & Mary 1996; Stokman & Zeggelink 1997). For instance, Zeggelink et al (1996) explored the process of friendship group formation by assuming that rational individuals act in order to achieve their intrinsic goal of desired number of friends, which is their basic model of friendship formation. Methodologically, they compared simulated networks derived from this basic dynamic individual oriented model with those that were derived from the basic model with additional components such as similarity. The point is that Zeggelink et al explained the variations in friendship network structures that were derived from simulation analyses by specifying the goals of social actors.

Snijders (1996) also conceived of actions of goal-oriented actors as the driving force behind network evolutions by proposing stochastic dynamic models that directly express evolution of networks. Methodologically, he integrated goal-oriented evolution models for networks with simulation-based statistical models for parameter estimation and testing. In this approach of methodological individualism, it is important to consider the optimization problems that arise not only from the limitations in the amount

of information[8] but also from individual's capacity of imagination that results from the simultaneous actions of other goal-oriented actors according to which social actors make decisions to realize their goals of network properties. By applying Snijders' (1996) actor-oriented stochastic dynamic model, van Duijn et al (2003) developed a theory that provides the underlying process for network change through time among sociology freshmen in the Netherlands. They found that proximity of program[9] and visible similarity of gender are important explanatory variables for friendship formation in the initial and middle stage of the group formation and disappear as explanatory factors at the final stage.

1.4.1.3 Individual Attributes

Feld and Elmore (1982) offered the mechanism of individual characteristics one of other possible explanations of disproportionate incidences of particular types of triads. Instead of supporting cognitive balance as a substantive explanation of transitivity, they proposed that non-cognitive social process of differential popularity[10] among individuals underlies the process of transitivity. Their research showed that inequality of popularity better predicted triad frequencies than transitivity did, which systematically implies that the patterns in a triad cannot be described by the operation of cognitive balance.

Methodologically, Feld and Elmore pointed out systematic differences between the triad frequencies in each pair of specific triad types[11] by assuming that the triad types that contain more inequality of popularity are more frequent than the ones that contain less inequality of popularity. Then, they compared the observed frequencies of each pair of triad types with the expected ones[12] and showed the weekly changes in differences for each of the two triads. Their results supported the differential

[8] As the level of complexity in network characteristics increase, so does the amount of information. For instance, social actors need more information as their goals of structural characteristics go from reciprocity, to transitivity, to group balance (Doreian & Stokman 1996).

[9] Zeggelink (2001) et al explains two programs; the regular four-year program and a special program of two years. For the former, students enter college right after high school (at the age of about 18 years), and for the latter, students enter college after having finished higher vocational training first (at the age of about 22). They treat these variables of program as opportunity variable.

[10] Individual variations in choice relation as the account for the substantive frequencies of transitive triad types has been already pointed out by Davis, and Holland and Leinhardt by using statistical models.

[11] Each pair of 111U/111D, 021U/021D, and 120D/120U were used.

[12] They used U/MAN random model.

popularity explanation of transitivity, which led Feld and Elmore to conclude that differential popularity plays an important role in determining incidences of triad types.

Leenders (1996a) also showed that individual characteristics, when compared to structural characteristics, have more influence on the underlying process for network change through time. He examined both structural effect of reciprocity and attribute effect of similarity, on friendship formation. His statistical analyses showed that significant effect of reciprocity has gone when we consider similarity effect simultaneously, which imply that structural effect can be explained by individual attributes. Leenders also found the significant effect of similarity that was based mainly on *gender* on friendship formation.

What the last two mechanisms on evolution of networks have in common is that they conceive of network properties as consequences of other mechanisms of goals of bounded-rational actors and individual attributes respectively. In other words, for both Zeggelink et al and Leenders, network structures are not assumed to be the driving forces nor the causes of network change through time. These network analyses that examine the generative mechanism of network structures have driven us to the question of causality (this issue will be discussed in detail later in the chapter of "methodology").

Leenders' (1996b) discussion of two types of network study that addresses causal relationship between actor attributes and network structure may be helpful to consider the generative mechanisms of network structures. Leenders calls the influence of network structure on the actor attributes *contagion process* and the influence of actor attributes on network structure *selection process*. More specifically, for the former process, network structure is an independent variable, and an actor attribute is regarded as dependent variable. For the latter process, an actor attribute is an independent variable and network structure is a dependent variable. His argument is that both contagion and selection processes will interact in such a way that actors shape their networks, causing dynamics in network structure, and simultaneously, being influenced by network structures via social influence. His idea of interdependence of contagion and selection allows us to consider the causal relationship between actor attributes and network structures, both of which are assumed to be changing through time.

It is important to notice that Leenders (1996b) has proposed a new network analysis that considers not only dynamics of network structures but also the dynamics of actor attributes such as actor attitudes, behavior, beliefs and etc. These network analyses would be promising to examine the generative mechanism of network structures by mobilizing 'causal explanation' in network analysis (Doreian 2001, 2002).

1.4.2 Summary

Network analysis has become a more powerful method for examining social theory by exploring generative mechanisms of network properties, goal-oriented actors, and individual characteristics, as driving forces of network change. Given these network approaches, the question is which approach is more useful to deal with the question of *how we can combine Microstructural Theory with Interactionist Theory.* First, the view of network properties as driving force behind network evolution hardly address individual agency, and thus it fails to integrate Interactionist Theory into Microstructural Theory. Second, the view of goal-oriented actors as underlying process for network change seems to be a promising candidate because it combines individual agency in terms of its goal-oriented actions with network properties. Third, the view of individual attributes as generative mechanism of network structure also incorporate the element of individual agency in terms of the dynamics of actor attributes such as actor attitudes, behavior, beliefs and etc, and thus it would also be promising for theory integration. It is important to notice that these latter two approaches theorize in bottom-up direction, and hence emergent view of network structures can be achieved. The limitations of the view of goal-oriented actions as generative mechanism is that individual agency is usually expressed in terms of limited view of rationality that assumes that individuals are goal oriented, and hence ignoring other types of rationality that contains expressive behavior. This issue will be discussed in the theory chapter.

1.5 Toward Integrated Theory of Gender Inequality

What is missing from feminist research within the framework of Microstructural Theory is the analysis of bottom-up social processes for forming relational structures, and thus little study on the evolution of gendered networks has been conducted in feminist quantitative research. My study aims at

filling this niche by integrating Microstructural Theories with Interactionist Theory to account for the emergence of gendered systems by focusing on individual agency while relying on quantitative methods to discover regularity in relational structures using abstract conceptualizations. My research will rely on qualitative feminist findings about how attitude and self-conceptions are gendered at the micro level, and examine how these individual characteristics affect their behaviors and expectations at the interactional levels, which drive the formation of "gendered social networks" at the macro level. I define "gendered social networks" as any social network that arises as a result of people's constant recreation of their own and their interaction partners' sense of gender during interactions, both within- and between-sex, by borrowing the interactionist concept of "doing gender." Therefore, according to my definition, even a homogenous social network in regard to the gender dimension can be "gendered," and my study focuses on an analysis of all-girl homogenous social network. At the macro level, I will employ quantitative methods such as network analysis and statistics to examine the emergent properties of "gendered social networks."

In my study, modeling American adolescent girls is an instantiation of a more general set of theoretical ideas about the formation of "gendered social networks." Cohen (1989) proposes the methodological idea of relating general theories to instantiations and associated notions. He claims that science begins with ideas, and turning these ideas into a scientific knowledge claim requires formulating them in abstract and universal terms. His notion of a scientific knowledge claim broadly means that "any statement about phenomena that can be accepted or rejected" (p.49), and is formally defined as "an abstract, universal, conditional statement in the form of a declarative sentence that has a subject and a predicate (i.e., is a grammatical sentence) where the predicate asserts something about the subject of the sentence" (p.75). According to him, the act of formulating an idea is equivalent to abstracting from the reality, and he emphasizes the distinction between ideas and reality. He argues that knowledge claims must be linked to empirical studies that usually take place in particular times at particular place, and without such linkage the science could not have an empirical character. Here, statements that report

research results (which are called singular statements) are not the focus of scientific concern but play an important role in science since they can affect the evaluation of the knowledge claim.

Cohen argues that one of properties of knowledge claims is the conditional requirement that "guides us to particular situations in which the claim should be true" (p.80). He claims that many unsolved problems remain in connection with this conditional requirement, and introduces three types of conditional statements that allow us to use the empirical world to evaluate abstract universal statements.

First, Cohen refers to "initial conditions" that play a central role in linking abstract knowledge claims to singular statements that describe empirical research. According to him, a chain of singular statements by means of the addition of statements of initial conditions constitutes a crucial feature in the use of empirical research to evaluate theory. Here, observation statements are, of necessity, singular since they describe the results of observing at a particular time and at a particular place.

Second, he introduced the term "scope conditions" for other types of statements of conditions. He defines scope conditions as "a set of universal statements that define the class of circumstance in which a knowledge claim (or a set of knowledge claims) is applicable" (p.83). Thus, scope conditions preserves the abstract and universal character of knowledge claims, and wherever scope conditions are met, we have many instances in which a knowledge claim is applicable. He argues that for a knowledge claim to be conditional, its scope of application must be explicitly stated and be linked to the empirical world through the formulation of statements of initial conditions (p.84).

Third, Cohen introduces a related, paired set of statements called "antecedent conditions" (If-clause) and "consequent conditions" (then-clause). According to him, statements in the antecedent-consequent form enables us to "use powerful tools to manipulate statements to arrive at new statements, and it emphasizes the relational nature of knowledge claims" (p.84).

Putting the above-mentioned notions of "conditions" together, Cohen introduces the idea of a simple knowledge structure that "spells out the entire logical argument and provides a basis for critical evaluation" (p.86). According to him, embedding the knowledge claim in simple knowledge structures helps us to make the idea subject to public evaluation by reason and evidence. He argues that simple

knowledge structures can be viewed as a theoretical activity in its involvement of analysis and the use of critical reason. However, they are not theories that are more complex than simple knowledge structures since they deal explicitly with the interrelationships of a set of knowledge claims.

In my study, the knowledge claims are the statements about the relation between status and people's relational behavior that eventually generates social network structures. My knowledge claims are applicable to "cohorts in any closed population where there exist organizational creations of status-conferring positions that are recognized and evaluated by the closed population," which are my scope conditions. My initial conditions are "American adolescent females in middle schools where there exist school-sponsored activities that confer status among peers in terms of popularity." My study focuses on cheerleading as school-sponsored activity because of "the fact that cheerleaders were so visible greatly enhanced their popularity among their peers and made cheerleading the central determinant of membership in the elite female peer group" (Eder & Kinney 1995, p.306).

Here, "American adolescent females in middle schools" is the instance of "cohorts in any closed population," and "school-sponsored activities of cheerleading that confers status among peers in terms of popularity" is the instance of "organizational creations of status-conferring positions recognized and evaluated by the closed populations." In addition, my knowledge claims are stated in the antecedent-consequent form such that "if X is higher than P in his or her status level, then X avoids affiliating with P. Conversely, if P is lower than X in his or her status level, then P fails in affiliating with X. These conditions generate hierarchal network structures. As an instantiation of these statements, my study heavily relies on Eder's notion of "Cycle of Popularity," which will be discussed in details in the "Theory" chapter. Other types of if-then statements are also formulated based on other empirical findings of girls' relational behaviors.

My study focuses on adolescent girls since adolescence is a critically important developmental period for girls, as they are increasingly confronted with expectations to conform to female gender roles (Brown et al 1999). My observation statements come from empirical research findings that describe relational behaviors and gendered social networks by observing adolescent girls at a particular time and at

a particular place. However, there exist discrepancies between quantitative findings and qualitative ethnographic findings with respect to describing girls' social networks, which will be discussed in the chapter of "Literature Review." In order to tackle this unsolved problem, my research employs the methodology of computer simulation, which will be discussed in the chapter titled "Computer Simulation," since it enables us to identify the conditions under which certain types of network structures emerge. In this way, my simulation research represents an instantiation of theoretically based social processes that generate gendered network structures, which are derived from the model of individual American female adolescents ethnographically observed by qualitative feminist scholars.

1.5.1 Significance of Study

From a feminist viewpoint, ascertaining the characteristics of gender differences in network structures and their dynamic nature is significant in order to address the issue of gender stratification and gender inequality. The social relationships, which early in life embed males females differently than females in networks, have an influence on their perceptions and preferences that influence their adult-life chances (Smith-Lovin & McPherson 1993). In addition, the preference for same-sex friendship relations in both classroom and non-classroom settings among girls may lead to "habituation of sex segregation that may be related to gender segregation among adults in the labor force" (Lockheed 1986, p.619). Similarly, girl network structures that are characterized by small groups and dense cliques may lead to gender differences in inter- and intra-organizational network structures.

The impact of the effect of gender differences in network structures on individual socio-economic status attainment cannot be overemphasized because it influences a woman's chances in life. More to the point, if gendered adult networks that embed women in a disadvantaged position for their status attainment stem mostly from their earlier networks, it is important examine more closely not only some of the important features of gendered network structures among school children or early adolescents (Smith-Lovin & McPherson 1993), but also their dynamic and evolutionary nature through time. In the following chapter, I review both quantitative and qualitative literatures about social networks among

school children and early adolescent to show how a homogenous all-girls social network can be regarded as a type of “gendered social networks.”

2 Chapter II: Review of Literature

Both quantitative and qualitative researches have documented the importance of gender in structuring the social networks of children and early adolescents. Research on the effect of gender on the structuring networks of school children can be categorized by four characteristics of (1) homophily in friendship relations, (2) size of friendship groups, (3) structure of internal peer groups, and (4) gender-stratified peer cultures. In the following section, I will review literature about gender differences in friendship relations among school children and early adolescents in the United States.

2.1 Homophily in Friendship Relations

There has been general agreement among researchers concerning children's preference for same-sex friends. For instance, homophily by gender in children's playmate patterns has been observed (Lever 1978; Thorne 1994). Other research findings also show that gender is a powerful predictor of close friendships among children in elementary classroom. For instance, Hallinan and Smith (1985) report that sixteen percent of the best-friend choices of boys and twelve percent of those of girls were cross-gender in classrooms for fourth through seventh grades. They conclude that gender has a greater effect of creating cleavage in the elementary classroom than race does.

However, some researchers point out that segregation of male and female friendships is contingent on developmental factors. For instance, Epstein (1983) considered the effect of age on the interaction patterns by assuming that as youngsters mature, "males and females increasingly acknowledge their proximity where they previously ignored each other" (p.47). Her longitudinal data from 5th to 12th grades report that there is a positive correlation between the number of cross-sex friendship choices and grade level although the majority of best friends are within the same sex and this positive correlation came mainly from an increase in girls' selecting boys as best friends (p.46).

Contrary to these findings, Lockheed (1986) found that although increased cross-sex interactions had an effect on male preferences for cross-sex work groups, it had no effect on female counterparts by examining the effect of teacher intervention on cross-sex work preferences in 4th and 5th grade classrooms. She attributes one of the possible explanations of the girls' preference for gender segregation to their normative responses, which is consistent with Best's (1983) observation of girls' tendency to make negative statements about cross-sex classmates even though they are otherwise friends (Lockheed 1986, p.627).

Shrum et al (1988) studied grade-related shifts in gender and racial homophily among children in grades 3-12 and found a curvilinear relationship between homophily and grade. They report an increasing trend in racial homophily in contrast to a gradual decreasing trend in gender homophily beginning in middle school onward. Their finding shows that feminine homophily had a striking peak in the entry into middle school (the largest value in grade 7 for white girls) and remained at higher values throughout the reminder of the school year.

Similarly, Graham et al (1998) conducted a longitudinal investigation of the effect of race and gender on children's friendship choices by using the same group of children with grade 1, 2, and 3 at the first time point and then grade 4, 5, and 6 at the second time point. They report that gender has stronger association with mutual friendships than race has, and an increasing preference toward same gender and race peers as children get older. They point out the importance of race when children consider same-sex friends and found that African American males and Caucasian females showed same-race preferences for same-gender peers. They also found the number of mutual friendships in terms of both gender and race generally increased with age.

The importance of the combination of organization of school environment and developmental factors was reported by Signorella et al (1996). They examined the effect of classroom setting (single-sex or mixed-sex) on girls' perceptions on stereotyping gender roles. Their longitudinal data from grades 2 through 12 showed that stereotyping declined with age in both types of classrooms. In addition to this, they found a decrease in stereotyping over time among younger girls in mix-sex classes (p.606).

These research results imply not only that children's friendship relationship is homophilious but also that preference for same-sex friendship is stronger for girls even though the degree of homophily changes across the grade and environmental factors. Dweck (1981) points out gender differences in the perception of norms against friendship relations with opposite sex. According to her, girls in the preschool years become "interested in prosocial behavior- in complying with and propagating social regulations" (p.326, cited by Karweit & Hansell 1983, p.116). On the other hand, since boys are not interested in this behavior, she argues, they tend not to comply with rules, which result in girls' rejection of friendship relations.

In summary, the effect of gender homophily on children's friendship relation is quite important although the degree of gender homophily would depend on other developmental, environmental, and structural variables. Fararo and Sunshine (1964) report measured homophily biases were about 0.96 for boys and 0.93 for girls in a junior high school[13] by calculating the ratio of making same-sex friendship choice to the total choices. In addition, Leenders (1996) reports that gender similarity among 4th though 7th grade students strongly increases the inclination of making and retaining a best friendship choice. He employed a continuous time Markov model to study change in social ties and incorporated a homophily effect into this Markovian framework. He reports the ratio of the inclination of a choice of a same-gender friend to the inclination of a friendship choice to an actor of a different gender is 6.7 to 1 indicating that best friend choices among same-gender students are much more popular than cross gender best friendships.

2.2 Size of Friendship Groups

Studies have demonstrated the tendency for girls to have smaller friendship cliques than do boys. For instance, Lever (1978) observed sex differences in the size of playgroups among 5th grade children. She found that boys' play required a large number of participants which imply social organization, but

[13] The population of his analysis comes from lower-income families in which over 98 percent of them are African-American at the Madison Junior High School in 1963, New York.

girls' activities occurred in small groups such as "tag, hopscotch, or jumprope, which can be played properly with as few as two or three participants and seldom involve more than five or six"[14] (p.478).

Eder and Hallinan (1978) also examined the sex differences in the interaction patterns of children aged nine through twelve, which result in the different size of groups by gender. By comparing the frequency of certain exclusive[15] and nonexclusive triad types, they found that girls' same-sex dyadic friendships were more exclusive than boys' counterparts. Added to this finding, they compared the patterns of triadic movement at six points in time throughout the school year and found that girls tended to resist intrusion on a mutual best friend over time, whereas boys tended to quickly expand a mutual best friend dyad to include a third person (p.246). Based upon the finding of sex differences in the degree of exclusiveness of children's dyadic friendship, they argue that once the gendered friendships are formed, they promote interaction patterns whereby girls' same-sex dyadic friendship tends to remain exclusive over the school year while the boys' same-sex dyadic friendships expanded to include newcomers.

The transitivity model frequently has been used for the explanation of sex-differentiated tendencies toward friendliness and implication of emergence of cliques. Transitive sentiment relationships are expressed that for any ABC in a triad, if A likes B and B likes C, A likes C (Festinger 1957). Hallinan and Kubitschek (1988) view intransitivity as a characteristic of an individual in a triad by shifting conceptually from viewing it as a property of a triad. By assuming that "an intransitive relationship causes cognitive or psychological distress in the person experiencing the intransitivity," (p.82) they examined the effects of characteristics of individuals experiencing the intransitivity as well as structural properties of dyadic and triadic ties on the tolerance for psychological distress. In so doing, they examined the way in which intransitivity is resolved. According to them, there are three ways to resolve the intransitivity in the triplets ABC that are intransitive from A's perspective at time t: that is, A chose B as a best friend and B chose C as a best friend, but A did not choose C as best friend. The

[14] By viewing children's play as the activity of socialization, Lever points out the possible effect of sex difference in the group sizes on the development of gender-specific social skills, which may affect children's later lives.
[15] Eder and Hallinan (1978) defined exclusive dyadic friendships as those in which dyad members fail to include third persons as friends.

dependent variable in their analysis is how A's friendship choice at the next time point (t+1) by specifying specific changes that A can make: that is, A may add the friendship choice of C, A may delete the friendship choice of B, or A may do both. They found that homogeneity of members of the dyads with respect to gender in the triplet affected a tolerance for intransitivity among 4th through 7th grade schoolchildren. More specifically, when A and B are of the same sex, A is less likely to remove the intransitivity than when A and B are not of the same sex. On the other hand, when A and C are of the same sex or the same race, A is more likely to remove the intransitivity[16] (p.88).

Hallinan and Kubitschek (1990) further examined the effects of sex heterogeneity in a triplet ABC on resolving intransitive friendships among 4th to 6th grade schoolchildren. They found that when A is of a different sex from B and C, A is more likely to resolve intransitivity by deleting a cross-sex choice of B than by adding a cross-sex choice of C (p.259). This result implies that gender serves as a barrier to the expansion of social networks. More importantly, they report that when B is of a different gender from A and C, girls are more likely to drop the choice of a boy B than to choose a girl C, which imply that "girls perceive gender differences to be a greater barrier to friendship than do boys" (p.259). In this way, they point out the exclusive nature of girls' interpersonal relations by their tendency to prefer to decrease the number of their friends rather than expanding their social networks[17] (p.261).

These research findings show us that gender predicts the emergence of small cliques for girls and the emergence of larger cliques for boys. However, some researchers have pointed out the effect of classroom settings on gender difference in the size of peer groups. For instance, Eder and Hallinan (1978) found different interaction pattern in open classrooms and report that girls' tendency to have more exclusive dyadic friendships[18] than boys was *least* strong in open classroom. It is not clear whether gender differences in the size of groups persist into adolescence. Some research findings show no significant gender difference in friendship cliques for high school students (Hansell 1981). Fararo and

[16] They also observed less effect of racial homogeneity of members of the dyads in the triplet on children's tolerance for intransitivity.
[17] Hallinan and Kubitschek (1990) report that this tendency is stronger for white girls than black girls.
[18] Eder and Hallinan (1978) define exclusive dyadic friendships as "those in which dyad members fail to include third persons as friends" (p.237).

Sunshine (1964) also found that there was little difference between the structure of subnetworks of boys and that of girls among African-American low-class junior high school students. Their study uses the structure statistics of the network such as sibling bias and double-role bias. They define sibling bias as the probability that y selects x, given that some z selects both x and y, and found that sibling bias for males is 0.33 and that for females is 0.27. In addition, they define double-role bias as the probability that y selects x, given that some z selects both x and y and that x selects y, and report that double-role bias for males is 0.73 and that of females is 0.70. Again, these research results remind us of the importance of considering the effect of other factors such as race, class, ethnicity, as well as other organizational and developmental factors, on structuring social networks.

2.3 Structure of Internal Peer Groups

A frequent claim is that boys' network structure is more hierarchical while the girls' counterpart is horizontal. For instance, Lever's (1978) observation of children's play showed that girls' play was interdependent in a cooperative context and boys' play was team affiliated in a competitive context. Other scholars examined a gender difference in the extent of reciprocity of friendship choice. Ray et al (1995) report that girls in elementary school are more likely to reciprocate best-friend relationship in the non-school setting than boys are. They attributed this finding to girls' preference for playing in smaller dyadic groups. Coleman (1961) also found that the extent of reciprocity in friendship ties within peer groups was greater for female adolescent than for male adolescents. Fararo and Sunshine (1964) also report a slightly higher reciprocity bias for females than for males.

Going beyond the examination of friendship reciprocity, other researchers have taken into account the bases of friendship selection by examining the way friendship choice interacted with status that was determined by popularity. By viewing status differences as barriers to children's friendship relations, Hallinan and Kubitschek (1990) examined the effect of the relative status of the members of an intransitive triplet ABC measured by relative popularity on the way in which intransitivity was solved. They found that among white males, if A is more popular than C, A is most likely to resolve intransitivity

by withdrawing an existing choice of a friend, B, rather than by choosing as friend a peer C who is less popular than himself (p.260-261). Therefore, they conclude that white males are more status conscious, which is consistent with the assertion that since white males have the highest social status in terms of ascribed characteristics of gender and race, their highest status in the classroom acts as a barrier to friendship choices (p.261). Another interesting finding is that members of the most popular white boy groups are less exclusive than others because they are "secure enough in their status to risk friendships with others" (p.261). These findings suggest that male network structure is more hierarchical but more inclusive as a whole network compared with female counterpart.

Karweit and Hansell (1983) further examined the gender difference in the effect of status characteristics on grounding friendship selection among high school students. They hypothesize that if status characteristics are a more important dimension of male friendship selection than female counterpart, the ranked-clusters model of Davis and Leinhardt (1972) delineates more accurately for male friendships than for female counterparts. By counting the number of unreciprocated choices made from lower to higher status peers, they found that males were more likely to choose up the status hierarchy than did females (p.127). Based on their findings, Karweit and Hansell speculate that "male networks are generally more elaborated in the vertical status dimension, whereas female networks are more completely developed in the horizontal, affiliative dimension" (p.128).

In partial summary, among researchers, it has been generally agreed that male social networks are characterized as hierarchical and inclusive in large networks with loosely coupled cliques. On the other hand, female social networks are characterized as cooperative based on egalitarianism in small groups with high density. These gender differences imply that males and females live in different cultures that help generate gendered patterns of social interaction.

However, some ethnographical studies hardly support these gender differences in internal network structures. For instance, Thorne (1994) asserts that viewing boys' and girls' groups as hierarchy versus connection exaggerates gender difference and therefore neglects within-gender variation, which might be determined by other factors such as social class and ethnicity. In addition, other ethnographical

studies have found hierarchical group systems for both boys and girls. For instance, Cannan (1987) reports that cliques were composed of 'three-tired ranking system' differentiated by appearance and demeanor for both boys and girls in the middle and high schools[19]. She observed that top-group girls were determined by their visibility and they employed gossip to "acknowledge their coolness and their superiority over girls in other groups" (p.394).

Eder (1985) also examined the relationship between status and friendship for girls in their middle school years and found the system of social stratification among them. Inconsistent with Karweit and Hansell's (1983) finding of female friendships as being developed in the horizontal, affiliative dimension, Eder found stable hierarchy of cliques in which "friendships with popular girls are an important source of peer status" (p.160) by proposing the notion of 'cycle of popularity' among white middle- and working-class girls from sixth to eighth grade. Eder's concept of 'cycle of popularity' states that at first popular girls are liked by less popular girls because "friendships with popular girls are important avenues for girls' status" (p.163). However, since popular girls are concerned about their friends' reactions to their friendship relations with less popular girls, they avoid associating with less popular girls by ignoring them to maintain their higher status. Since less popular girls are rejected, they feel that popular girls are stuck up and come to dislike them. This negative stereotype of popular girls impedes the development of positive friendship relations among female peer groups.

In addition, Adler et al (1992) also found that there was 'cycle of popularity' for elementary school girls. They observed that many less popular girls did not like the more popular girls even though they acknowledged that these girls were popular. These qualitative researchers observe cultural practices at the level of everyday interaction by examining the processes of structuring the gendered nature of social networks. These inconsistent quantitative and qualitative results concerning gendered friendship patterns and their dynamic nature across grades suggest to us the complexity of social system of gendered networks. Qualitative feminist researchers seems to better capture process and individual agency by examining how gender differences in values or interactional norms are created and reinforced so as to

[19] Cannon also found that ranked clique system became more flexible in high school.

structure gendered nature of networks. The following is a literature review of qualitative research on cultural analysis of the effect of gender on structuring social networks.

2.4 Gender Stratified Peer Cultures

Corsaro and Eder (1990) define 'peer culture' as a "a stable set of activities or routines, artifacts, values, and concerns that children produce and share in interaction with peers" (p.197). By employing an interpretive approach, they view children as active participants in everyday cultural routines by sharing appropriate information from adult worlds and discovering a world endowed with meaning to creatively produce their own unique peer cultures. Since children themselves are creating their own peer cultures through active participation, peer friendship relations are central elements of peer culture and therefore the most striking aspect of school life for most students.

Similarly, Adler et al (1992) report that elementary schools are powerful sites where children create their own interactional norms by constructing culturally patterned gender relations, which result in the creation of gender-stratified peer cultures where "boys and girls produce differential 'symbolic identity systems'" (Wexler 1988, in Adler, et al 1992). In order to congregate the cultural norms of appropriate gender identity constructed by elementary school children, Adler et al examined the cultural norms of appropriate gender identity that constitute the determinants of popularity for school boys and girls. They found that boys' popularity factors that determine the rank in the status hierarchy are composed of athletic ability, coolness, toughness, savoir-faire, cross-gender relations, and academic performance. On the other hand, girls' popularity factors are composed of family background, physical appearance, social development expressed by precocity and academic performance. They argue that these gender differences in cultural factors that determine children's popularity and their rank in the status hierarchy have an effect on gender socialization. By being guided by gender-appropriate models of masculinity and femininity in gender-role system, boys actively participate in the creation of the 'cult of masculinity and coolness' (p.184) and for girls the "culture of compliance and conformity which denote their passive adherence to the normative order" (p.184).

Adler et al's findings indicate that gender-stratified peer culture socializes girls to be attracted to the 'culture of romance' (Holland & Eisenhart 1983), by which girls learn to be bestowed with their high status by sharing popular boys' prestige and status at the earlier age. This finding suggests that since peer culture is stratified by gender, popularity that determines girls' rank in the status hierarchy is also determined by their social relations with boys but not vice versa. In this way, Adler et al's work showed that culturally determined gender-appropriate models of masculinity and femininity guide both boys and girls in elementary schools distinct patterns of peer relations that are determined by distinct popularity factors within each peer culture for boys and girls.

Eder's (1995) ethnographical study showed the influences of both institutional practices and language practices that reflect the nature of gender inequality, on gendered nature of interactional pattern at middle schools. She argues that institutional practices such as male athletics and cheerleading play an important role in conveying gender messages regarding masculinity and femininity. By viewing students' daily language practices as an active force in creating their own gender meanings, she argues that adolescents collectively create or maintain their own cultural beliefs regarding gender and sexuality. Since students are quite concerned with gaining peer recognition and avoiding peer rejection, it is within this construction of notions of cultural belief in masculinity and femininity that yet another hierarchy of gender inequality emerges. Therefore, Eder calls for school policy that serves as reducing the extent of social ranking within middle school.

In the similar line of argument, Eder and Parker (1987) has shown the importance of school activities on the formation of gender difference in peer cultures in middle schools. They explored the connections among structured activities, peer status, and peer culture by examining the effect of cultural significance of school-sponsored extracurricular activities on the promotion of gender differences in values and social behavior which are in line with traditional gender roles. They found that the cultural significance of female activities of cheerleading promoted values of appearance and a bubbly personality conveyed through a smile and male athletic activities promoted values of aggressiveness and personal toughness. They argue that extracurricular activities encourage males and females to develop different

values and behaviors by pointing out how middle schools play an important role in reproducing gender differences in interaction styles among peers.

Given that there exists the hierarchy of gender inequality that is governed by cultural beliefs about traditional gender roles in middle schools, it is plausible to assume that adolescent concern and values also differ by gender and therefore, their friendship relationship is shaped by hierarchy of gender inequality. Eder and Sanford (1986) examined the nature of adolescent interactional norm in everyday peer activities in order to understand the components of adolescent culture through participant observation in middle schools. Their findings show that values and concerns of adolescent girls are composed mainly of social status based on value of egalitarian relationship with their peers, appearance that is expressed by clothing and make-up, and interpersonal relationships with boys and other girls.

In short, these ethnographic studies show us that the significant effect of gender on processes of structuring and maintaining social networks would be intermediated by cultural factors such as gender stratified peer cultures that are governed by interactional norms. Rich qualitative feminist research findings on gender stratified peer cultures offer insight into individual mindset and behavior because of its focus on individual agency. In this way, quantitative feminist findings are quite useful in thinking how a homogenous social network in regard to the gender dimension can be regarded as a type of "gendered social network."

The current study explores the evolution of social networks by focusing on girl-to-girl friendships, paying little attention to the environmental impact of girl-to-boy friendships on the girl-to-girl network. The reason for this is somewhat indirect. Acknowledging that being popular with "the boys" enhances a girl's status among their peers (Coleman 1961), this enhancement is conditional on the norms concerning relationship with boys shared by the girls network. As Eder and Sanford (1986) observed, adolescent girls engage in direct discussion to communicate their norms and expectations about appropriate male-female behavior. For example, if a girl violates the norm of sexuality (such as wearing overly-sexy clothing to attract boys) and thus become popular among the boys, this does not necessarily enhance her status among her peers because of the violation of appropriate male-female behavior. Furthermore, girls

have an increasing concern with the quality of their friends such as their beliefs and values, and intimacy in terms of sharing one's thoughts and feelings with close friends is the central feature of adolescent girls' friendship (Savin-Williams & Berndt 1990; Brown et al 1999).

Research also indicates stronger tendency for early adolescent girls to interact primarily with members of the same sex (Hallinan 1979; Eder & Sanford 1986; Epstein 1983; Bjorkqvist, et al 1994; Brown et al 1999). For instance, Shrum et al (1988) report that feminine homophily had a striking peak in the entry into middle school (the largest value is grade 7 for white girls) and remained higher values throughout the reminder of the school year. For this reason, the current study will emphasize girl-to-girl relations to explore the evolution of adolescent-girl networks by employing feminist perspectives to explain relational patterns among adolescent girls.

The challenge of this study is how to integrate qualitative feminist findings into the quantitative analysis of gendered network structures to understand the effect of "doing gender" on the underlying process of network changes through time, as well as to fill in the discrepancy in findings reported by qualitative and quantitative research. In the following section, I will address this issue.

3 Chapter III: Theory

The intellectual domain that this research concerns is the intersection of formal network models and models based on Feminist Theory (FT). This centers on using both some elements of Rational Choice Theory (RCT) and FT inside Social Network framework. It is apparent that Rational Choice Model (RCM) and Feminist Model (FM) are divorced literatures, and one of the main reasons for this stems from differences in their epistemologies.

Feminist epistemology is distinct from epistemology in RCT by its assumptions of rationality, abstraction, and individuation. Feminist epistemology is grounded in an ontology that conceives of realities, which are socially constructed differently by those who occupy different social locations and therefore have different living experiences[20]. This alternative feminist epistemology is often called the feminist standpoint, and it criticizes masculinist social sciences by claiming that "social scientific knowledge represents the world from a standpoint in the relations of ruling, not from the standpoint of those who are ruled" (Smith 1996, p.47). This feminist standpoint epistemology is the core of feminist methodology, and leads to methodological differences between RCT and FT.

Most feminist scholars tend to take an inductive approach by generating concepts and theory in the research field with the aim of obtaining information about women's lived experiences and true consciousness. This approach is usually employed by feminist empiricists to give a voice to the oppressed in such a way as not to impose definitions of reality on them. By giving a voice to women, feminist scholars believe that feminist methods allow them to obtain more valid data about women's experiences from the perspective of the oppressed.

However, some Marxist feminists have pointed out the limitations of inductive research methods advocated by the feminist empiricists who consider the role of a feminist researcher as giving voice to

[20] This feminist epistemological foundation has lead feminist scholars to substitute women's views of social relationships in systems of oppression for men's counterparts as the basis for knowledge.

women as a means of consciousness raising. Their claim is that giving a voice to women is not enough since women's direct experience has limitations in understanding the "hidden structure of oppression and their hidden relations of oppression" (Gorelick, 1996, p.25). These feminist scholars are concerned with the integration of abstract with concrete through "webs of connections" among people who are situated in particular locations and have partial knowledge about social world (Harraway 1988, pp.587-89, cited in Sprague & Zimmerman 1993, p.270). The particularities of women's experiences in various systems of oppression have instigated feminist scholars to search for a social science that "reveals the commonalities and structured conflicts of the hidden structures of oppression" (Gorelick 1996, p.38).

In addition to the qualitative feminist scholars, quantitative feminist researchers have also advocated the importance of abstract conceptualizations of gendered social structures. For instance, Sprague and Zimmerman (1989) criticize postmodern qualitative feminist approach that rejects abstraction due to its separation from context. Instead, they argue that abstraction is necessary as a tool of understanding the social structure of oppression as a patterned regularity and therefore is fundamental to social research. Quantitative feminists (e.g. Dunn et al 1993, McPherson & Smith-Lovin 1986; McPherson & Smith-Lovin 1982; Smith-Lovin, & McPherson, 1993) who support this abstraction employ traditional social science techniques and assumptions in their explanation of gender inequality in an effort to uncover patterned regularities of the hidden structure of oppression.

I believe that RCT is quite helpful to achieve abstraction in feminist research because "[I]t is through abstraction and analytical accentuation that general social mechanisms are made visible" (Hedström & Swedberg 1998, p.25). Of particular note, Friedman and Diem (1993) argue that RCT is useful to explain the mechanisms of choice within existing structural constraints in the forms of institutional forces (Brinton 1988; Diem 1989; Luker 1984), opportunity cost (Gerson 1985a), and individual preferences (Schelling 1978). Although there are some limitations in its assumptions[21], RCT would still be helpful in uncovering the mechanism of the maintenance and perpetuation of gender

[21] Friedman and Diem (1993) categorize the issues critiqued by feminist scholars about RC assumptions into four categories of the issues of (1) interpersonal comparison of utility, (2) stable and exogenous tastes, (3) the opposition of rationality and emotion, and (4) choice itself.

inequality at the micro level (Friedman & Diem 1993). In addition, RCT is useful to explain the emergence of puzzling social outcomes by the action of purposive actors in a given situation, as illustrated by Schelling's (1978) simulation work that shows an "unraveling" process[22] of residential segregation. Via RCT, as Friedman and Diem (1993) argue, it is worth pursuing the questions of "how gender inequalities structurally originate and how they are maintained," to reveal general theoretical progress.

It seems that some notion of the RCT would provide a means to achieve abstraction in feminist research in order to identify social mechanism of gendered social organization[23]. Hedström and Swedberg (1998) argue that a mechanism-based explanation always refers to causes and consequences of individual action oriented to the behavior of others and thus social science explanations should always include explicit references to them. They also include intentions among the possible causes of individual actions. They link this principle of methodological individualism to the core idea of the mechanism approach. In the following section, I will switch from the RCT terminology to Rational Action Theory (RAT) terminology to make more explicit the underlying generative mechanism that link one state or event to another since individual actions constitute this link in the social sciences (Hedström & Swedberg 1998).

3.1 Rational Action Theory

Raymond Boudon summarizes and proposes an approach with respect to RCT and I will use his proposal in this study. Boudon is on one hand very critical of RCT, but on the other he is supportive of an approach that uses the concept of individual rationality within a methodological individualist framework. I will discuss the three main components of the Rational Action Theory: social mechanism, methodological individualism, and rationality.

[22] Unraveling process means a process of a chain reaction where an action of one person affects the environment, which affects the actions of others. Schelling uses the term "tipping" to describe this phenomenon in his original paper published in 1971.
[23] I define gendered social organization as a social system of gender stratification, gender inequality, etc, which place women at disadvantageous social positions within organizations and society at large.

3.1.1 Social Mechanism, Methodological Individualism, Rationality

Boudon (1998) defines a social mechanism as "the well-articulated set of causes responsible for a given social phenomenon" (p.172). Here, the ultimate causes should be analyzed in terms of the outcome of individual beliefs, decisions, actions, etc., grounded in the principle of individualism. In this methodological individualism paradigm, any social action can be understood (Principle of Understanding), and is caused by strong reasons in the mind of individuals (Principle of Rationality). The RCM is characterized by this notion of rationality[24] within methodological individualism paradigm, and interprets any social phenomenon as the outcome of rational individual actions (Boudon 1998). Because of these features, RCM has a strength in efficiently explaining a host of social phenomena without need of a black box[25] (Boudon 1998, 2001; forthcoming), and therefore are capable of uncovering the social mechanisms underlying some puzzling empirical outcomes (Friedman & Diem 1993).

3.1.2 Limited View of Rationality

Boudon (2001) argues that the RCM is incapable of explaining (collective) beliefs and or actions grounded in beliefs, turning easily to the "irrational" explanation[26]. However, there are RC theorists who try to explain collective beliefs without turning to irrationality explanations, but this is usually just cloaked instrumental rationality. Here, instrumental rationality is labeled as "the procedure aiming at choosing the best means to satisfy a given goal" (Boudon 2001, p.42). For instance, Brustein and his colleague (Brustein 1997; 1998a; 1998b; Ault & Brustein 1998; Brustein & Rirgen 1994) explain who joined the Nazis and why by testing an interest-based theory of political behavior that assumes that individuals are purposeful actors, and hence will support the party that they perceive will maximize their wealth (and thus is goal oriented).

More generally, one of the shortcomings of the RCM comes from its move to reduce all rationality to its instrumental rationality (Boudon 1998; 2001; forthcoming; Ferree 1992). In addition, the

[24] Boudon (2001) acknowledges that it is tautological to define rationality by the notion of strong reasons. However, according to him, it is the only way of removing the discussions as to "what rationality really means." (p.67)

[25] Boudon (2001) points out that rational choice model leads to final explanations in comparison to other models that use concepts such as the "internalization of norms," "socialization," etc. In these models, explanations that leads to further question as to which mechanisms are hidden behind them (p.119)

[26]

specific set of postulates that describe the RCM further restrict the notion of instrumental rationality, and therefore lose explanatory power when confronted with many phenomena. These postulates are consequentialism, egoism, and maximization. According to Boudon (forthcoming) consequentialism postulates the actor's consideration of the consequence of his or her actions when s/he reasons, egoism postulates the actor's concern with the consequence on himself or herself of his or her action, and maximization postulates the actor's calculation of the costs and benefits of alternative lines of action and choose the action with maximum expected utility. These postulates necessarily reduce rationality exclusively to instrumental rationality of a utilitarian nature[27], i.e. "the instrumental rationality when the goal is to satisfy one's interest" (Boudon 2001, p.42).

In this way, the RCM is weak in accounting for social phenomena where normative (collective) beliefs would be explained in non-consequentialist terms (what Boudon (forthcoming) calls "non-consequentialist prescriptive" beliefs), as well as people's considerations of issues that have nothing to do with their own interests (such as opinion behavior). It is necessary to reformulate a model that includes non-instrumental (or alternately non-consequential) form of rationality[28] to better explain social action. For this purpose, Boudon (1998; 2001; forthcoming) proposed Cognitivist Theory of Action (CTA) where, as much as possible, beliefs, actions, and attitudes are treated as being rational.

3.2 Cognitive Theory of Action (CTA)

Boudon's words "cognitive" and "cognitivists" have a meaning different from the meaning they have in "cognitive science" (Boudon 2001, p.44). In his cognitivist model, beliefs, actions, and decisions, etc are assumed to be derived from reasons, and therefore they are meaningful to a social actor in the sense that they are perceived by him or her as grounded on strong reasons (Boudon 1998; 2001; forthcoming). If the reasons are constrained to belong to the utilitarian type, we get RCT within a cognitivist model (Boudon 2001). Boudon (2001) assumes even though an actor cannot identify these

[27] Boudon (2001) clarifies that instrumental rationality is a genus of which utilitarian rationality is a species (p.42). In addition, Boudon (1998) argues rationality is one thing, expected utility another.
[28] Weber (2000) explicitly distinguished instrumental and non-instrumental forms of rationality (Boudon 2001). This will be explored more in the discussion of "axiological rationality."

reasons clearly, s/he has the intuitive impression that beliefs, actions, and decisions are grounded on reasons. In addition, the cognitivist model assumes that the reasons motivating an actor could belong to several types (not being restricted to a utilitarian type), and people's actions are understandable because they are moved by these reasons. The cognitivist model also accounts for a "trans-subjective" dimension of beliefs; that is, "as soon as an actor has the feeling that his (or her) beliefs are grounded on strong reasons, he (and she) has also the feeling that other people should accept these reasons as strong" (Boudon 2001, p.40). In this sense, the CTA is nothing more than the Weberian motto "deutend verstehen[29]," which consist of two postulates: "individual beliefs should be analyzed as meaningful to the actor" and "collective beliefs result from the aggregation of individual beliefs meaningful to the actor" (Boudon 2001, p.122). Within this cognitivist framework, Boudon (forthcoming) focus on two types of rationality in the "cognitive" and "axiological" dimensions, which are based on collective assertive ("X is true, plausible, etc.,") and normative ("X is fair, legitimate, etc") beliefs, respectively.

3.2.1 Cognitive Rationality

In "cognitive" rationality, assertive beliefs produced by cognitive psychology ("X is true, likely, plausible, false, etc.") could be explained as being grounded in reasons perceived by an actor as strong, and thus likely to be considered as strong by other people. In this rationality in "cognitive" dimension, actions are moved by reasons that belong to non-instrumental type, and the actor pursues the aim at determining "whether, to the best of his (or her) knowledge, an idea is acceptable" (p.65), not at maximizing something.

3.2.2 Axiological Rationality

In "axiological" rationality[30], normative beliefs are grounded in the mind of actors on reasons which they perceive as valid and, hence, are likely to be considered valid by others. As in "cognitive" rationality, actions are moved by reasons that belong to non-instrumental (or alternatively, non-

[29] The Weberian "verstehen" (meaning understanding) says that explaining a belief, an action, and an attitude amounts to finding out the reasons as to why social actor endorses and undertakes them (Boudon 2001).
[30] Boudon (forthcoming) points out that Weber's "axiological rationality" is synonymous with "value rationality."

consequential[31]) type. In this rationality in "axiological" dimension, people have strong reasons to endorse normative statements such as "the observed people believe that X is good, legitimate, fair, unfair, etc.," (Boudon 1998, p.182), which describes the situation where "subjects do not follow any goal, but aim at behaving in a way congruent with principles they consider worth following" (Boudon 2001, p.42).

3.2.3 The Strength of the CTA

The CTA has five main strengths. First, it extends types of rationality by "lifting the restriction that the reasons of social actors should always be of the cost-benefit type" (Boudon 2001, p.120). In other words, it accounts for actions grounded in beliefs, where reasons by which people's actions are moved are non-instrumental or non-consequential (such as moral commitment and self identity-affirmation).

Second, the CTA, whether beliefs are assertive or normative, offers explanations without resorting to black boxes by providing social mechanism of conviction formation. The cognitivist model attributes feelings to the outcome of reasons by explaining "the social subject has normally a feeling of conviction and not of internalization or of constraint" (Boudon 2001, p.123). However, internalized beliefs may also be held with some conviction because they are internalized (e.g., the beliefs held by fundamentalists in any religion), and not be explicitly "felt" as internalized.

Third, the CTA accounts for public nature of reasons by introducing a "trans-subjective" dimension of beliefs; beliefs that are grounded in the mind of actors on reasons which they perceive as strong and thus are likely to be considered strong by others. In the cognitivist model, reasons are not private since actors do not see their beliefs as preferences (Boudon 2001). Therefore, the cognitivist model also provides a social mechanism of collective feelings of conviction within a framework of methodological individualism, which "appears as definitely and clearly immunized against the objection of atomism" (Boudon 2001, p.141).

Fourth, cognitivist model provides an idea of "cognitive context" (Boudon forthcoming) where strength of reason is a function of the context. In contextual-rational paradigm, a system of reasons is

[31] Boudon (1998) notes that these nonconsequential reasons are the core of Weber's notion of "axiological rationality," which have nothing to do with affective motivations and should be distinguished from "values."

more easily evoked in one context than in another one (Boudon forthcoming). In addition, this notion of contexutality of reasons implies that preferences are the result of "cognitive context," and depend on availability of knowledge in the mind of actors based on which actors look for a satisfactory system of reasons (Boudon forthcoming). In this way, the cognitivist model provides a more realistic view of preferences, being different from the assumption of stable and exogenous preferences[32] in the RCM.

Lastly, cognitivist model accounts for the validity of reasons by using comparative notion of rationality. More specifically, cognitivist model allows us to explain "a system of reasons can be stronger or weaker than another" (Boudon forthcoming, p.24) in a relative sense[33] because we have strong reasons for considering it as such. For instance, a system of reasons evoked by instrumental rationality can be stronger than a system of reasons evoked by axiological rationality, or vice versa. This implies that the CTA is capable of combining axiological rationality with instrumental rationality in social action as Weber asserts (Boudon forthcoming).

In a nutshell, the CTA inherits the strength of RCM in that it provides final explanation with a framework of methodological individualism paradigm, and therefore identifies social mechanisms underlying social phenomena. At the same time, the CTA expands its applicability by accounting for other forms of rationality by considering other types of reasons (i.e. "axiological" or "cognitive"). However, cognitivist "axiological" rationality does not explicitly address the issue of emotion[34] although Boudon (forthcoming) acknowledges that "Reason is the servant of passions" (p.26).

Feminist scholars, on the contrary, are concerned with integrating experience, knowledge and emotion[35] by positing that people acquire their own perspectives and learn either to challenge or to respect the definition of value provided by the hegemonic order from direct emotional experiences such as anger

[32] Friedman and Diem (1993) assert that the stable and exogenous assumptions of tastes are simplifying assumptions because no adequate theory of preference formation exists in RCT literature.
[33] Boudon (forthcoming) asserts that there are no general criteria of rationality to decide a system of reasons is stronger than another. According to him, we consider one theory truer than another "from the moment when we find hard to imagine a theory which would be better" (p.24).
[34] Weber asserts that an "axiological" reason to endorse normative statements ("X is good, legitimate, etc.") has nothing to do with affective motivations (Boudon forthcoming).
[35] Ferree (1992) points out that the reason why resource mobilization theory seems to have difficulty in dealing with the women's movements would be the attempt to integrate reason and emotion, both in theory and in the practices of organizing (p.43).

or joy (Ferree 1992, p.43). In the following section, I will develop general FT to construct a less reductionist and more empirically useful theory of rational action.

3.3 Feminist Theory

Feminist scholars provide quite different model of the self from that of the rational choice counterpart due to their different view of human nature and social relationships. This section will show what the FM entails in terms of four components of (1) a connective model of the self, (2) substantive view of rationality, (3) multidimensional self, and (4) deconstruction between reason and emotion.

3.3.1 A Connective Model of the Self

Feminist scholars (England 1989; Folbre & Hartmann 1988; Hartsock 1983; Gilligan 1982; Ferree 1992) view human nature as connected and human relationships as social, assuming "our first and most fundamental human relationships are those of trust and dependence as infants" (Ferree 1992, p.36). These feminist assumptions are hardly compatible with a separative model of the self in RCT that assumes human natures as abstract individuals and human relationship as asocial (Friedman & Diem 1993). Feminist scholars (England 1989; England & Kilbourn 1990) argue that the separative model excludes women from consideration because the "view of the self that has predominated is one that glorifies individuation, and assumes a lack of emotional connection between self and other" (Friedman & Diem 1993). Instead, they proposed a connective model of the self that postulates contextualized view of individuals and considers other forms of subjective and emotional experiences as a result of being structurally located, rather than "universalizing experience and perspective of white, Western, middle-class men" (Ferree 1992, p.47).

3.3.2 Substantive View of Rationality

In studies of social movements, Ferree (1992) argues that the RCM of rationality imported into the Resource Mobilization (RM) approach[36] is a Trojan horse, and "threatens the ability of RM to explain

[36] Ferree (1992) explains that RM approach asserts that social movement activities are not disorganized and participants are not irrational, which are seen as rebuttals of the classical collective behavior model. The advantage of RM approach is to look at material resources they command rather than the social psychology of their participants.

what social movements are and do" (p.30). She argues that RCM presents a decontextualized view of individuals and offers one-dimensional view of rationality, failing to recognize ambivalence, altruism, and emotional experience invisible and irrelevant. Instead, she suggests for "a broader but more realistic view of rationality" (p.31) where "both self- and other-regarding behaviors are seen as structurally situated" (p.31).

Ferree (1992) relies heavily on socioeconomic literatures (e.g., Etzioni 1988; Hirschman 1986) to introduce meta-rational behavior in the sense of Weber's "value-rationality" as contrasted with instrumental rationality. In the socioeconomic framework, Etzioni (1988) posits the view of human nature as "a concept of individual governed by normative commitments and affective involvements, referred to as N/A (Normative-Affective) factors[37]"(p.93), breaking out of the rationalist framework. Socioeconomic models define the motivations for behavior as "sources of value other than being better off, no matter how 'better off' is defined" (Ferree 1992, p.33). Here, values act as 'meta-preferences', by which an individual consciously reflect on and deliberately change one's preferences (Hirschman 1986) making efforts to express (or affirm) one's values for its own sake (Ferree 1992).

3.3.3 Multidimensional Self

Ferree (1992) refers to the notion of a multidimensional self (Etzioni 1988) where inner tensions between conflicting desires and commitments can occur. In this substantial view of rationality, she asserts that self-expressive behaviors may be in conflict with the satisfaction of individual self-interest (Taylor 1988) when an individual arrives at reasoned decisions. By proposing a more realistic view of rationality where types of behavior "carry a variety of meanings for the individual actor" (p.32), Ferree criticizes the RC view of a one-dimensional self as those who are motivated only by self-interest[38]. As Gilligan (1982) argues, "a choice between self-interest and altruism as opposite poles of a single scale

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However, according to Ferree, even researchers who see themselves as working within RM framework recognized a problem of the absence of a plausible account of values, grievances, and ideology in the basic model.

[37] Etzioni (1988) argues that the majority of choices people make, including economic ones, are largely based on normative-affective consideration, not merely with regard to selection of goals, but also of means (P.93).

[38] In response to feminist critique, Freedman and Diem (1993) claim that self-interest is not the same as selfishness and it simply means "being cognizant (even vaguely) of one's own values and then using them as a guide for action" (p.94). In addition, they point out that self-interest need not be part and parcel of the separative model of the self.

makes sense only within the individualist value system" (Ferree 1992, p.37). In the feminist connective model of the self, it is more plausible to consider good of self is not separate from that of others. For instance, Ferree (1992) states that "women, working-class people, and disadvantaged racial-ethnic groups may be likely to reject competitive individualism as a feasible value and prefer maintaining viable networks of relationship" (p.37).

3.3.4 Deconstruction between Reason and Emotion

Ferree (1992) criticizes "the false dichotomy imposed on reason and emotion" (p.41) as one historically constructed value central to the rational choice perspective. In the separative model, emotion is divorced from rationality, and often is treated as something that interferes with good decisions (Ferree 1992). Etzioni (1988) points out the importance of affective factors in people's choice making, asserting that most values contain an affective element that serve as the motivational force. According to him, "(t)he relationships between normative values and rationality is in many ways akin to that of affect and rationality" (p.106), and both affect and normative values often play important positive functions, and therefore they are not merely hindrances to reason (p.108). From a feminist perspective, Jaggar (1989) argues that "emotions provide the experiential basis for values. If we had no emotional responses to the world, it is inconceivable that we should ever come to value one state of affairs more highly than another" (p.153, cited by Ferree 1992, p.43). In a connective model where reasoned choice of values is added to rationality, feminists' argument for deconstructing dichotomy between reasons and emotion[39] seems to be more reasonable.

The feminist connective model that postulates contextualized view of individuals where people acquire their own perspectives and learn their own value from emotional experience offers "useful models of the relations among value, knowledge, and social position" (Ferree 1992, p.43). In addition, the feminist substantive view of rationality where good of self is not separate from that of others casts doubt on the usefulness of centralizing free riding on the efforts of others as a problem in RC accounts of mobilization. Ferree (1992) argues that "well-socialized actors are not likely to be insensitive to the costs

[39] Feminist scholars have criticized the separative bias of RCT that is characterized as a "tendency to separate human qualities into oppositionally defined dichotomies" (England & Kilbourne 1990, p.157 in Friedman & Diem p. 99).

their actions imposed on others" (p.38) by rejecting individualized view of both costs and benefits. In this way, FT provides a less reductionist and more realistic theory of action.

Although feminist connective model provides a richer account for rationality, it is less powerful when compared to the RCM due to the side-effects of introducing concepts such as the "internalization of values," "socialization," etc., that "lead to further questions as to which mechanisms are hidden behind them" (Boudon 2001). The cognitivist model is promising because it provides a social mechanism within FT which emphasizes the role emotions play in rational decision making, and allows us to achieve abstract conceptualization within feminist framework.

It is also important to note that both cognitivist and feminist approaches have little say about the structured context within which individual decisions are made. Social Constructionist (SC) perspective would help augmenting feminist idea of contextual frame with structured social context within which communication arises. SC model assumes that communication is the collective creation of meaning and something that "surrounds people and holds their world together" (Trenholm 1995, p.49) where people use cultural tools of symbolic codes[40], cognitive customs[41], cultural traditions, and sets of rules that guide people's actions. In SC perspective, the goal is to achieve social consensus where people choose certain lines of action and follow certain rules, "recognizing the rules of appropriate conduct that allow social groups to operate" (Trenholm 1995, p. 40). Feminist connected model via the SC idea of communication as a means of creating "collective representations of reality" (p.37) would helpful to explain how contextual frames are structured in systematic way. Table 1 shows a summary of assumptions among RCM, cognitivist model, and FM to compare and contrast them.

[40] Symbolic codes refer to the ways people have been taught to process information (Trenholm 1995).
[41] Cognitive customs refer to the beliefs, attitudes, and values that compose cultural traditions (Trenholm 1995).

Table 1: Assumptions for RCM, Cognitivist Model, and FM

Models / Assumptions	RCM	Cognitivist Model	FM
Model of the self	Separative model	"Cognitively" connective model	Connective model
Human nature	Abstract	Abstract	Contextualized
Human relationship	Asocial	Collective	Social
Individuals	Independent	Independent/dependent	Dependent
Type of rationality	Instrumental	Cognitive/Axiological	Substantive
Types of behavior	Consequential	Expressive	Expressive
Motivations	Self-interest	Meanings	Meanings
Emotions	Devalue and treat as irrationality	Treat as different from value	Treat as experiential basis for value
Preferences	Stable and Exogenous	Result of "cognitive context"	Result of contextual frames
Values	Incentives	Normative beliefs	Subjective and emotional experience
Choice	Competitive individualism	Competitive individualism/Altruism	Altruism
Identity expression	Unchangeable	Changeable	Changeable

3.4 Toward Feminist Cognitivist Theory of Action (FCTA)

Creating a 'synthesis' involving RCM, cognitivist model and FM is very difficult considering some of the contradictory assumptions that reside in them individually. Thus, the goal is not to integrate

these theories together into a single universal theory but instead to draw upon them for their most fruitful ideas and contributions. The CTA is a promising way to work within the elements in both the RC and the feminist framework so as to expand intersection between them. The aim in this section is to develop a new terrain of Feminist Cognitivist Theory of Action (FCTA) to contain the elements of both RCM and FM via the CTA.

3.4.1 Cognitively Connective Model of the Self

The RCM uses a separative model of the self and takes views of asocial and abstract individuals. On the other hand, the FM uses a connective model of the self and takes contextualized view of individuals by considering other forms of subjective experiences as a result of being structurally located. A cognitivist model takes both abstract and collective views of individuals by its idea that individuals achieve feelings of conviction that have collective nature within a framework of methodological individualism; i.e., that reasons are not private since actors do not see their beliefs as preferences. The FCTA takes both contextualized view of individuals in feminist connective model in modification with a SC model, and cognitivist notion of collective feelings of conviction within a framework of methodological individualism. Here, individuals are assumed to be connected between self and other through communications to create collective ideas of themselves and share subjective and emotional experiences, each of who trans-subjectively (and hence collectively) achieves feeling of conviction in his or her own mind.

3.4.2 Cognitivist Substantive Rationality

The RCM considers instrumental rationality of a utilitarian nature where individuals are motivated by self-interest. On the other hand, the FM is concerned with rationality in the substantive dimension, where people are motivated by meanings to express their own values for their own sake. Here, emotions are assumed to provide experiential basis for values rather than being devalued[42] or treated as irrationality. Cognitivist rationality agrees more in the direction of feminist side, providing both "cognitive" and "axiological" dimensions of rationality that deal with actions grounded on beliefs where

[42] Feminist scholars (England & Kilbourne 1990) criticize that in RCT separate reason from emotion since emotions are subsumed under tastes which are assumed to be exogenous (Freeman & Diem 1993)

reasons are not consequential. Cognitivist rationality takes both advantages of the FM and the RCM -- expanding a view of rationality while providing final explanation of social mechanism. More specifically, cognitivist rationality provides social mechanisms of conviction formation to explain non-consequential behaviors that are meaningful to a social actor. A FCTA adds this advantage in cognitivist modeling to the feminist view of substantive rationality. Assuming that individuals acquire their own perspectives and learn their own value from emotional experience, they engage in expressive (or identity-affirming) behaviors because they have strong "axiological" reasons of doing so, and hence they have a feeling of conviction.

3.4.3 Contextual Cognitive Frames

The RCM assumes individual preferences are stable and exogenous[43]. Conversely, the FM assumes that preferences are changeable because it is "the result of contextual frames by which the outcomes are interpreted" (Ferree 1992, p.35). However, Freeman and Diem (1993) cast doubt on feminist argument for changing preference by pointing out that "What may appear to be changes in tastes may appear so because the objects chosen to satisfy those preferences vary according to availability of knowledge rather than as a result of changes in underlying preferences (p.98)." Cognitivist model assumes that preferences are the result of "cognitive context" where strength of reason is a function of the context and depend on availability of knowledge in the mind of actors. A FCTA combines feminist with cognitivist arguments for changing preferences and assumes that preferences may change at the individual "cognitive" level as the result of contextual frames in which choices are perceived through communication.

3.4.4 Comparative Rationality within Multidimensional Self

Boudon (2001) argues that "the essence of utilitarian theories of norms and values[44] consists in attributing to the social actor a capacity of calculating rationally the best means to satisfy his preferences" (Boudon 2001, p.43). On the other hand, FM assumes that values act as 'meta-preferences', by which an

[43] Freeman and Diem (1993) argue that many RC theorists adopt the simplifying assumptions of stable and exogenous preferences because no adequate theory of preference formation exists.
[44] Ferree (1992) argues that "when values enter RCM of social movements, they do so as 'non–material incentives'" (p.34).

individual consciously reflect on and deliberately change one's preferences. Here, individual identities are viewed as changing, striving to express one's value, as opposed to unchangeable identity assumed by the RCM. Since the FM assumes a multidimensional self, self-expressive behaviors may be in conflict with the satisfaction of individual self-interest. Under this situation, individuals' choice of the value of altruism is not totally divorced from that of competitive individualism. The cognitivist model also assumes relative strengths of a system of reasons, hence implies the possibility of combining one type of rationality with another in social action by providing mechanism of conviction formation when people arrive at reasoned decisions.

A FCTA takes both the feminist notion of multidimensional self and the cognitivist view of relative strength of a system of reasons. Rephrasing Ferree's statement that "women, . . . may be likely to reject competitive individualism as a feasible value and prefer maintaining viable networks of relationship" (p.37), within feminist cognitivist framework, I would say that women, having multidimensional self, have strong reasons to endorse value statements that "maintaining viable networks of relationships is good" and "pursuing competitive individualism is bad." Hence, they consciously reflect on or deliberately change their preferences by making decision in such a way that their normative belief of altruism is more reflected in their actions than that of self-interest. The mechanism that women tend to feel more convinced in altruistic behavior than incentive-driven counterpart provides powerful explanation of their tendency to prefer maintaining viable networks of relationship. In the next section, a FCTA as general theory will be applied within a network analytic framework, using some feminist empirical findings about adolescent girls' friendships.

3.5 Evolution of Female Adolescents' Social Network

Within a feminist cognitivist framework, this project seeks to identify the major driving forces through which network structures emerge by systematically exploring the interaction process among American adolescent girls. This research will employ methodology of computer simulation because it is useful to develop and explore theories of social processes. Simulation is also helpful to understand how

the 'macro' properties of social network emerge from the individuals' behaviors at the 'micro' level. Furthermore, since simulation is an experimental methodology, it is possible to explore effects of different parameters by varying the conditions in which simulation model runs (Gilbert & Troitzsch 2002).

The motivation of my simulation stems from some discrepancies between quantitative findings that describe girls networks as horizontally fragmented small groups with high density (Lever 1978; Eder & Hallinan 1978; Hallinan & Kubitschek 1988; Ray et al 1995; Coleman 1961; Karweit & Hansell 1983), and qualitative ethnographic findings that emphasize hierarchically dimensional network structures among girls (Cannan 1987; Eder 1985; Adler et al 1992). The goal of my research is to bridge this divide by identifying the conditions under which certain types of girl-network structures emerge. In my study, modeling American adolescent girls is an instantiation of a general set of theoretical ideas about evolution of social networks where gender is a significant feature in both of the social process and of the resulting network structure.

My research employs some feminist ideas to explain the emergence of gendered relational patterns with the aim of constructing a more inclusive and contextual representation of adolescent girls' friendships and interactions with their peers. There is an agreement among feminist scholars about the lack of research on the contexts of adolescent[45] girl friendships and peer relations focusing on adolescent girls' relationships with other girls (Eder 1985; Brown et al 1999). Especially, comprehensive studies on negative aspects of friendships are lacking as Brown et al (1999) argues that friendships among adolescent girls can be "a source of struggle, hurt, and confusion, particularly as girls move into adolescence and begin to negotiate dominant cultural views of gender relations, femininity, appearance, and sexuality" (p.217). Feminist theories may be helpful in developing theories about the negative aspects involved in adolescent girls' friendship and peer relations, and help explain "why girls become increasingly other-directed and insecure during early adolescence" (Eder 1985, p.155, cited in p.214

[45] My research focuses on *adolescent* girls since adolescence is critically important developmental period for girls when they are increasingly confronted with expectations to conform to female gender roles (Brown et al 1999).

Brown et al 1999). From now on, I will introduce some feminist ideas and empirical findings about friendship relations among adolescence girls.

3.5.1 Feminist Findings of Girls' Friendship Relations

Feminist sociological research focuses on the process of generating the stable system of status ranking among adolescent girls by viewing them being actively participating in creating interactional gender norms in their everyday life. This research views a stable hierarchy of cliques as a result of school-sponsored activities that are governed by dominant culture. Donna Eder's (1985) notion of "Cycle of Popularity" provides the insight into how hierarchical cliques in networks of adolescent girls emerge as a result of their negative feeling in their peer relations.

3.5.1.1 Cycle of Popularity

Eder's (1985) qualitative research examined the relationship between status and friendship for American adolescent girls in their middle school years and found systems of status ranking among white middle- and working-class girls from the sixth to eighth grade. She found stable hierarchies of cliques in which "friendships with popular girls are an important source of peer status" (p.160), and proposed the notion of a "Cycle of Popularity." Eder's "Cycle of Popularity" notion assumes that visible girls are popular and states that at first popular girls are liked by the less popular girls because "friendships with popular girls are important avenues for girls' status" (p.163). However, since popular girls are concerned about their friends' reactions to their friendship relations with the less popular girls, they avoid associating with the less popular girls (by ignoring them) to maintain their higher status. Since the less popular girls are rejected, they feel that popular girls are stuck up and come to dislike them.

3.5.1.2 Norm of Egalitarian Relationships

An adolescent girl's desire to make it to the top of the hierarchy is in conflict with her gender norm. Eder and Sanford (1986) identified the content of emerging interactional norms among American adolescent girls. They found that status norms (one of the major concerns for American adolescent girls) value egalitarian relationships with their peers and disapprove of girls who think they are superior to

others. Eder and Sanford's observation that "on the most basic level, girls expected that all students should have to abide by the same rules and were annoyed when someone violated these rules" (p.287) implies that negative feelings such as anger and distrust toward those who did not comply with this gender norm could occur among adolescent girls.

3.5.1.3 Gender role

Feminist social-psychologists (Basow & Rubin 1999; Brown et al 1999; Brown 1999; Johnson & Roberts 1999; Worell 1999; Brown & Gilligan 1992) focuses on individual's subjectivity by examining the impact of the dominant culture on adolescent girls' development as reflected in their friendships and peer relations. They emphasize the adolescent girl's developing awareness of the female gender role, as well as the negative impact of such awareness on an adolescent girl's development. Gender roles are defined as gender expectations onto which the societal expectations of behaviors that require a more communal orientation to women, and a more agenic orientation to men (Basow & Rubin 1999) are overlaid. Gender expectations are the most salient for adolescent girls who are "increasingly confronted with expectations to conform to female gender role prescriptions" (Basow & Rubin 1999, p.25).

3.5.1.4 Commitments and Competitive Individualism

There is an agreement among feminist scholars that loyalty and trust in terms of self-disclosure with same-sex friends are important in adolescent-girl friendships and peer relations (Brown et al 1999; Savin-Williams & Berndt, 1990; Way 1996). These research results indicate the important role adolescent-girl friendships and peer relations play in "establishing security and forging a healthy defense against being hurt or treated badly, as girls begin to comprehend the wider culture and their place in it" (Brown et al p.216). However, as Duff (1996) suggests, societies that value individualism and competition may undermine trust in the context of girl's close friendships (Brown et al 1999).

Feminist social-psychological research reports that adolescent girls tend to suffer from the conflict between autonomy and connection -- struggling in the conflict between their true feelings and the

gender role expectations[46]. Basow and Rubin (1999) point out the conflict between the societal expectations of independence for the European American, and the dominant female gender role that values the feeling of others more than one's own feelings. They argue that this conflict between autonomy and connection is the source of many negative outcomes, such as a higher incidence of low self-esteem, depression, and restricted achievement strivings, when compared to adolescent boys.

However, research studies indicate that the quality of friendships among adolescent girls is interrelated with race, ethnicity, and social class. For instance, Gallagher and Busch-Rossnagal (1991) report that middle-class girls were more likely to self-disclose beliefs and attitudes to their friends than were a low Socio-Economic Status (SES) counterpart, regardless of race (Brown, et al 1999). Duff (1996) also found differences in quality of close friendship and its meanings, reporting that 95 % of the upper- and middle-class suburban White girls regarded competition as an issue in their friendships, compared with 38 % of poor and working-class urban girls of color (Brown, et al 1999).

According to Brown (1998), the conflict between autonomy and connection is more evident among the middle-class girls who navigate the extremes between the competition for individual success, and solidarity with their friends. Brown et al (1999) suggest that, because they view this ideal as a worthy goal, "middle-class girls' larg[ly] struggle with their place in the dominant culture and their relationship with those who have the authority to judge and protect and secure them a place in the hierarchy" (p.213). This may provide an explanation for the emergence of adolescent girls' peer groupings that are characterized by exclusivity in girls' relationships, in addition to the roles popularity and attractiveness play. Considering the milieu adolescent girls are placed in, where they compete for the top of the hierarchy while at the same time valuing trust and loyalty based on equal relationship in their friendships, an adolescent girl's indirect aggressive behavior toward violators of the gender norm and their betrayal behavior are both understandable.

[46] Brown and Gillman (1992) term this girls' developmental age as "crossroads."

3.5.1.5 Indirect Aggression (Relational aggression)

The social-psychological literature on Developmental Theories reveal stressful peer relations among adolescent girls, which is demonstrated by a large increase in indirect aggression. Research on the Developmental Theory of Aggressive Strategies indicates indirect or relational aggression (Grotpeter & Crik 1996) to be more typical of females[47] than of males (Lagerspetz, et al 1988; Bjorkqvist, et al 1992; Rys & Bear 1997; Bjorkqvist & Pirkko 1992; Bjorkqvist 1994). Here, indirect aggression[48] is conceptualized as social manipulation, and defined as "the aggressor manipulates others to attack the victim, or, by other means, makes use of the social structure in order to harm the target person, without being personally involved in attack" (Bjorkqvist, et al 1992, p.52) by mean of such behaviors as "character defamation (lies, gossip), betrayal of trust (revealing a peer's secret to others), social exclusion by the aggressor, and influencing others to shun the victim" (Rys & Bear 1997, p.88) as an intention to control or hurt others.

Indirectly aggressive acts tend to occur within the same gender among adolescents, and Bjorkqvist and Pirkko (1992) point out that status, dominance, and competition being important mediators of aggression. According to Bjorkqvist and colleagues, girls' earlier maturation and development of social intelligence helps them learn the strategies of harming others by attacking peer's social reputation without risking direct retaliation (Rys & Bear 1997).

There is an agreement among social-psychologists that the pressure of social norms in the society in question reinforces adolescent girls' development of more refined, sophisticated strategies to cover-up one's aggression, through gossiping and other types of indirectly aggressive acts since aggressive behavior is socially undesirable for girls (Bjorkqvist 1994; Bjorkqvist, et al 1992). An adolescent girl's tendency to indirect aggressive behavior is especially notable in middle-class girls, who tend to struggle

[47] For instance, Bjorkqvist, et al (1992) found that females of their samples revealed higher levels of indirect aggression through gossiping at age levels of 11, 15, and 18-year-old Finnish adolescent.

[48] The scales of indirect aggression, developed by Bjorkqvist and colleagues, consist of the following nine items: "gossips," "tells bad or false stories," "becomes friend with another as revenge," "plans secretly to bother the other," "says bad things behind the other's back," "says to others: let's not be with him/her," "tells the other one's secrets to a third person," "writes nasty notes about the other," "tries to get others to dislike the person" (Bjorkqvist, et al 1992, p.55).

with "staying in touch" (as opposed to the "unfeminine" feelings such as anger) and remaining in supportive relationships with one another (Brown 1998; Brown et al 1999).

Eder's ethnographic study implies adolescent girl's indirect aggressive behavior through the observation of enemy attachments directed toward those who betrayed their friendship relations for the sake of increasing their status. Since friendship with popular girls is an important avenue for peer status, a betrayal of the former friend by joining popular group leads many of her old fiends to strongly dislike her (Eder 1985, p.160-1). Thus, once a less popular girl succeed in joining a group of popular girls, she ends up with receiving enemy feelings from her former friends.

However, adolescent girls' response to their friends' betrayal behavior is also interrelated with race, ethnicity, and social class. Research on close friendship among working-class nonwhite adolescents report that girls are more likely to pursue intimacy than boys despite friends' past betrayal behavior (Way 1996). In addition, Duff (1996) report that 81 % of the white upper- and middle-class suburban girls reported jealously as an issue in their close friendships with other girls, compare with 31 % of poor and working-class urban girls of color (Brown, et al 1999). These findings imply that middle-class white girls are more likely to engage in indirect aggression and adjusting their opinions about others in response to others' opinions, compared with working-class girls of color. If middle-class white adolescent girls actively participate in relational aggression in their peer relations, it would be one of the major driving forces in the emergence of a stable status hierarchy in their network.

Observing that girls have a tendency to form small, intimate groups, often "pairs," while for boys to form bigger, less defined groups, Lagerspetz, et al (1988) point out that these are effective social settings for performing indirect aggression, and that the social structure itself may be vulnerable to this kind of manipulation (Bjorkqvist, et al 1992). Thus, the social structure itself encourages such behavior.

It is important to point out the effect of race, ethnicity, and social class on nature and development of adolescent girls' friendships and peer relations that are introduced by sociological and social-psychological theories. As Brown et al (1999) noted,

> When researchers have ventured out of the white suburbs to explore the peer networks and friendships of ethnically and socioeconomically diverse teens, they have detected different patterns of friendships from those commonly found among White, middle-class adolescents. (p.210)

Acknowledging diversity in adolescent girls in terms of race, ethnicity, and social class, the current research explore the evolution of network of *middle-class white adolescent girls* in the United States, leaving the study of other categories of adolescent girls for future study. Purely as a convenience and unless otherwise noted, this study refers to "White Middle-class female adolescents in the United States" as "WM adolescents".

Recapitulating empirical results provide rich understanding on the nature of WM adolescents' friendships and peer relations, especially illuminating negative aspects of their relationships with other girls. It should be safe to assume that WM adolescents embrace mainly three values in their friendship. First, they hold competitive individualism by which they try to make friends with the few popular girls, who already have guaranteed positions in the top group, to increase their own visibility. Second, WM adolescents value egalitarian relationships with their peers and disapprove girls who think they are superior to others, and feel annoyed when someone violated this status norm. Third, WM adolescents value commitment based on loyalty and trust in their friendship, which reflect societal expectations of behaviors that require a more communal orientation to women and more agenic orientation to men. However, research shows that WM adolescents tend to navigate the extremes between the competition for individual success and commitment with their friends. They compete for the top of the hierarchy while valuing loyalty in their friendship. Under this situation, WM adolescents feel enemy attachments toward those who achieved individual success by violating norm of commitment by betraying their friends for the sake of increasing their status. It was also pointed out that the pressure of social norms reinforces WM adolescents' indirect aggressive act, characterized by more refined strategies to cover-up one's aggression though gossiping and other types of indirectly aggressive acts.

3.5.2 Behavioral Assumptions

Based on feminist ideas and above-mentioned empirical findings, I will construct behavioral assumptions to model WM adolescents that are a special case of modeling a rational human being based on the FCTA. I will use Lindenberg's (1992) method of decreasing abstraction, by which a sequence of versions of models becomes more realistic by auxiliary assumptions on cognitive contextuality and multi-dimensional self. As models become more concrete, the model increases face value in terms of its descriptive power at the cost of its analytical power.

3.5.2.1 Definition of Values

I define values as "an overarching criteria people use to make choices," (Etzioni 1988, p.105) which is either personal or social. In addition, most values are assumed to contain an affective element that is "the source of the commitment to the content of the value, the motivational force" (Etzioni 1988, p.105). As an instantiation of this, I presume that the personal value for WM adolescents is the value of competitive individualism, and the social value is the value of egalitarian relationships and the value of group commitment.

3.5.2.2 Evaluative Gossip

Based on the first component of FCTA, I presume that WM adolescents are connected to others by sharing subjective and emotional experiences by interaction[49] and achieve collective feelings of conviction in their minds. To instantiate the "cognitively" connected model of the self, I will use *evaluative gossip* as a way of communication at the aim of achieving social consensus. Eder and Sanford (1986) found that American adolescent girls rely on indirect method of gossip as the means of communicating expectations through which "members of the students' own peer group learned about what was viewed as appropriate and inappropriate behavior through such discussions" (p.287).

Eder and Enke (1991) found that students who were friends often had conversational episodes where opinions about others were shared. They call this *evaluative gossip* by formally defining it as

[49] Wellman (1988) argues that items such as norms emerge in interactions over network ties.

"episodes in which there was a positive or negative evaluation of someone who was not present followed by a response by other student" (p.496), which may involve more than two students. Since the gossip structure described by Eder and Enke involves the acts of support, expansions, and exaggerated affect, it is more likely for actors to agree with a particular piece of gossip if their friend initiates it, and subsequently adjust their behavior in such a way that conforms to expectations. Therefore, I assume that as soon as an WM adolescent has the feeling that her beliefs are grounded on strong reasons, she has also the feeling that other people should accept these reasons as being strong as a result of his or her gossiping.

From the perspective of recipients of evaluative gossip, I assume that their preferences change at the cognitive level as a result of being influenced by structured context through communication in which their choices are perceived. Here, individual preferences are the result of gossiping structure where the strength of reason depends on availability of knowledge in the mind of actors. In this way, evaluative gossip via gossiping structure contributes to achieving collective feelings of conviction about values by shaping others' preferences, which lead to the nature of adolescent girls' friendships and resulting networks.

3.5.2.3 Value of Increasing Visibility

Eder's notion of "Cycle of Popularity" reflects both personal value of competitive individualism and social value of egalitarian relationships and illustrates how instrumental rationality is changed to substantive rationality. Eder argues that at first less popular girls try to make friends with popular girls because they can increase their visibility (and hence popularity) by hanging out with them. However, since popular girls do not want to affiliate with the less popular girls, they ignore the less popular girls to maintain their higher status. When the less popular girls are ignored, and therefore interpreted as being rejected in their friendship offer, they feel that popular girls are stuck up and come to dislike them. Here, girls endorse the personal value of competitive individualism and their actions are based on instrumental rationality of utilitarian type where individuals aim at choosing the best means (i.e. hanging out with

popular girls or avoiding less popular girls) to satisfy their self-interest of increasing (or maintaining) their own visibility.

The first two behavioral assumptions are that WM adolescents *initiate friendship offers based purely on visibility level with the aim of satisfying the self-interest of increasing their visibility, and hence becoming popular. When girls are rejected in their friendship offer, they regard the rejecting person as stuck-up and come to dislike them.* This is the simplest version of Eder's notion of "Cycle of Popularity," which emphasize girls' endorsement of value of increasing status by becoming more visible (at least initially). Here, the feminist idea of empathetic connection to others is not considered because I will use this simplest model as baseline to compare with the more complicated models. In addition, the first assumption does not assume that when WM adolescents are rejected, they are likely to see themselves as inferior, in addition to seeing the others as struck-up. The reason of this is that Eder's does not explicitly talk about girls' tendency to blame themselves in the case of failing to friendship formation; instead, her notion expresses girls' cognitive rationality by blaming others. Therefore, my first behavioral assumption specifies the girls' rationalization to be one that blames the rejecting girls.

3.5.2.4 Value of Egalitarianism

The second behavioral assumption adds to the first assumption of individual self-maximization the idea of weighing courses of action grounded in beliefs by introducing a cognitivist, substantive rationality where WM adolescents are motivated by meanings to express their own values for its own sake. Eder's "Cycle of Popularity" states that when a girl is rejected in her friendship offer by popular girls, she comes to dislike them. Here, a less popular girl underwent the *emotional* experience of being embarrassed by popular girls and her *subjective* experience of seeing herself as inferior, which may provide an experiential basis against competitive individualism in favor of egalitarianism.

Rephrasing in cognitivist terminology, after rejection, less popular WM adolescents have strong reasons to endorse normative statements ("rejecting friendship offer is unfair and violating norm of egalitarian relationship is illegitimate"). Instead, normative belief of egalitarianism becomes grounded in the mind of these girls for reasons that they perceive as valid and have a strong feeling of conviction.

This feeling of conviction is also transmitted to their friends by sharing subjective and emotional experiences through evaluative gossip and achieves *collective* feelings of conviction in their minds. Consequently, WM adolescents engage in expressive behavior of avoiding those who do not conform to the normative belief of egalitarianism and are motivated by meanings to express their own values for its own sake.

The second behavioral assumption adds the feminist idea of altruistic behavior expressed by empathetic connection to others, which reflects feminist empirical findings that early adolescent females in middle school are learning greater empathy for the feeling of others than boys[50] (Eder & Sanford 1986; Evans & Eder 1993). My study implements the influence of evaluative gossip with respect to an observance of value of egalitarianism on other girls' preferences for popular girls in their friendship choice. In other words, the second behavioral assumption assumes that WM adolescents consider not only visibility level but also compliance with the value of egalitarianism, relying on evaluative gossip when they choose target of friendship offer and make decision about friendship offer. It is important to note that under this logic, empathetic behavior is activated for girls who engaged in evaluative gossip, and hence the information propagation mechanism plays an important role here. In addition, individuals are assumed to have bi-dimensional self where individuals' choice of the value of egalitarianism is not totally divorced from the value of competitive individualism. The last behavioral assumption takes the third value of trust and loyalty in WM adolescents' friendship relations into account, and hence assumes individuals as multidimensional self.

3.5.2.5 Value of Group Commitments

The last behavioral assumption concerns with the value of group commitment that is not totally divorced from the value of individualism. Feminist research report that WM adolescents tend to suffer from the conflict between the societal expectations of independence and a female gender role that values the feeling of others more than one's own feelings, navigating the extremes between the competition for

[50] Research on early adolescents in middle schools conducted by Eder and colleagues report that *male* peer groups formed around athletics teach boys to ignore the feelings of others as they pursue their competitive goals (Eder & Parker 1987; Eder & Kinney 1995).

individual success and commitments to their friends. WM adolescents attempt to compete for the top of the hierarchy while at the same time keeping the friendship relations based on trust and loyalty. Under this situation, enemy feelings are more likely to be directed toward those who succeeded in joining popular groups by betraying their friends (and hence violating the norm of commitment) for the sake of increasing their status. Here, betrayed girls experienced the envy feelings, which provide experiential basis for values against individualism.

Rephrasing in cognitivist terminology, I assume that betrayed WM adolescents have strong reasons to endorse normative statements ("succeeding in individual competition by betraying friends is bad and violating the norm of friendship based on loyalty and trust is illegitimate"). Instead, the normative belief of commitments becomes grounded in the mind of actors on reasons that they perceive as valid and they come to embrace enemy feelings toward those violated this norm. Since the dominant culture restricts the "unfeminine" behaviors of anger and direct aggression, an WM adolescent engages in indirect aggressive behavior by excluding the perpetrator from other groups by labeling her as a "betrayer," and by gossiping their enemy feelings about them behind the scenes. The last behavioral assumption adds the WM adolescents' value of group commitment to the first two behavioral assumptions. I assume that WM adolescents *weigh the value of individualisms against the value of commitment when they make decision about friendship.*

Some readers may find the above arguments to be a complicated set of assumptions about motivation and beliefs. However, the theories are complex and thus the arguments are complicated. The mechanisms generating complex behavior may be simple but they might also be complex, and thus this discussion reflects the complexity of outcomes. The plausible mechanisms are explored in the simulations of successive complexity. As I add assumptions, my models focus more and more on individual theory and become greater face value by adding the information about WM adolescents. These more concrete models that are in the direction of individual theory are employed to offer the explanations for some properties of girls network structures at the aggregated level. While I am increasing actor

complexity, my analysis will try to explain the mechanisms of individuals' action by focusing on the resulting network structures. Precise assumptions will be addressed later.

4 Chapter IV: Computer Simulation

Computer Simulation (CS) is a "particular type of modeling" (Gilbert & Troitzsch 1999, p.2) in the form of a computer program used for formalizing social theories at the aim of discovering fundamental micro mechanisms that generate the macro-social structures of interest. Axelrod (1997) describes simulation as "young and rapidly growing filed in the social sciences"(p.22), and points out its strength of applicability in virtually all of the social sciences and the weakness of little identity as a field in its own right.

CS is often used as a method of theory development to study complexities in social world by "doing research" on social theories themselves. Simulation as a methodology of theory development has been emphasized in sociological simulation studies. As illustrations, many expressions of computer simulation can be found in terms of theory. For instance, computer simulation is described as "a methodology of theory building and evaluation" (Hanneman 1988, p.323), "theoretical method to develop ideas" (Fararo & Hummon 1994, p.26), and "a spur to theory construction" (Collins 1988, p.515). All of these descriptions imply that one of the main roles of computer simulation is to understand the theory itself for the advancement of theoretical sociology. The utility of computer simulation as a method of representing dynamic social world goes hand in hand with the development in programming language (such as object oriented languages like C++ and Java) that better represents sociological dynamic theory in the field of computer sciences.

Hummon and Fararo (1995a) also conceive of computational sociology as "an area in which advances in computation are merged with sociological ideas" (p.87), computational development plays an important role in constructing sociological theories and advancement of theoretical sociology. Hummon and Fararo (1995a) propose the incorporation of computation as an additional component of a science in

theory and empirical research, as illustrated the triangle of three components of science (Figure 1, Hummon & Fararo 1990, p.80).

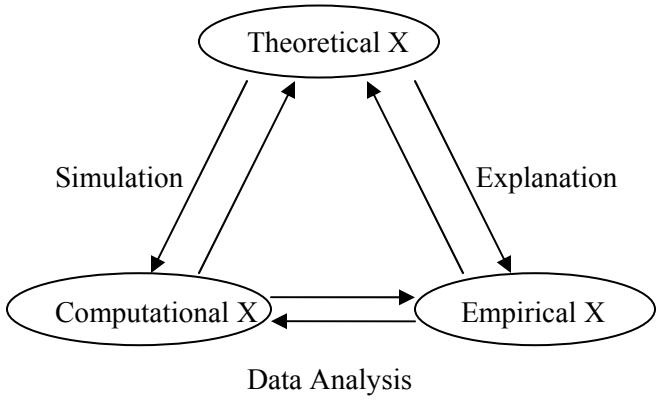

Figure 1: Three Components of Science and Relationship among Them

They pointed out that simulation analysis works as the interplay between theory and computation, through which the research on theories can advance explanatory capabilities of a science with indirect empirical validation and therefore serve as the further development of empirical sociology as well. Before talking about the value of CS as "a new way of conducting scientific research" (Axelrold 1997, p.24), I will discuss some background of the methodology of CS by explaining how CS employs the two standard methods—induction and deduction-- in conducting research, and then consider how it can overcome weaknesses while retaining the strengths inherent in deductive approaches—verbal or mathematical-- to theory formulation.

4.1 Background

Axelrod (1997) discusses the two standard methods of 'induction' and 'deduction' in conducting scientific research. He defines 'induction' as "the discovery of patterns in empirical data" (p.24), and 'deduction' as "involves specifying a set of axioms and proving consequences that can be derive from these assumptions" (p.24). According to him, CS, like 'deduction', starts with a set of assumptions. However, CS does not prove theorems, and instead, it generates data that comes from a specified set of rules in a simulation model, which can be analyzed inductively. In this way, CS takes an inductive

approach to find patterns in simulated data, not data from direct measurement of the real world, and a deductive approach to find consequences of assumptions.

Traditionally, there are two deductive approaches, labeled verbal and mathematical, for doing research on theory about process of complex social systems. The first methodology takes a logical deductive[51] approach in which theories are formulated verbally in terms of rules of logic. The strength of using verbal language in theory formulation is its features of openendedness and multidimensionality, and therefore it is more capable of connecting various realms of argument (Collins 1988). However, the flip side is that these theories tend to be too generalized to specify the conditions under which the proposed relations among concepts hold. In addition, verbal language fails to deal with the technical questions concerning the order of the functional forms (linear or polynomial) and time shapes of the relationships among variables (Hanneman 1988).

The second deductive approach takes a more direct solution that uses formal mathematical language tools such as differential equations or difference equations to study dynamic theory. In this approach, theories are formulated by expressing the relations among concepts in terms of mathematical operators and functions. Although the direct solution approach is capable of avoiding the problem of overgeneralization, mathematical formulations tend to be overly restrictive and therefore too simple to deal with the complex systems of social action and interaction (Hanneman 1988). In this regard, mathematical formulations are less powerful with respect to the applicability to theories about dynamics although they are technically solvable.

Both verbal and mathematical formulations have limitations in representing dynamic theories of complex social systems that contain multiple actors or variables, multiple states and relations over time. Even simple mechanisms have complex consequences when they involve concatenation over time (Fararo & Hummon 1994; Hummon & Fararo 1995a), which can make comprehending the results difficult.

[51] Deduction usually requires specifying a set of axioms and proving the results that can be derived from those assumptions.

As the combination of verbal and mathematical methodologies of theory formulation, CS can overcome the problems of overgeneralization and oversimplification inherent in logical deduction approach and direct solution approach, respectively. By specifying the conditions under which the proposed relations among variables hold, CS is capable of dealing with the problem of overgeneralization by generating the specific historical instances. At the same time, CS retains the strength of logical deductive approach since it allows us to explore multidimensionality in complex theories through the experimentation with simulation models. Gilbert and Troitzsch (1999) regards simulation as being akin to an 'experimental methodology' in a sense that one can explore the effects of different parameters by varying the conditions in which a simulation model runs and then execute it many times.

CS is capable of dealing with the problem of oversimplification in the direct solution approach. Gilbert and Troitzsch (1999) argue that CS is more appropriate for formalizing social science theories than mathematics by pointing out three reasons. First, they argue that computer languages are more expressive and therefore less abstract than most mathematical techniques. Second, they point out that computer programs can deal more easily with parallel processes and processes without well-defined order of actions than systems of mathematical equations. Third, they argue that it is easy to build simulation systems that include heterogeneous agents and therefore allow us to simulate people with different perspectives on their social world, which is usually difficult using mathematics (p.5-6).

I believe that the first and the third features of CS are explicitly compatible with doing feminist research using methodology of CS[52]. In other words, the less abstract feature of CS is promising in addressing feminist criticism of abstraction in RC while keeping the importance of it. The third feature of heterogeneity among actors reflects feminist epistemology that people are structurally located and therefore have different perspectives and experiences. In addition, this also reflects the cognitivist view that individuals may differ in their amount of knowledge in their minds.

[52] For the second features of CS, this seems to be irrelevant unless feminist methodology imply any parallel process of separate making choices.

In summary, a methodology of CS is "a third way of doing research" (Axelrod 1997, p.24), taking both inductive and deductive approach. Induction is used to find patterns in simulated data that is derived from theory-informed assumptions and rules. Deduction is used to find consequences of these assumptions and rules in such a way to avoid overgeneralization by its capability of experimenting with a model by varying conditions. It also prevents from oversimplification by its ability to formalize social theories with less abstraction, to deal with parallel processes, and to contain heterogeneity among actors. These features of CS as a methodology help us addressing the issue of causality in the study of evolution of social networks.

4.2 Algorithmic Causality

Doreian's (2001; 2002) conceptualization of algorithmic causality[53] is promising in understanding generative mechanisms in social network analysis. According to him, algorithmic causality embodies theoretically informed rules for action and interaction in the code of algorithms that is "a sequence of computation steps that transforms inputs to outputs and generates new system states" (Doreian 2001, p.107). Here, substance is coupled with the specification of the rules as sequence of computational steps[54]. For these reasons, algorithmic causality is very flexible because it uses a set of rules and the operation of these rules that generate specific outcomes. Doreian (2001) also notes that algorithmic causality

[53] Doreian (2001; 2002) discusses still other types of causality; that is, system causality, statistical causality, and mechanism causality. According to him, in terms of system causality "a social system can be expressed in terms of a set of variables and one or more social processes linking and generating trajectories of these variables through time" (Doreian 2002, p.99-100). Here, "the idea of variables causing variables has a clear and simple meaning" (Doreian 2001, p.88), and the basic differential equations usually provide a set of transition rules to govern the operation of the system. The second causal modeling is statistical causality where "the use of statistical machinery to determine or locate causal relationships between variable" (Doreian 2001, p.91), in terms of partial correlation, regression equations, and structural equation models as a systems of equations. Both system causality and statistical causality are variable-centered approach and provide foundations for precise predictions. The mechanism causality focuses on specific sequences of events, drawing us into the area of social mechanisms. According to him, mechanism causality and sequences of events involve the task of constructing general descriptions of mechanism and event sequences that generate network evolution. As an example, he uses 'fighting' and 'bystander' mechanisms as generators of dominance hierarchies among primates, citing from Chase (1992) and Fararo et al. (1994), to explain his conceptualizing mechanism causality and sequences of events. Relating to this type of causality to social network analysis, he argues that "mechanism causality is the most seductive as it seems to permit a simultaneous descriptions of the form of networks together with events that generate both actor and network outcomes" (Doreian 2001, p.109).

[54] This is different from system causality that requires an equational generator.

generates many different trajectories and that many of these will never be observed in real data due to a huge amount of indeterminacy in the operation of the algorithmic rules.

By relating the usefulness of algorithmic causality in the study of structural balance theory, Doreian (2002) assumes that actors have goals to achieve balance in their minds. He asserts that one successful area of structuralist theory is structural balance that works in actors' heads, which was theorized by Heider's (1946). However, the empirical domain for the structural balance dynamics was taken out of individuals' minds and located at the level of a social group by Cartwrigth and Harary (1956). Therefore, he argues for the need to incorporate actor-level processes in studying event sequences to discern the operation of balance theoretic processes.

Doreian (2002) discusses simulation results from Hummon and Doreian (2003), which suggest that "actors can come to have local information that is not veridical with respect to the group structure and how they may have images that are inconsistent with each other. The mechanism for creating this was communication" (p.116). According to him, when the actor level processes are excluded, the study of balance theory is impoverished and therefore, "understanding event sequences and the operation of algorithmic rules may be the understanding of network evolution that we seek" (2002, p.117). Relating to the way of actually doing simulation research, Doreian believes that "notions of object-oriented programming and parallel processing are used to represent rich social processes via rules operating on actors, events and relations" (Doreian 2001; 2002). In the following, I will discuss the technique of CS in accordance with Doreian's conceptualization of algorithmic causality for stimulating phenomena by introducing agent-based Modeling, Discrete Event Simulation (DES), and Object-Oriented Programming (OOP).

4.3 Agent-based Modeling

From an evolutionary perspective, agent-based modeling is important to simulate "bottom-up" social processes. Agent-based model is called multi-agent model if there are more than one actor. Cederman (2002) defines agent-based modeling as "a computational methodology that allows the analyst

to create, analyze and experiment with, artificial worlds populated by agents that interact in non-trivial ways and that constitute their own environment" (p.16). Here, artificial worlds are, according to Epstein & Axtell (1996), viewed as "laboratories where we attempt to 'grow' certain social structures in the computer" (p.4), and the aim of simulating 'artificial societies' is to discover fundamental micro mechanisms that are sufficient to generate the macroscopic social structures. Agents refer to a set of simulated actors of artificial worlds who interact with others controlled by agent's perception as well as other's perception, each of who has his or her own attributes (such as gender, race, etc) and behavioral rules. Environment refers to "a medium separate from the agents, on which the agents operate and with which they interact" (Epstein & Axtell 1996, p.5).

The goal of agent-based modeling is to enhance our understanding of fundamental processes. One of the themes of using a methodology of CS in social science research is "emergent property" of social phenomena where simple assumptions generate the consequences that "may not be at all obvious" (Axelrod 1997, p.24). In this sense, as Axelrod (1997) warns, the assumptions underlying the agent-based model should be simple and complexities of the agent-based model should be in the simulated results. Simple assumptions are represented by rules of behaviors for the agents that influence interaction pattern among agents and connect the agents to their environment. Here, we do not make assumptions about aggregate level behavior. Instead, we treat macro-level outcome as emergent phenomena, mapping micro-level behavior to aggregate outcomes (Benoit 2002). In this way, the study of emergence is, as Benoit (2002) views, the most important insight to be gained from computational modeling.

In this generative approach, modeling agents becomes quite important and therefore contributes to advancing sociological theory. As Coleman (1990) pointed out, social theory should provide a micro-macro mechanism that accounts for how individual social actions and interactions aggregate to generate macro-level social structures. One of the contributions of this project is to introduce micro-macro linkage in *feminist* sociological theory development.

4.3.1 Modeling Agent

Gilbert and Troitzsch (1999) argue that when applied to people in real worlds, the concept of agency is usually used to express the purposive nature of human activity, relating "concepts such as intensionality [sic], free will, and the power to achieve one's goals" (p.4). However, according to them, when the concept of agency is applied to agents as computer program, the scope of agency becomes rather weaker. The properties of computer agents typically are represented by autonomy that refers to agent's ability of operating without others having direct control of their actions and internal state (Gilbert & Troitzsch 1999). Agents decide for themselves whether or not to perform some action, as well as flexible behaviors such as social ability[55], reactivity[56], and proactivity[57] (Wooldridge & Jenning 1995, in Gilbert & Troitzsch 1999, p.159).

The term 'agent' is commonly used to express "self-contained programs which can control their own actions based on their perceptions of their operating environment" (Huhns & Singh 1998, p.158 in Gilbert & Troitzsch 1999; p.14 in Benoit 2002). Gilbert & Troitzsch (1999) asserts that the aim of agent design is to create programs that interact intelligently with their environment (p.158).

Agents are assumed to have a degree of intention and their behavior is interpreted in terms of "a metaphorical vocabulary of belief, desires, motives, and even emotions, concepts which are more usually applied to people rather than to computer programs" (Gilbert & Troitzsch 1999, p.159) for the purpose of modeling. Gilbert and Troitzsch (1999) warns that "attributing intensionality [sic] to software agents is liable to cause a great deal of philosophical confusion to the unwary" (Shohan 1990, in Gilbert & Troitzsch 1999, p.160), and therefore it is important to keep in mind that a computer agent does not have intentions, but is built to simulate simplified aspects of human intentions. In order to model with agents, I

[55] Social ability refers to agent's ability to interact with other agents via a computer language, rather than natural language (Gilbert & Troitzsch 1999).
[56] Reactivity refers to the agent's capability of perceiving their environment in a simulated world with other agents and respond to it (Gilbert & Troitzsch 1999).
[57] Proactivity means agent's ability not only to react to their environment but also to take the initiative, and engage in goal-directed behavior (Gilbert & Troitzsch 1999).

will list the assumptions of agents' attributes[58] in terms of knowledge and knowledge representation, learning and adaptation, goals and planning, emotions, and languages.

4.3.1.1 Knowledge and Knowledge representation

My simulation assumes that agents have abilities of perceiving or knowing their environment that is composed of other agents. Gilbert and Troitzsch (1999) talk about erroneous information that is caused by faulty perception, faulty inference or incomplete knowledge as beliefs and distinguish them from true knowledge (p.169). In my simulation, actors may have incomplete knowledge, but not erroneous information. In addition, agents have capability of knowing the interrelationships between other agents by putting together a picture of the social relationships in their environment[59] while the simulation runs (Gilbert & Troitzsch 1999). Knowledge representation refers to techniques for representing their knowledge, which is often done using a matrix (the network).

4.3.1.2 Learning and Adaptation

Agents are assumed to have capability of learning from experience and observation. Here, I do not necessarily conceive of learning as a means of improving performance of any kind. Instead, I refer to learning as gaining knowledge of social context (or information structure) that affects agents' decision-makings through inference. I separate learning from knowledge by adding the former to the ability of agents to infer further information from knowledge. Agents may learn in a solitary way (stand-alone learning) or in an interactive way (interactive learning). In stand-alone learning, an agent is assumed to learn independent of other agents. In interactive learning, learning activities of an agent are assumed to be influenced by other agents, where an agent learns by being told or observing other agents. Here, multiple agents engage in the same learning process.

In addition, agents are assumed to be adaptive to their environment through learning at the individual or group level, which may influence interaction among agents (e.g. individuals change with whom they interact, etc) and the formation of macroscopic social structures. For instance, a bystander

[58] Gilbert and Troitzsch (1999) listed eight attributes of knowledge and belief, inference, social models, knowledge representation, goals, planning, language, and emotions. For detailed explanation of these, see p.160-163.
[59] Gilbert and Troitzsch (1999) call this a 'social model'.

mechanism (e.g. if A observe how B acts toward C, then A, as bystander, may develop an instant dislike feeling toward B, and sympathizing with C, or alternatively may feel contempt for C, alighting him or herself with B) can be modeled in a way that the agent A learns the relationship between B and C from observation and adapt his or her behavior. Fararo and Skvoretz (1986) introduced this concept into a dynamic network model and explained its logic by using a certain theoretical method. Skvoretz et al (1996) applied the idea of bystander mechanism to the emergence of dominance structures in human small group processes. Simulation, as Axelrod (1997) argues, is the only viable way to study the population of adaptive agents, since it is very hard to deduce the consequences of adaptive processes when multiple agents interact following rules that have non-linear effects (p.25).

Axelrod (1997) argues that the main alternative to the assumption of rational choice is some form of adaptive behavior, and one of the main advantages of simulation is its ability of analyzing adaptive as well as rational agents. The assumption of 'adaptive rationality'[60] is very useful to express "a process-oriented type of theoretical idea implementing a conception of rational action by human beings in situations" (Fararo & Hummon 1994, p.35). It should be noted that while an actor can alter existing goals by adaptation, the actor cannot create new goals by this mechanism.

4.3.1.3 Goals, Sub-Goals, and Rationality

Agents are assumed to engage in action being driven by a need to satisfy some internal goal that is composed of some sub-goals. One or more goals are overriding concerns for the agent, and drive many of its proactive actions. A sub-goal is a distinct step that moves the Actor directly towards fulfilling a Goal. A rational agent may employ Adaptation as a way of determining what behavior is likely to lead to the satisfaction of its goals (or sub-goals)[61], and for choosing among immediately available sub-goals. It is important to note that agents have the ability to alter goals dynamically through Adaptation as well as emotional states that will be discussed next.

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[60] The principle of 'adaptive rationality' is that "the probability of an action changes with its consequences in terms of the sanction significance of those consequences, whether positive or negative." (Fararo 1989, p.224, cited in Fararo & Hummon 1994, p.3)

[61] Gilbert and Troitzsch (1999) argues that action rules, if a number are used in combination, can be very powerful.

4.3.1.4 Emotions

Gilbert and Troitzsch (1999) point out lack of clarification of some basic questions about emotions[62] and consequent little research that has been conducted within artificial intelligence on how emotions can be best modeled. I assume that agents are motivated to alter one or more of their Goals by their emotions that take a form of control signaling[63] (Ortony et al 1988, in Gilbert & Troitzsch 1999). For instance, if the agent is sad because s/he did not succeed in achieving a sub-goal, this emotional state impels him or her to look for other sub-goals that make him or her happier.

4.3.1.5 Language

The agents are assumed to interact with other agents by passing information from one agent to another with the intention of communicating with other agents, which is modeled by specifying a 'language' for communication. This 'language' need not be a natural human language, but instead be some sort of programmatic way that two (or more) entities can 'communicate' with each other. Examples of this communication could be 'Messages', 'Event Tokens', coded 'Strings' or numbers, etc.

4.3.2 Modeling Environment

The agents are located in and constitute their own environment that "can be a more abstract structure, such as a communication network whose very connection geometry may change over time" (Epstein & Axtell 1996, p.5). Agents perceive their local neighborhood and actively affect the environment through communication by exchanging messages among them. Here, agents are assumed to be capable of receiving or sending information that move in the environment through messages among agents.

4.3.2.1 Information Movement and the Consequence of Time

Information moves either *sequentially,* where only one piece of information moves, or in *parallel,* where more than two pieces of information move at the same time. Also, there are two ways of

[62] According to Gilbert and Troitzsch (1999), unresolved issues are to determine (1) whether emotional states are entities, or are emergent features of other cognitive and subconscious states, and (2) the relationship between emotions and goals (p.163).

[63] Still another theory views emotions as epiphenomenal, a specific emotional state indicates to oneself that one has succeeded or has not succeeded in managing within one's environment (Wright 1996 in Gilbert & Troitzsch 1999).

specifying systems to control information movement. The first way is *synchronized,* where information moves in a sequential order because of the agreement between agents about the order of the process. The second way is *asynchronized,* where information moves without agreement between agents. Movement of information adds the concept of time to a simulation. In other words, at one point in time a piece of information is one place, and at the next point in time the information has spread (or moved) to another place. One example of this instantiation would be the act of gossiping. When information is exchanged between two discrete points in time, the buffering of events/messages is usually used as an instantiation of a discrete time approximation. Buffering messages mean that all messages that are exchanged between two points in time are stored, and all these stored messages are delivered to the agents at the next point in time.

So far, I have discussed the properties of modeling agents and some specifications of modeling environment. From now on, I will discuss two techniques for simulating dynamic theory that involves qualitative aspect of social phenomena on a computer by introducing Discrete Event Simulation (DES) and Object-Oriented Programming (OOP) methodology.

4.4 Discrete Event Simulation (DES)

DES has many nuances depending on the area of science. It is important to note that a DES model [as applied to Computational Sociology] is a computational method analogous to mathematical method (such as difference or differential equations) and it defines (or represent) a theoretical model only when it is given theoretical context, and is not in itself a theoretical model. Hence, the empirical grounding of the theoretical model in DES form will vary since DES allows an infinite number of possible contents. However, a caveat of DES is that model becomes complex with simple change of parameters. Practically, we cannot model complex social systems because in so doing we need to explore whole parameter spaces. As scale (number of actors) and parameters increase, we face the problem of computational power and quickly reach the limitation in understanding complex social world. This

reminds us of what is important in DES or in modeling in general; that is to say, a simple model is best[64], and we should choose only a few critical variables that are theoretically driven.

With regards to how one can formulate DES models that are applicable to sociology, Fararo and Hummon (1994) provide a whole set of menus required to construct a formal-theoretical model of a process (p.29-31). Those menus are state space (categorical, continuous), parameter space (categorical, continuous), time domain (discrete, continuous), timing of events (regular, incessant, irregular), generator (deterministic, stochastic), postulational basis (equations, transition rules).

State space and Parameter space

Fararo and Hummon (1994) define state space as "the complete set of combinations of all possible values of all the dynamic variables" (p.29) where categorical state space represents qualitative features of the world, whereas continuous counterpart represents quantitative features. Parameter space applies the same conceptual distinction as in state space but applied to the conditions that are expressed by the configuration of fixed parameter values, under which some processes of change in state variables occur. These two menus define the formal setting for the study of dynamic phenomena.

Time domain and Timing of events

Time domain and timing of events deal with how to represent time. The former is determined by how the state variables are defined and analyzed. A discrete time model is used when the state variables are defined and analyzed only at discrete time points, whereas a continuous time model is used when the state variables are defined for every moment of time. Fararo and Hummon (1994) use 'timing of event' to represent a second feature of representing time where they defines an event as "a change of state at an instant of time" (p.37). Timing of events can be regularly scheduled as in being observed many institutionalized action settings, occur incessantly as in being observed in physical space or in an ecosystem, or occur at irregular internals of time as many social actions and events occur in such a way.

Generator and Postulational basis

[64] If social phenomena we are modeling is known to be nonlinear and modeling linear would violate the essence of a model, we can think about using piece-wise linear functions by which to approximate the social phenomena.

Fararo and Hummon (1994) refer to the generator of a process as "the formal representation of the mechanism, or combination of mechanisms, that produces changes of state 'in the small'" (p.30). According to them, a deterministic generator is a special case of a stochastic one conceptually since for the former, transition occurs with probability one between pairs of states in the state space either in discrete or in continuous time, while for the latter, such transitions occur in a probabilistic fashion. Postulational basis refers to what they call the postulational basis of a theoretical model. If postulation is based on equations, the theoretical process models are also specified by equations. Classically, systems of differential equations for continuous time or systems of difference equations for discrete time are used to frame theoretical process models. On the other hand, if postulation is based on transition rules, the theoretical model might be framed as a set of rules. Fararo and Hummon argue that rule-based postulation is critical for the categorical types of state space, and "the development of formal theoretical analysis in sociology must include work that enables dynamic analysis involving qualitative aspect of social phenomena" (p.31).

Definition of DES

By using above menus, Fararo and Hummon (1994) defines DES as "a dynamic model implemented on a computer in which there is a system of interdependent entities and their activities described in terms of the following: categorical states, a continuous time domain, with events occurring at irregular times, and a postulation basis of transition rules among the categorical states" (p.32). This is different from Hanneman's (1988) simulation work that represents continuous state continuous time dynamics of social theory. In his continuous simulation approach, the mode of representation of system dynamics is variable-based by using empirical data where all variables represent aggregate attributes to produce some statistics.

DES sets the basic components of a system in the 'entities'. Fararo and Hummon (1994) spell out three features of entities. First, entities are not only acting units but also compounds or relations such as ties among such units. Second, entities have attributes that may be fixed for the duration of a simulation run or may be time-variable. For the latter case, attributes are state variables that change when events

occur. Third, entities may be permanent, meaning that they necessarily endure through the history generated by the model, or temporary, meaning that they are subject to birth and/or death. These features in DES allow us to examine network processes that are "series of events that create, sustain and dissolve social structures" (Doreian & Stokman 1996, p.3).

For a DES using an agent-based framework, the entity is each agent who stores the information about his or her attributes[65] (including his or her relationship with other agents). Here, transition rules are defined in terms of agent-based behavioral rules, and therefore transitions occur at the agent level[66]. More specifically, each agent acts independently according to the information available at the time when he or she makes decision, so that any reactions to received information are immediately processed/sent, without consultation with any other agents. This means that actors do not necessarily know what is going on in the rest of the network at the very moment of making their decisions.

Conversely, in Carley's (1991) formulation, transitions occur simultaneously at the group level regardless of the individual-based, decision-making rule. In other words, events occur at discrete time points, representing the process of inequalibrium at each point of time in terms of the structure of the group. This is another type of discrete time model in the category of DES models, in which the set of rules is represented by difference equations. Hummon and Doreian's (2003) work also introduces the notion of group-level process to explore the theory of group stability. At the individual level, their assumption is that individuals make decisions to minimize imbalance. At the group level, their assumption is that a social network is partitioned such that it defines a group, which occurs in time. Then,

[65] As an alternative way of formulating problem, Carley (1991) does not consider attributes of individuals. Instead, she represents whole network in terms of matrix that change with respect to discrete points in time. While in DES, dynamic system representation is each actor who independently makes decision and behaves (that is, actors do not simultaneously make decisions), in Carley's formulation, all changes occur simultaneously by using method that is similar to traditional simultaneous differential equations. In a nutshell, in DES, the level of processes is at the agent level (each agent has his or her goal, balance and maximize rationality), while in Carley's framework, the level of processes is at the group level.

[66] This is different from Hanneman's (1988) simulation work where the level of aggregation of the social phenomena is variables that reflect real world (or behave like real world), looming at the macro level. In this regard, Hanneman's (1988) continuous simulation is more appropriate for societal level analyses such as Marxian and Durhkemian theories.

actors make decisions based on the partition under different information and conditions, which produces new a network structure. Thus, they examined the cyclic process at both individual and group levels.

4.5 Object-Oriented Programming (OOP)

The second technique of CS is a programming methodology of Object-Oriented Programming (OOP) design that has the ability to represent "entities" in terms of objects. Objects are program structures that hold both data and procedures (or member of functions). They are instantiated from source-code templates for objects (called a "class") that specify the composition of the objects to access and manipulate data. The advantage of OOP design is that objects that are derived from the same class have similar data member (variables and constants that store the values that model the real-world concept the objects represent) and functionality (member methods where statements grouped into a standalone "module" for accessing or modifying data content within a class) although the data values differ by each object. One of the important features of OOP design is its side-effect of encapsulating information into (fairly intuitive) blocks.

OOP design facilitates constructing agent-based models since both agents and environmental sites are naturally mapped as objects (Epstein & Axtell 1996). Here, an agent's data member represents internal states (i.e. attributes) and agent's member functions represent cognition in terms of rules of behavior that generate changes of state. The usefulness of OOP design within agent-based model is that all agents instantiated from that the same class can share the same behavioral rules by specifying them at the class level, while the contents of their memories can differ between agents (Gilbert & Troitzsch 1999). In addition, OOP allows individual agents clearly distinguished from each other within the program because of its feature of encapsulation of internal states and rules.

When OOP technique is applied to social network analysis, the dynamic nature of networks as objects can also be examined from actor centric point of view[67], representing the idea of methodological individualism in programming technique. In other words, OOP design allows us to model evolution of

[67] The detailed explanation of Object oriented programming approach is provided in Hummon and Fararo (1995).

networks as a result of interaction among the agents who behave rationally in terms of initiating, maintaining (and breaking off) their friendships for their own needs[68].

In summary, the methodology of CS is a new way of constructing dynamic social network models, using two standard methods of induction and deduction. The strengths of CS are its abilities to formalize less abstract social theories in terms of a programming language, to deal with parallel processes, and to contain heterogeneity among actors. As far as modeling concerned, an agent-based model is promising in enhancing our understanding of fundamental processes, and therefore useful in understanding generative mechanisms in social network analysis. Here, agents are assumed to have a degree of intention and their behavior is interpreted in terms of a metaphorical vocabulary of belief, desires, motives, and even emotions.

With regard to techniques for simulating dynamic theory, DES sets the basic components of a system in the "entities." In the agent-based framework, entities are acting units as well as relations among such units, and transition rule is defined in terms of agent-based behavioral rules, which incorporate actor-level processes in studying event sequences to discern the operation of social processes. As a programming methodology, OOP design has the ability to represent "entities" in terms of concrete, programmatic constructs (objects) that encapsulate both Knowledge and behavioral rules. In agent-based modeling, and object's data members represents a given agent's internal state, and the member functions represent cognition in terms of rules of behavior that generate changes of state, thus representing the idea of methodological individualism in the actual programming technique. When OOP technique is applied to social network analysis, the dynamic nature of networks is also treated as objects that bundle data member and functionality. In the next section, I will illustrate how DES and OOP design in actor-based modeling can be employed to formulate dynamic social network models among adolescent girls using Eder's notion of COP.

[68] Other simulation modelers define the goals of rational individuals as (1) the need for social contact (Zeggelink 1993; 1994), (2) the preference for similarity (Zeggelink 1993; 1996), and (3) the structure of friendship relations (Zeggelink et al 1996) based on methodological individualism.

4.6 Agent-based Modeling for WM adolescents

The current research uses agent-based modeling to simulate bottom-up social processes of formation of peer relationship, which leads to the structure of all-girl networks. Agents are a set of WM adolescents who have the ability to make decisions about forming, changing or deleting friendship ties according to certain criteria formed by feminist ideas. My simulation does not place restrictions on the number of friends (outdegrees), although other simulation results report that once individuals achieve the goal of making a certain number of friends, they are less likely to seek out more friends at the expense of existing friend (e.g. Zeggelink 1995). The reasoning for this is that such a limit on maximum friends may cause artifacts in the resulting networks.

4.6.1 Scope of Simulation Study

My simulation study refers to some qualitative findings in school settings; ideally, the scope of my simulation study would be an open system from a general standpoint, and an entire school setting from an instantiation standpoint. However, WM adolescents would be limited by their opportunities to interact with other students to some degree due to organizational structures such as programs to which they belong. For this reason, it would be more realistic to assume a *closed* network from a general standpoint, and any program-related settings (such as self-seated lunch time settings) that constrain WM adolescents to interact with others from an instantiation standpoint. Hence, my simulation study assumes a closed population of actors and no individual enters or leaves the population.

4.6.2 OOP design

Actor-based model is implemented by using OOP design that allows objects to act and react each other in their environment through communication. The major objects in my simulation are an Actor and a Network.

4.6.2.1 Actor Object

Each Actor object possesses her attributes, behavioral rules, and her own image of the network. Actor attributes and behavioral assumptions will be explained in greater detail later. The actor's decision making based on her behavioral rules of forming both positive and negative ties as well as deleting

positive ties, and are more generally referred to as the rules which transform state, or "transition rules." Each Actor acts independently according to the information available at the time when she makes decision, so that any reactions to received information are immediately processed, without consultation with any other agents. This means that Actors do not necessarily know exactly what is going on in the rest of the network at the very moment of making their decisions.

4.6.2.2 Network Object

From the perspective of a single Actor, a given relationship with another Actor can be placed into one of four categories of (1) Friend, (2) Null, (3) Dislike, and (4) Enemy. The first category I will refer to as a "positive" tie, and the third and fourth as "negative" ties. All categories will not necessarily be used by a given decision process. These feelings may or may not be mutual depending on the decision processes. The Network object is composed of the web of the relationships between actors.

4.6.3 DES

A Discrete Event Simulation uses as its fundamental unit a theoretical "event." In my simulation, a message being passed from one Actor to another Actor is an event. I will use a Message object as an instantiation of this event, and is analogous to a real actor using their voice[69] to communicate in the real world. Each message is one of four following types:

1. Offer: information about making a (positive) tie offer is transmitted
2. Response: information about acceptance or rejection of a previous offer is transmitted
3. Notification: information about a change in the sender's ties or group membership is transmitted
4. Gossip: information about a third person's change in ties or group membership is transmitted

It should be noted that when actors make a friendship offer, only positive choices are allowed, representing the individuals' desire to form a friendship with the ideal target to their needs. For the remainder of this document, I will refer to sending a message of the associated type as "offering," "responding," "notifying," and "gossiping," respectively. These messages will processed in parallel (more

[69] Simulation message could be a stand-in for a real world e-mail message as well as cell phones, especially in regard to gossip about third parties among girls.

than two pieces of information move at the same time) and asynchronously[70] (information moves without agreement between actors). Thus, these messages exchanged back and forth between actors will serve to approximate the information transfer that a real conversation would achieve, and these "conversations" can happen simultaneously among many people (Actors).

My simulation uses a custom DES library (written by a third party just for this application) to handle the transmission and delivery of events (Messages) between Actors. This library is used in a way analogous to the U.S. Postal Service, and allows Actor objects to communicate using simple but powerful interfaces to "mail" Messages to each other, and have them delivered at a particular "virtual" time. Actors each have a private "mail box"[71] which accumulates their mail until processed. Unlike the Postal Service, the library also provides a "wake up" service for the Actors, keyed to the "virtual" clock. Thus, programmers who use the library need not concern themselves with the intricacies of DES implementation, and instead can focus on the Actor logic. Indeed, the Actors need not implement anything beyond their "transition rules." The library also provides for some control over the life of the simulation, and for exhaustively searching simulation parameter spaces.

4.6.4 Assumptions about Actors

My simulation assumes that an actor holds three values in their peer relationship. Those are (1) the value of becoming popular by increasing status level, (2) the value of egalitarian relationship, and (3) the value of group commitment. Given these three values, my simulation assumes that an actor has a degree of intention and her behavior is interpreted in terms of the following assumptions of actor's attributes.

Goals, sub-goals, and rationality

An actor is assumed to have a goal of becoming popular by increasing her status level, and her sub-goal is to select targets of her friendship offers in such a way that moves her directly towards fulfilling a goal of

[70] These messages may be automatically recorded to disk by the simulation library for later review.
[71] This is similar to the "priority queue class" in Hummon and Fararo's (1995) simulation study in terms of function.

increasing status. Learning and adaptation may influence her sub-goals of choosing a target, by which girls alter their goals rationally through adaptation.

Learning and adaptation

An actor has the capability of learning from observation. When an actor hears about her friend's experience of being rejected by a popular actor, she learns that a popular actor violated the norm of egalitarian relationship and feels empathetic to her rejected friend. Thus, an actor rationally adapts her choice of the target when she herself makes a friendship offer. For instance, if a WM adolescent A is rejected by a popular WM adolescent X, A then talks about her experience to her friend B. When B considers a friendship offer to X, she takes A's experience with X into account in such a way as to possibly avoid making friendship offer to X because B feels empathetic to A's experience. Thus B is adapting her choice because of A's previous experience with X. Here, multiple actors are more likely to engage in the same learning process about a violation of the norm of egalitarian relationship in an interactive way (interactive learning) through gossiping.

Emotions

I assume that if an actor's friendship offer is rejected her by a popular actor, she feels sad, and this emotional state impels her to look for other sub-goals that make her happier by reducing the chances of being rejected again, altering her goal of becoming popular by rational adaptation. For instance, if the a WM adolescent A is rejected by a popular WM adolescent X, A then feels embarrassed and gets angry at X. These emotional feelings impel A to devalue increasing her status, and thus to look for other targets who will be less likely to reject A's friendship offer. Here, A is rationally adapting her choosing friendship targets by altering her desire of increasing her status more in the direction of the value of egalitarian relationship.

Knowledge of friendship relations

In my simulation, every actor eventually perceives all positive ties and negative ties that are directed toward them by means of direct notification. However, each actor is not necessarily informed about all positive and negative ties directed toward others by means of gossiping. This means that each actor has

the ability of knowing the interrelationships between other agents, which may or may not be complete due to the gossip structure. An actor's knowledge about relationships is represented by a cognitive map of the network in order to keep her own image of the network structure. Furthermore, every actor knows the total number of actors in the population and is able to observe other group memberships as well as their own through gossip (this will be discussed later). In addition, an analyst's representation of the whole network (global map) is provided, which collect each actor's image of her own outgoing relationships[72].

Language

In my simulation, an actor is assumed to communicate with other actors by exchanging messages. This will be discussed in detailed in the section of "Modeling Environment."

4.6.4.1 Actor Attributes

In my simulation, an actor has her own set of attributes that do not change once the actor is created in the following.

1. Publicly organized popularity attributes
2. Private popularity attributes

My simulation specifies publicly organized popularity attributes and private popularity attributes as determinants of status ranking. The former refers to any status-conferring attributes whose positions are created by organizational activities and recognized by everyone who belongs to those organizations. The latter refers to any status-conferring attributes whose positions are not created by organizational activities but are recognized by individuals privately.

For instance, although many American middle schools have school activities like cheerleading for girls and athletics for boys that are important features in determining popularity, elementary schools may not have these school activities. However, they have other means for students to gaining peer approval as Adler et al (1992) found that there was "Cycle of Popularity" for elementary school girls. They report that many less popular girls did not like the more popular girls even though they acknowledged that these

[72] This method is used by other scholars who employ an objected-oriented programming approach (see Hummon & Doreian 2003; Hummon 2000; Hummon & Fararo 1995).

girls were popular. For elementary school girls, according to them, popularity factors are composed of family background, physical appearance, social development expressed by precocity and academic performance. The difference between "cheerleading" in middle school settings and popularity factors in elementary school settings is that the former is organizational creation, but the latter is not.

My simulation instantiates the first actor attribute of publicly organized popularity attributes as being cheerleading status and the second actor attribute of private popularity attributes as being attractiveness level. These two instantiated actor attributes are defined as follows. Each actor has her own attributes of:

1. Cheerleading status:

$$C = \begin{cases} 1, & \text{if an actor is a cheerleader} \\ 0.5, & \text{if an actor is not a cheerleader, but a friend of any cheerleader(s)} \\ 0, & \text{otherwise} \end{cases}$$

My simulation assumes that being a cheerleader is more important in the sense of social status than being a friend of a cheerleader.

2. Attractiveness level

   $A \sim \text{Uniform}(0, 1)$

In order to allow for the variability in attractiveness level in a network, my simulation randomly assigns attractiveness levels for all actors from a uniform distribution. Since the distribution of attractiveness levels is not known and attractiveness is relative (dyad specific), I use a uniform distribution as the most plausible distribution to assume, and trust the fact that I will be drawing my outcome statistics from hundred of simulation runs to deal with this issue (central limit theorem). Under the given parametric conditions, the number of cheerleader positions is specified by cheerleading density relative to the population, and reflect the available positions for social approval. These positions are filled according to the ordered attractiveness level since "physical attractiveness . . . is typical of female cheerleading" (Eder & Kinney 1995). Visibility level can be determined by the combination of Cheerleading status and Attractiveness level. I call this combined score "Status" from now on because a cheerleader is visible but

the relevance to my study is that cheerleading confers status among girls and the same is true of physical attractiveness.

$$S_{1i} = \alpha C_i + (1-\alpha)A_i \qquad 0 \leq S_{1i} \leq 1$$

where α is a social approval weight factor which range from zero to unity.

For a given parametric condition, there is a set of vector with N actors $\{S_{1i}; j = 1, \ldots, N \mid \alpha\}$ in a network. For non-cheerleaders, their status scores may increase (being updated) during the simulation run if a friendship offer to a cheerleader is accepted, which reflect Eder's (1985) finding that the non-cheerleaders who made friendship relations with cheerleaders gained access to top groups during the year. For cheerleaders, their status scores are constant during a simulation run. Note that measurement of status assumes that being a cheerleader and being a friend of a cheerleader is mutually exclusive to avoid over-emphasizing the intra-cheerleader friendship in the measurement of status.

Rationally, if one wants to improve their status, one must associate with those of higher status, and thus the concept of "association acceptability" is created. Consequently, we must be able to compare two status scores. Mathematically, $S_{1x} > S_{1y}$ is easy to evaluate using rational numbers, but equality is a bit more tricky when we consider what the numbers are supposed to represent. How will two girls be able to evaluate who is the higher status when their status score differ by some very small value? Intuitively, both girls would find each other acceptable (equivalent), but the mathematics would be less forgiving.

Thus, my approach to this "status equality problem" is to define equality in status with a certain +-delta, and in particular, I chose to use the Inter-Quartile Range (IQR) of the status values. IQR covers 50 % of simulated status values as calculated in the standard way of 3rd Quartile minus 1st Quartile. The reasoning of using IQR as a measure of "association acceptability" is that it will adapt automatically to the given status values for a particular simulation run, as opposed to constant value (which would be even more difficult to justify). The advantage of using IQR is that we do not assume any distributional forms of status values. However, simply using IQR seems to be too wide for the criterion of association acceptability. Therefore, my simulation specifies a more stringent criterion by dividing IQR by half.

Consequently, when checking for association acceptability, the simulation will be using this *"within half-IQR or exceed"* rule (either the target under consideration's status value exceeds the actor's, or it is at least within a half-IQR of the actor's), which will be discussed more later. As a side note, if we choose another criterion that is more stringent than the one-half IQR, my simulation may generate more negative ties caused by the increase in rejected friendship offers, and this may in fact cause the system to stabilize with smaller groups. Conversely, a less stringent criterion may generate more positive ties caused by the increase in accepted friendship offers, and depending on the model logic may in fact cause the system stabilize with larger groups. While it is possible for my simulation to use another way of calculating the criterion of acceptability, the current study limits its analysis to only to the one-half IQR criterion.

My simulation explores the value of alpha (α) is 0.2 in all the simulations. The reason of this choice is to avoid the huge gulf between non-cheerleaders and cheerleaders. Given that the half-IQR covers approximately 0.25, it would seem reasonable to choose an alpha less than that so that non-cheerleaders with high status values can be accepted by cheerleaders.

4.6.5 Modeling Environment

In my simulation, the environment is constituted by a communication network where actors receive or send information about their own relations (as well as others) through the exchange of messages. This communication network forms the basis for the mechanism by which information is propagated to other Actors.

4.6.5.1 Formation and Recognition of Potential Groups (P-Groups)

Gilbert (1995) views one capability of humans which is not shared by other animals as "an ability to perceive, monitor and reason with the macro-properties of the society in which they live," (p.155) which is related to or even a consequence of the ability of human to use language. My simulation allows agents to detect the emergence of groups and react to this structure by implementing a functionality by which agents are capable of recognizing their group membership, and realizing what this implies about member's actions.

However, from an instantiation point of view, many social network scholars acknowledge the difficulty in defining friendship groups into which a network can be divided by pointing out the need for satisfying friendship network evolution models (Zeggelink et al 1996; Fararo & Doreian 1998). Freeman (1992) argues a concept of "group" that meets the two requirements of eliminating overlap and permitting the display of the internal structure of groups. He derived a new model that provides an alternative to the one defined by Winship (1977) that specifies that there be no intransitive triples at any level of interaction. Since "intransitivities are always present and present in considerable number" (p.159), he proposed a new model of group structure that base on Granovetter's (1973) conception that distinguishes between "strong" ties (individuals are closely affiliated), and "weak" ties (individuals are less intimately affiliated). Freeman's proposed Granovetter's model permits any intransitive triples except those containing two strong ties and one complete lack of ties, which actually fit the data better than Winship one. This result suggests that transitivity is not necessarily important in defining a group.

Instead of defining groups in terms of permitted and forbidden triads, Davis and Leinhardt's (1972) ranked clusters model provides a graph theoretical model of Homans' (1950) proposition about a social structure that is characterized by differentiation into cliques and elaboration into ranks. Ranked clusters model deduces such characteristics of a group from the pattern of *pair relations* within the group. The main idea of ranked clusters model starts with *relations of the sort we have called A (asymmetric relations) are assumed to connect persons in different levels, while M (mutual positive relations) and N relations (mutual non-positive relations) are assumed to connect persons in the same level. Further, we assume that in pairs connected by A relations the recipient of the positive relationship is in the higher level* (p.220). Ranked clusters model is based on the notion of a social structures where the group members tend to be divided into cliques by the pattern of their M and N relations within levels, and tend to be divided into levels by the pattern of their A relations.

Doreian et al (2000; forthcoming) propose a generalized version of blockmodeling and their method of the Symmetric-Acyclic Decomposition (SAD) of the network, which is grounded in the idea of ranked clusters model from Davis and Leinhardt. SAD is designed to partition social networks into

clusters where the actors in a cluster are linked by symmetric ties or null ties and to delineate the structure of the whole network in terms of the clusters and the relations between them. They distinguish the two important properties for the ranked clusters model and formulate both the block type (symmetric ties within diagonal blocks) and the decomposition itself (acyclic specification) by assuming that actors within clusters are linked only by mutual ties (symmetry requirement) while asymmetric ties are directed only up between the ranked clusters (acyclic requirement). Thus, SAD is a method that causes the network analysts to focus on internal structure of the blocks of a blockmodel. When networks do not fit exactly with the specification of the ranked clusters model, the iteration of the symmetric-acyclic decomposition reveals the structure that minimizes the inconsistencies with the acyclic requirement as well as with the symmetry requirement. SAD allows us to split up the clusters so that each diagonal block only has actors involved in symmetric ties, which focus on allowed and not-allowed blocks, instead of considering permitted and forbidden triads.

My simulation study uses Doreian et al's operational method based on a ranked clusters model, defining clusters in terms of pairs within a cluster that have two positive relationships. This seems to describe girls' network structure more appropriately than defining clusters in terms of a triadic closure bias. This is because empirical findings do not support a girls' tendency to form dense friendship triads over time, and instead support their tendency to remain in exclusive dyadic friendship by resisting intrusion on a mutual best friendships over time (Eder & Hallinan 1978; Hallinan & Kubitschek 1990). The only modification to Doreian et al's method is to change their "acyclic upward positive tie" requirement into one defined by upward acyclic negative ties, and this is consistent with the assumptions within "Cycle of Popularity." My simulation identifies a series of snapshots of partitions from the state of positive mutual ties. Thus, at any given point in time, regardless of whatever patterns of ties that have emerged to define the directed graph, the graph is partitioned into a set of disjoint connected components as the process unfolds. A cluster that comes out of each point in time, then, is any one of these components, which I call a "potential group" (p-group). When the simulation reaches a steady state, it is

assumed that the "groups" were formed. This is in contrast with the p-groups that existed during the transient phases of the process.

The Figure 2 shows the example of two sets of disjoint connected components, each having a set of mutual positive ties that span from one p-group member to every other p-group member.

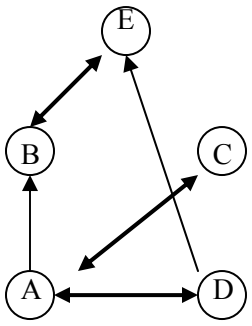


Figure 2: Example of Defining P-Group Membership

In the above network, the first p-group is composed of B and E. The second p-group is composed of A, C, and D. C and D share the same membership through their mutual friendship with A. It is important to note that this method defines p-group members in terms of pairs of mutual positive ties, and not by a triadic closure bias, which is substantively consistent with girls' tendency to not close triples over time[73], as opposed to boys' case (Eder & Hallinan 1978; Hallinan & Kubitschek 1990).

When a simulation starts, there are no p-groups in existence. My simulation assumes that members of a p-group are linked together by two types of friendship: reciprocated friendship ties and asymmetric friendship ties. As a p-group forms, initially asymmetric friendships may become reciprocated ones. When this happens, the reciprocated members then share the same p-group membership. An actor may only have only *one* p-group membership at a time, and hence avoid overlapping p-group membership, while an actor may have asymmetric ties to members of other p-groups. In this way, my simulation allows reciprocated actors to share the same p-group membership on a dyad basis, albeit a temporary one. Therefore, it is possible for indirectly connected actors to share the same p-group membership as long as both of them have symmetric ties to the third person, but this is not

[73] Earlier in this paper, I cite the Fararo-Sunshine result of the closure bias such as "sibling bias" and "double-role" bias that hardly showed any difference between boys and girls. However, their data comes mainly from African-American lower-income families, which may differ in the nature of peer relations among WM adolescents.

expected to be the steady-state result. This situation may further evolve into a group of positive ties on a dyad basis (but giving the appearance of steady-state closure), and furthermore it is still possible that certain event sequences and actor attributes will instead result in a "closure" by symmetric negative ties. However, it must be noted that closure is not an explicit mechanism in its own right.

Furthermore, when a member of one p-group changes to another p-group, this will cause perturbation in the member's friendship ties to the original p-group (if any) since the remaining p-group members are not guaranteed to desire to join the new p-group. This possible "severing" of friendship ties will be instantiated by replacing the original tie with a null tie to represent this uncertainty (and thus the "severed" actor will be included as a potential recipient for a future friendship offer). Depending on the Actor's logic, the strong friendship may or may not reform as the network converges.

In an abstract sense, a p-group starts as a single person. Then, as positive ties form, a p-group will emerge that initially buffers itself from other p-groups by the absence of ties (null ties) but then later on by the formation of negative ties. In addition, as part of the in-group estimation, my behavioral rules specify that whenever a pair of actors succeeds in forming a strong friendship, and there is a difference in p-group memberships, the lower-status actor joins the higher actors' p-group. For instance, A and C form dyadic p-group and so do B and D, with A having higher status than B. Then A accepts B's overture so that there is a mutual tie between them. This causes B changing her p-group membership to A and C's p-group membership, temporarily canceling her shared p-group membership with D, but it is expected that eventually D joins the shared p-group membership with A, C and B through B's friendship offer to D, forming mutual tie between them. Hence the whole set of person A, C, B, and D ultimately forms a single p-group (as opposed to instantaneously linking together).

However, in CP3 where betrayal behavior is included in the above example, when B cancels her friendship tie to D (and her shared membership with D) in order to join A and C's p-group membership, D reacts to B's membership change by sending enemy tie to B, by which the mutual tie between B and D will not be formed again. This process results in the set of person A, C, and B forming one p-group, and D starting to form the other p-group in the network. The reason for the lower-status actor joins the higher

actors' p-group is to satisfy the value of increasing status, as opposed to the value of group commitment which has already been abandoned in favor of increasing status, and the fact that the upper side accepted only the lower actor and not their group (value of egalitarianism). Changes of allegiance are also treated as gossip and propagated as such. With regards to actor's recognition of p-group membership, this knowledge is universal.

4.6.5.2 Information Propagation Mechanism

Information propagation limits define how far the information can spread in a network of ties. I will classify information propagation into two mechanisms: Direct (first hand) and Indirect (second hand). When an actor engages in the transmission of first-hand experiences or knowledge, I will refer to it as "notification" or "notifying." Then an actor repeats second-hand information and/or experiences related to them by another Actor, I will refer to this as "gossip" or "gossiping." For example, when something happens (change of state) to an actor, that actor will engage in Notification. This represents the fact that the actor would inform her friends (and possibly disliked actors as well) about the new relationship and/or rejection. The friends may now tell their own set of friends about what they have just heard (Gossiping).

My specification of gossip flow goes beyond many research simulations because most limit their information propagation to only the former type. For instance, Carley (1990; 1991) assumes that directly interacting with someone means sharing knowledge and her model looks only at dyadic benefit that was accrued by direct interaction in terms of similarity of shared knowledge between a focal person and others, but not between others and others. By incorporating the concept of second-hand gossip flow, we can also simulate the effect of reputation (first and second-hand gossip) by considering a predicted friend's reaction to a new direct tie (thus avoiding rejection).

My concept of gossip flow is based on some findings of research on the structure of gossip among adolescents in the middle school. Eder and Enke (1991) report that students often had conversational episodes where opinions about others were shared through evaluative gossip, and that it is most likely for students to agree with a particular piece of gossip if their friend initiates it. From these

observations, first-hand gossip seems to be a realistic mechanism by which information is passed among friends. It is also reasonable that friends would later talk with other friends, thus propagating the initial information farther than just one actor. Therefore, it seems reasonable to include the concept of second-hand gossip as well.

My simulation specifies that both direct and indirect information of tie changes be propagated among positive ties. In the case of a simple "dislike," the target of the negative tie will also be informed (but not in the case of an "enemy" tie). The reason for this special case (which is a model simplification trade-off) is that the alternative would seem to be 3rd party (conditional on a chain of people) information transmission (gossip), which would seriously complicate the model. These complications would be in the form of (1) low probability of the formation of symmetric negative ties and (2) increased model execution time. Furthermore, there is a limitation in information propagation mechanism of my simulation that only allows individuals to propagate newly formed tie information (no repetition of past Actor transitions).

In addition, in the case of model CP3 but not for CP1 and CP2 (to be defined below), the p-group membership identification of a particular actor is also automatically communicated through *any* message interaction with that actor and serves as a group change notification that has meaning only in CP3. The reason for this is that p-group membership can be communicated in a myriad of ways that are outside the primary reason for the message exchange (for example, the observation of distinctive in-group behaviors).

4.6.6 Global Parameters

The models will explore all combinations of the global parameters in a given parameter space as a generic properties of a process. The following parameters will be considered:

1. Number of actors
2. Density of available positions for social approval

My simulation sets number of actors constant throughout simulation runs. It also allows setting the density of available organizationally created position that is socially accepted. The goal here is to explore under what conditions that are represented by combination of parameters certain network structures emerge.

4.6.7 Stopping Rules

My simulation assumes that an actor progresses through a life cycle that has two stages as follows:

1. Active stage: during this stage, an actor still has valid targets for friendship offers. When the actor has a chance (wakes up), they will process all waiting messages, and then make a *single* friendship offer to one of the remaining valid targets for friendship offers. If she has no remaining valid targets, she will then make a transition to the next stage (Passive).
2. Passive stage: an actor is not generating offers any more because she cannot find a valid target for her friendship offers. At this stage, she will only react to messages sent to her such as gossip and information propagation messages. In essence, her friendship ties have become stable as the entire network move towards equilibrium (and only sudden, radical changes to the network will cause her to change back to the active stage).

As networks reach equilibrium, all actors will pass through both stages in sequence. However, each actor individually will complete her life cycle at her own rate. My simulation stops when few structural changes occur over a long span of virtual time (to handle possible oscillating behavior). These stopping rules are based on the idea of equilibrium in a process-oriented framework where the social process moves toward an equilibrium (Fararo 1989), though this equilibrium could be a static (non-oscillating) one or a dynamic (oscillating) one. When an equilibrium or steady state is reached, then the set of clusters is a system of groups and not just transient states called p-groups. My simulation tries to capture a general process by which a network as a generator works itself out as far as it will go under the given parametric conditions.

4.6.8 Overview of Decision Rules

CP1 is the first "Cycle of Popularity" model. It models a rational actor who makes friendship choices based on the value of status. My second "Cycle of Popularity" model (CP2) modifies the CP1 by adding the effect of evaluative gossip on an actor's choosing of a target for her friendship offer and making decision about friendship offer, and thus being directed more in the direction of the value of egalitarianism. CP2 implements the adaptive behavior of altering her sub-goals in accordance to the

expressive behavior by taking the compliance of value of egalitarianism into account when an actor chooses a target for her friendship offer and making decisions about friendship offer. The last model, called the "Enemy model" (CP3), adds a new element to CP2 in order to model girls' weighing of individualism against group commitment when they make decisions about friendships.

In terms of the logic of model building, CP1 emphasizes girls' endorsement of the value of increasing status by becoming more visible. CP1 assumes that girls initiate friendship offers based on visibility level with the aim of becoming popular. When they are rejected in their friendship offers, they regard the rejecting person as stuck-up and come to dislike them. CP2 adds to CP1 the behavioral assumption of empathetic connection to others and consequent formation of collective feelings of conviction that "rejecting a friendship offer is unfair and in violation of the norm of egalitarian relationship." CP2 models expressive behavior that takes others' information of compliance of the egalitarian value into account when an actor makes decision about choosing a target and accepting friendship offer. CP3 adds to CP2 a third behavioral assumption of girls' indirect aggressiveness toward their former friends who violated the norm of group commitment, labeling them as a betrayer and sending "enemy" ties, and thus endorse the statements that "success in individual competition by betraying friends is in violation of the norm of friendship based on loyalty and trust." The girls' indirect aggression will take the form of gossiping about these violations.

4.6.8.1 Model 1: Baseline "Cycle of Popularity" Model (CP1)

The first model, CP1, assumes that actors are more likely to make a friendship offer to a target with high status. This reflects an actor's rational calculation that hanging out with others with high status helps to increase her own status. The first behavioral rule specifies that when an actor is rejected her friendship offer, she becomes angry and sends a dislike tie to a rejecting person[74]. Here, my simulation

[74] The specification that negative ties are formed only on the basis of rejection of friendship offers may strongly constrain the process of network formation and the development of a status ordering among the actors by not including other mechanisms such as bystander mechanism in the formation of negative sentiments. The reason for this is that my simulation is intended to focus and explore the mechanisms of "Cycle of Popularity." Although my simulation model does not include explicitly triadic bystander elements, it incorporate the role gossip plays in the process of network formation, which allow us to include interlocking among dyads.

makes the choice process probabilistic. More specifically, my simulation chooses a target based on probability distribution where each possible target actor (i=1. . . N-1) has a S_{1i} value and then the probability that a possible target is chosen is given by her S_{1i} divided by the sum of all the S_{1i} from i=1 to N-1[75]. The advantage of making the choice process probabilistic rather than deterministic by choosing a target with the highest S_{1i} value is to avoid a single actor with highest status score in the network receiving all the initial friendship offers.

4.6.8.2 Model 2: Modified "Cycle of Popularity" Model (CP2)

The second model (CP2) examines the effect of evaluative gossip on choosing a target for friendship offer and making decision about friendship offer. In CP2, an actor is assumed to take others' experience into account when she chooses a target for her friendship offer, and adaptively refrain from choosing ones who violate the norm of egalitarianism. Considering an actor's empathetic connection to others, the second behavioral rule in the CP2 modifies the first one (CP1) by incorporating the role network structure plays on selecting a target of friendship offer or making decision about acceptance by taking into account a penalty for being stereotyped as stuck-up (through evaluative gossip). This modified status index is defined as follows:

$$S_{2i} = S_{1i} / (m_i+1) \qquad 0 \leq S_{2i} \leq 1$$

where m_i is the number of the choosing actor's friends whom the target *i* has previously rejected, and *i* ranges over all remaining possible targets. Therefore, the denominator of the modified status index represents a penalty of being stereotyped as stuck-up, and interpreted as violating the value of egalitarian relationship with the choosing actor's friends. As the given actor *i*'s penalty for being stereotyped as stuck-up increases, her value of S_{2i} decreases and hence she is less likely to be chosen as a target of friendship offer. Additionally, from *i*'s point of view, she becomes more likely to be rejected in her friendship overtures to others. In this model, when an actor makes a friendship offer, she is more likely to choose a target whose value of S_{2i} is high in a network. Additionally, when an actor makes decision

[75] Since the distribution is discrete, one can easily calculate its corresponding cumulative distribution function. One can then simply chooses a number from a uniform distribution (0, 1) and determine the corresponding actor index.

about friendship acceptance, S_{2i} is used to represent girls' expressive behavior of complying the norm of egalitarian relationship by penalizing those who violated this before. As in CP1, CP2 also makes the choice process probabilistic. If we write m_i as $k*m_i$ with k=1 for model 2 and k=0 for model 1, then we capture model 1 as a special case of model 2. It is important to note that an actor's decision is now influenced by constraints in network structure.

4.6.8.3 Model 3: Enemy Model (CP3)

My third model considers the third value of loyalty and trust by making a commitment to the current group members, and the consequences of violating the norm of group commitment in terms of indirect aggressive behavior. Since friendship with popular girls is an important avenue for peer status, a betrayal of one group for another leads many of her old friends to *strongly* dislike her (Eder 1985, p.160-1). Therefore, once a less popular WM adolescent has her friendship offer accepted by a more popular WM adolescent and becomes a member of a more popular group, she ends up receiving "enemy" ties (not "dislike" ties) from her former friends, and is considered as violating the norm of loyalty through group commitment. Assuming that other WM adolescents are actively participating in indirect aggressive behavior through gossiping (by adjusting their opinions about others in response to others' experience), the "enemy model" incorporates the third behavioral rule that models indirect aggressiveness toward those who violate the female gender expectation of loyalty and trust in friendship relations (by labeling them as a betrayer and sending "enemy" ties).

CP3 assumes that an actor tries to balance an individual success in increasing status, and the gender norm of loyal and trustful relationships by making commitment to her current p-group members. Here, an actor is assumed to make decision so that increasing Status ($S_{1future}$) would exceed Indirect Aggression from her current p-group member ($S_{1current}$). Mathematically, if

$\beta*S_{1future} - (1-\beta)*S_{1current} > 0$, accept friendship offer

Otherwise, reject it.

Where β is a weight parameter that ranges from zero to unity and I call this the "disloyalty" parameter. Thus, when β is zero, all the weight goes to the second term ($S_{1current}$) and when β is one, all the weight

goes to the first term ($S_{1future}$). When β is a half (0.5), it drops out of the equation. The first term ($S_{1future}$) is the average value of status scores of the offering p-group theoretically including herself, and the second term ($S_{1current}$) is the average value of status scores of her current p-group.

My simulation introduces the disloyalty parameter β to control an actor's consideration of the worth of joining another p-group to increase her status (and thus violating the norm of commitment by betraying her current friends) versus staying in the present p-group to make commitment to current p-group members (by obeying gender norm of trustful relationship). The greater the value of β, the less loyal the actor is to the current group. Thus it would seem meaningful to explore the values of disloyalty parameter at 0.2, 0.3, 0.4, and 0.5. When an actor has not formed p-group yet, CP2 is inherited to decision criteria. CP3 assumes that gender norms exist among WM adolescents in the first place by relying on research findings from qualitative feminist research, and therefore current simulation does not model the emergence of gender norms per se. In the following section, I will show the details of these models.

As we shift from model CP1 to model CP3, we see increasingly sophisticated models[76] that reflect the fact that "*people are routinely capable of detecting, reasoning about and acting on the macro-level properties (the emergent features) of the societies of which they form part*" (Gilbert 1995, p.151). In my models, the relationship between micro and macro properties are conceptualized by forcing actors to make decisions based on her personal image of the network (through the medium of message exchange), and this reflects the influence of macro-level emergent properties on micro-level actions.

4.6.9 Details of Transition Rules

My simulation models specify allowable actor behavior in terms of (A) forming asymmetric positive ties, (B) forming symmetric positive ties, and (C) forming negative ties. All models share the same decision rules in (A), while they are different in (B). In the beginning of the simulation run of all models, the IQR of $\{S_{1i}; j = 1, \ldots, N \mid \alpha=0.2\}$ is calculated. All models use the half-IQR in calculating

[76] Gilbert (1995) argues for sophisticated models as essential to model human interaction if "we are to progress with the simulation of human societies" (p.155).

the measures of *association acceptability* for a given actor. Essentially, when an actor has a choice as to whether or not to associate in some way with another actor, this check is performed. This will affect an actor's choice of to whom friendship offers are made, and their decisions regarding offers from others. More specifically, this "within half-IQR or exceed" criterion is used in the following three types of situations and rules. These explanations will be forthcoming in the next section.

1. When an actor cannot find anyone who exceeds her status level (in the raw sense of a strict comparison of the two S_i) at the time of choosing a friendship offer target.
2. When an actor is deciding whether to accept or reject an asymmetric positive tie formation.
3. When an actor is deciding whether to accept the formation of a *symmetric* positive tie formation with a *p-group member* in CP3.

4.6.9.1 Formation of Asymmetric Positive Ties

Formation of an asymmetric positive tie starts with the acceptance of a friendship offer. In model CP1, reciprocations of friendship ties are automatic in the case of an offer from a higher-status actor, but not in the case of accepting an offer from a lower status actor. "Automatic" means that the conditional probability of friendship tie formation is unity when an offer is made from a higher status actor to a lower status actor. This is further relaxed for model CP2 and CP3, as being accepted does not necessarily ensure being reciprocated. The reason for this is to avoid the confounding mechanism of reciprocity in my simulation study.

In the case of CP1, more specifically in "automatic reciprocation," the actor making the offer interprets the offer as having been accepted (and reciprocated) and thus a "perceived" acceptance on the part of the offering actor exists. This "perceived" acceptance means that, from the network image of an initiating actor, she becomes a friend and group member of an accepting actor (there exists positive symmetric tie, from the initiating actor to the accepting actor). Essentially, the offering actor knows that the target will be a new group member before the target does.

In the cases of CP2 and CP3, while an accepting actor is not necessarily a friend of an initiating actor, there does not exist a "perceived" positive asymmetric tie from an accepting actor to an initiating actor. In these models, the accepting actor may make friendship offers to other desirable targets in a network at the same time accepting friendship offers from less desirable others (without reciprocation). In this case, since the tie between an initiating actor and an accepting actor is not reciprocated, they do not necessarily belong to the same p-group (unless both happen to have a common reciprocated third actor). This assumption that "reciprocation does not necessarily follow friendship acceptance" is reasonable since as long as an actor has her own desirable reciprocated friends, she would not be bothered by incoming asymmetric ties from less desirable but socially acceptable others. In addition, she would even benefit from receiving gossip from them.

As a side note, since it is unlikely that a single solitary cheerleader would desire to remain isolated (no friends at all), in this rare case, my simulation specifies one exceptional in asymmetric tie formation: the penultimate cheerleader, who might be otherwise barred from making offers to those of lower status because her status far exceeds any other actor, is allowed to make offers to the next-highest actor (who may or may not be a cheerleader in their own right).

4.6.9.2 Formation of Symmetric Positive Ties

In forming symmetric ties (and hence forming shared p-group membership), both CP1 and CP2 use the "within half-IQR or exceeded" criterion that relates to falling outside the range defining "my equal" when individuals make decision about acceptance[77]. On the other hand, CP3 modifies decision rules when an actor makes a decision about reciprocated tie acceptance that represents girls' conflict between the values of increasing status versus group commitment.

In CP3 model, individuals make decision based on status score (S_{1i}) at the p-group level. CP3 implements that when an actor responds to the friendship offer from an actor with different p-group membership to form symmetric ties, the receiving actor first calculates the average value of status scores

[77] Since individuals' status value may be updated by making a friend with cheerleader, it is not guaranteed that asymmetric friend ties lead to symmetric friend ties.

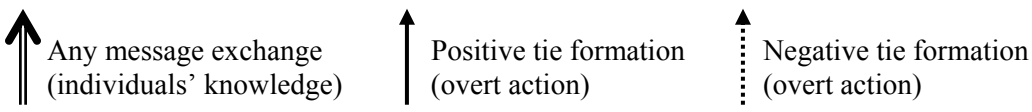
of her present p-group, and compares this value with the average value of status scores of the offering p-group plus herself. The weight of the comparison of these two averages is controlled in terms of the parameter β. If the average value of the weighted status score for her current p-group is less than the average value of weighted status score of her potential new p-group, she accepts the offer, and hence she will betray the former friend(s). If not, then she will not. When an actor responds to the friendship offer from an actor with the *same* p-group membership to form a symmetric tie, the receiving actor does not consider this betrayal (both parties share the same p-group membership) and so makes her decision based upon her usual default criteria of "within half-IQR or exceeded."

4.6.9.3 Formation of Negative Ties

Negative ties are composed of "dislike" ties and "enemy" ties. The former is used for all models and the latter is used only for CP3 that model betrayal behavior. There are two cases of the formation of negative ties. The first case is that an individual sends a "dislike" tie as a response of being rejected by a target that she made a friendship offer to previously. The second case is that an individual sends a "enemy" tie as a response to being notified that a current p-group member has betrayed her by joining another p-group (i.e. as a result of changing p-group membership).

4.6.9.4 Illustrations of Transitions

The following examples illustrate the possible transitions during a simulation run. The process of message exchange and resulting tie formation will be explained by using actor A and actor B, where the latter has higher status than the former ($S_{1A} < S_{1B}$). In addition, the example of "enemy" tie formation uses an actor C who has higher status than B ($S_{1B} < S_{1C}$). I use the following symbols to represent message exchanges and tie formation.



It is worth pointing out that just sending a friendship "offer" message does not automatically lead to actual positive tie formation. Any ties are formed through the processes of exchanging "response" message, "notifying" message, or "gossiping" message.

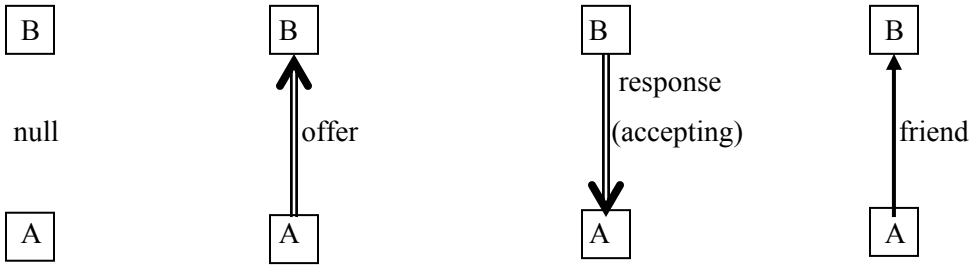
4.6.9.4.1 TIE CHANGE FROM "NULL" TO "FRIEND"

When an actor makes decision about acceptance of friendship offer, the resulting state of dyad is either *asymmetric* positive tie formation or *symmetric* positive tie formation.

4.6.9.4.1.1 Transition From "Null" To "Asymmetric" Friend

For the formation of asymmetric positive tie, no tie exists between a receiving actor (B) and an offering actor (A) initially, and B uses the "within half-IQR or exceeded" criterion to make decision about accepting offer from A. The process of message exchange between A and B to complete asymmetric friendship formation is illustrated in Figure 3. Time progresses from left to right.

Figure 3: Formation of Asymmetric "Friend" Tie



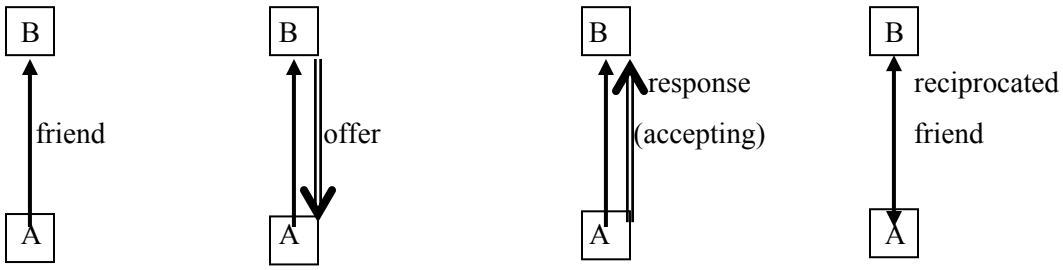
Starting at "null" tie condition between A and B (the first figure), A sends her friendship "offer" message, and B receives it (the second figure). B accepts A's offer based on her decision logic, and then sends "response" message about the acceptance to A (the third figure). Finally, A notes B as a "friend" (the last figure).

4.6.9.4.1.2 Transition From "Asymmetric" To "Symmetric" Friend

Assuming A (lower status) has an asymmetric tie to B (high status), if a higher status actor makes an offer to a lower status actor, and the latter accepts, then a symmetric friendship tie is formed. Here, the receiving actor (lower status actor) makes a decision about acceptance by comparing status scores

between the offering actor (high status actor) and herself. The expected sequence of forming a symmetric positive tie is illustrated in Figure 4, but this is not the only possible sequence.

Figure 4: Formation of Symmetric "Friend" Tie

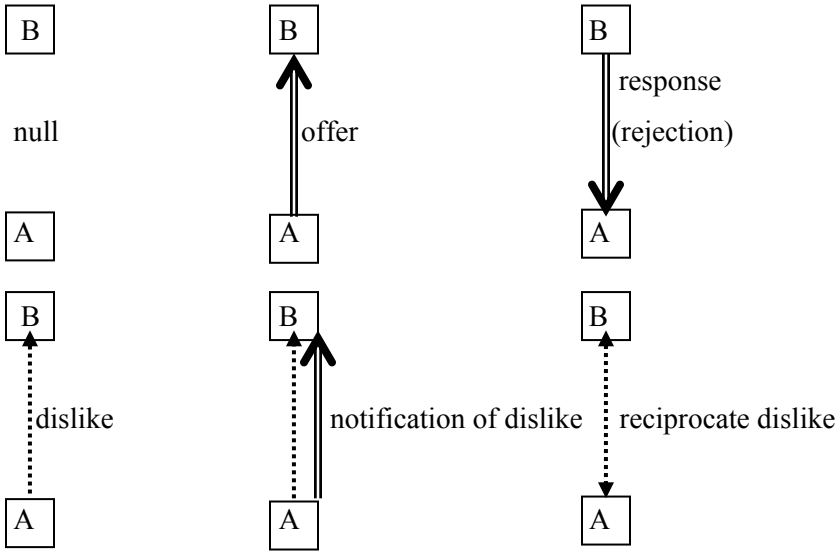


More concretely, starting with the asymmetric tie from A to B (the first figure) in Figure 4, B sends her friendship "offer" message (the second figure), and A receives it. A accepts B's offer based on her decision logic, and A sends "response" message about acceptance to B (the third figure). Then, B notes A as a "friend" (the last figure).

4.6.9.4.2 TIE CHANGE FROM "NULL" TO "DISLIKE"

Starting from a lack of any tie between a receiving actor and an offering actor, the formation of negative asymmetric tie occurs when an actor does not accept a friendship offer (based on the "within half-IQR or exceeded" criterion). The process of message exchange is illustrated in Figure 5.

Figure 5: Formation of "Dislike" Tie



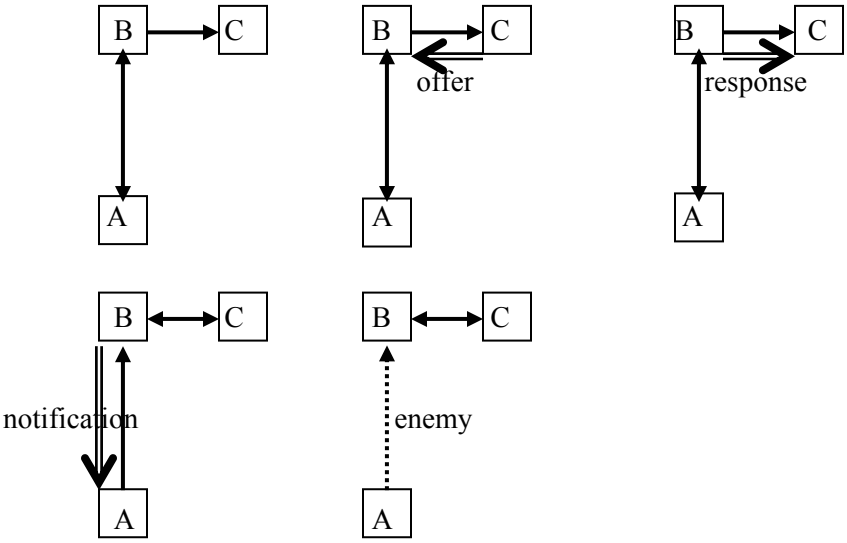
Starting with a "null" tie condition between A and B (top-left figure), A sends her friendship "offer" message to B (top-middle figure). However, B does not accept her offer, and sends "response" message

with a rejection to A (top-right figure). Note that CP model does not distinguish between true rejection and simply being ignored. Since A was not accepted by B, A notes B as "dislike"(bottom-left figure), and A sends "notification" message about asymmetric negative tie formation from A to B so that B can realize that A dislikes her (bottom-middle figure). Since B now recognizes that A does not like her, it is reasonable to assume that B will reciprocate dislike tie to A (bottom-right figure).

4.6.9.4.3 TIE CHANGE FROM "FRIEND" TO "ENEMY"

This transition occurs only in CP3 model. When an actor changes her p-group membership to another one, her previously reciprocated friends (who shared the former p-group membership) send "enemy" ties to her as punishment for her betrayal behavior. The following example in Figure 6 shows the process of generation of "enemy" tie from A to B as a result of B's changing her p-group membership.

Figure 6: Formation of "Enemy" Tie



A and B have reciprocated their friendship (and hence share the same p-group membership), but B also has an asymmetric positive tie to C (top-left figure). When C sends a friendship "offer" message to B (top-middle figure), since the average status score between B and C is greater than the average status score between A and B, B sends a "response" message about acceptance to C (top-right figure). Now, B reciprocates her friendship with C and shares the same p-group membership by severing the tie from B to A since B cancels the same p-group membership with A. Then, B sends a "notification" message about

p-group change to A (down-left figure). Since A interprets B's behavior of changing her p-group membership as a betrayal, A notes an "enemy" tie to B (down-middle figure), and then gossips to her friends about A's new p-group (indirect aggression). Unlike in the case of a dislike tie where the target of the negative tie is notified directly, depending on the tie structure of the network, B may or may not receive "gossip" messages about "enemy" incoming the "enemy" tie from A.

Recall that my simulation specifies that in the case of a "dislike" incoming tie, the recipient of the negative tie will be informed by direct notification (first-hand), while in the case of "enemy" incoming tie, the target of the enemy will be informed by indirect notification (second-hand). This is reasonable assumption to make since it may be easier in the former case to explicitly express the "dislike" feeling to the rejecting actor, compared with the latter case where the receiving actor does not necessarily perceive "enemy" incoming ties from her former friends while at the same time she is being derided behind her back by those friends. This reflects the notion of "indirect aggressiveness."

It is worth pointing out that in the case of generating an "enemy" tie, tie transition from the perception of the betrayed actor occurs from "friend" to "enemy," while in the case of generating a "dislike" tie, tie transition from the perspective of rejected actor occurs from "null" to "dislike." This difference in previous tie states is worth examining further. In the case of "dislike" tie formation shown in Figure 5, B's rejection of A's friendship offer happened before A actually noted her feeling to B in her mind. Therefore, the actual state of the tie is still "null," and then changes to "dislike." On the other hand, in the case of forming an "enemy" tie shown in Figure 6, A already noted B as "friend" and B's betrayal behavior happened after this. Therefore, the transition is from "friend" to "enemy."

4.6.9.5 Comparisons Among Models Based on Decision Rules

Table 2 summarizes three simulation models in terms of (1) selection of a target for friendship offer, (2) the formation of symmetric friendship, and (3) response to friends' p-group membership change from the perspective of low-status individual.

Table 2: Summary of Model Differences

Models / Events	Baseline Model (CP1)	Modified Model (CP2)	Enemy Model (CP3)
(1) Selection of a target	Stochastic choice of actor with high S_{1i}	Stochastic choice of actor with high S_{2i}	Stochastic choice of actor with high S_{2i}
(2) Symmetric friendship formation	Individual-level status comparison S_{1i} (Association acceptability)	Individual-level status comparison S_{2i} (Association acceptability)	P-Group-level status comparison S_{1i} (under weight parameter β)
(3) Response to p-group membership change	No reaction	No reaction	Send enemy tie

There is a difference between CP1, CP2, and CP3 when an actor selects a target for her friendship offer. In CP1, an actor stochastically chooses a target based on the simple status score (S_{1i}), while in CP2 and CP3, an actor uses modified version of this status score (S_{2i}). When an actor tries to form reciprocated friendship, CP3 differs from CP1 and CP2 in the criterion that an actor employs to make decision about acceptance: CP1 and CP2 use actor-based comparison criterion, and CP3 uses p-group-level comparison criterion. When an individual changes her p-group membership by reciprocating a positive tie with a member of another p-group, the difference between CP1 and CP2, and CP3 become apparent. In CP1 and CP2, when an actor changes her p-group membership, her previous friend who used to share the same p-group membership does not react to her friend's switching current p-group membership. On the other hand, in CP3, when an individual changes her current p-group membership, her former friend(s) who shared the same p-group membership reacts indirectly to her betrayal behavior by sending enemy ties and by gossiping. All models use the criterion of association acceptability (criterion of "half-IQR or exceeded"), and in CP1, the case of a downward asymmetric friendship tie results in automatic reciprocation.

4.6.10 Validation

One of the issues that always arise when using any model is validation, and I will address this in two parts: Face Validity, and Verification.

4.6.10.1 Face Validity

Face validity refers to the way of checking a model (right type of thing to use), and in my case, to model WM American adolescents. Qualitative, empirical research findings are quite detailed in explaining the individual's behavior and social processes. My baseline CP model (CP1) is a reasonable simplification of reality by representing an individual's rational behavior of tendency of choosing the individual with the high status value in a network as a target of friendship an offer to achieve their goal. My modified CP model (CP2) takes empathetic connection to others into consideration, which helps to increase face validity of the baseline CP model. The Enemy model (CP3) incorporates the anthropological findings of indirect aggressiveness into the sociological or social-psychological account of the effect of gendered norm of egalitarianism on individual's behavior by introducing enemy feelings toward a betrayer in a wake of breaking trustful relationship and gossiping as such among friends. This inter-disciplinary approach increases the expressiveness of the model in a way that is consistent with observed behavioral patterns among WM American adolescents by qualitative sociologists. My simulation takes a multi-agent modeling approach, and that is cognitively realistic even though it is still limited (as will be discussed later), and hence increases face validity by simulating individuals.

4.6.10.2 Verification

Verification refers to a set of techniques to determine the validity of models' prediction relative to non-computational, real-world data. Verification involves testing a model's predictions given a set of real data. In order to demonstrate that my model's predictions approximately match non-computational data, non-computational results as well as the results of a virtual experiment must be available. However, it is quite difficult to obtain a real dataset that contains information about individual attributes such as attractiveness level and negative feelings toward others such as "dislike" and "enemy" feelings, let alone time-series data of any kind. Maureen Hallinan's data about adolescents in the middle schools contains

longitudinal information about friendship relations (7 time points during academic year) and she did not limit the students to a maximum number of friends. However, her data does not contain information about negative feelings toward others, attractiveness level, and cheerleading status.

Since my simulation takes (non-uniform) multi-agent approach, information about an individual's attributes is essential, but Hallinan's lacks this information. Modell and Trent's (1997) data about high school students does contain such information. His dataset contains the information about friendship relations, students' attractiveness, and official extra-curricular activities (school organized activities). However, I cannot use their data because their data come from high school students who would not reflect early adolescent peer relations. This issue of the difficulty of collecting the desired data will be discussed later in this paper.

4.6.11 Global Parameters

All models will explore all combinations of the parameters in a given parameter space as generic properties of a process. My selection of global parameters refers to some empirical findings with respect to relationship between school-sponsored extracurricular activities and peer status processes (Eder & Kinney 1995). My simulation specifies the following global parameters:

1. Number of actors {10, 20, 30, 40}
2. Cheerleader density {0.1, 0.2, 0.3, 0.4}
3. Weight parameter β in the Enemy Model (CP3): {0.2, 0.3, 0.4, 0.5}

My simulation study assumes that cheerleading position is an institutionalized social role in the American school environment that exists as embedded in the systems of social networks. Therefore, my simulation specifies certain background conditions that could be at least one "cheerleader" in the context of initial state. The number of cheerleading positions is specified for each level of number of actors and calculated by multiplying the value of cheerleader density by number of actors. The weight parameter β controls an actor's consideration of increasing her status versus making commitment to current p-group members, which is used only in CP3.

4.6.12 Statistics Calculation for Final Network Structures

My simulation uses a reciprocity measure and a measurement of hierarchy and inequality to describe the characteristics of the resulting network structures as well as actor attributes under each parametric condition. The level of reciprocity is evaluated by calculating the proportion of mutual dyads for both positive ties (friendship) and negative ties (dislike or enemy relation). The level of hierarchy is evaluated by obtaining the length of the longest path of upward negative ties that reflect the levels of hierarchy in the final network. The measure of inequality is evaluated in terms of the mean log deviation by individual final status values.

4.6.12.1 Measure of Reciprocity

The proportion of mutual ties is calculated as follows:

For the proportion of positive mutual ties (P_+):

$$P_+ = n_+ / [N(N-1)/2] \qquad 0 \le P_+ \le 1$$

Where n_+ is a count of positive mutual dyads and N is the number of actors in the network

Similarly, for the proportion of negative mutual ties (P_-):

$$P_- = n_- / [N(N-1)/2] \qquad 0 \le P_- \le 1$$

Where n_- is a count of negative mutual dyads and N is the number of actors in the network

4.6.12.2 Measure of Hierarchy

Any negative upward ties from lower status to higher status actors reflect the levels of hierarchy in the resulting network, while symmetric positive ties reflect intra-level actors of "equal" level in the hierarchy. Thus, a measure of hierarchy can be calculated by simply following the upward-directed negative ties of the network. Algorithmically, obtaining the length of the longest upward path of negative ties (starting from any actor) should reflect the overall number of levels in the hierarchy. The first step in calculating this measurement is to create a recoded matrix R, where:

$$R_{ij} = \begin{cases} 1, & \text{if } S_{1i} < S_{1j} \text{ and the arc (i,j) is negative} \\ 0, & \text{otherwise} \end{cases}$$

The new matrix R (which I call rank matrix) is then searched for the maximum length path that exists from a given actor to any other actor. This resulting maximum will be my measurement of hierarchy. The standardized version of this measure is obtained by dividing maximum possible path length of (N-1).

My study also calculates a measurement of hierarchy at the cluster level by using a rank matrix R. The algorithm for obtaining a cluster-level measurement of hierarchy is similar to the method used by Hummon and Fararo (1995b) to measure hierarchy in a network, where clusters were defined by cycles and positive arcs defined the hierarchy. Their algorithm first extracts cyclic clusters from the original matrix and then creates a clustered matrix by "condensing" the original matrix. Then it finds the longest path that is normalized against number of actors minus unity. In my case, instead of using cycles I used positive reciprocated ties to define clusters, and negative upward arcs were used to define the hierarchy. My algorithm starts by extracting the symmetric tie clusters from the original matrix, and then creates the clustered matrix by condensing the rank matrix. Lastly, it finds the longest path that is normalized against number of actors minus unity. This measure reflects the level of hierarchy at the cluster level.

4.6.12.3 Measure of Inequality

Based on the outcome of N individual status values (S_{1i}), a single statistic of mean log deviation as a measure of inequality will be calculated. Mean log deviation is the member of the Generalized Entropy class GE(λ)[78] with parameter λ.

$$GE(\lambda) = \frac{1}{\sum_i w^k} \sum_i \frac{w_i^k y_i}{\mu(n)} \log\left(\frac{\mu(n)}{y_i}\right)$$

[78] When λ =1, it becomes Theil's T index and when λ =2, it becomes squared coefficient of variation. As the value of parameter increases, GE is more sensitive to changes that affect the upper tail. Because of conversion from tie to ranking, it is appropriate to choose small value of α which is more conservative. So, my simulation employs GE(0) as a measure of inequality. Generalized Entropy class meets the six criteria of desirable inequality measures:

1) Mean independence (the inequality measure should be invariant to uniform proportional changes)
2) Population size independence
3) Symmetry (the inequality measure should be independent of any characteristic of individuals other than their status value)
4) Pigou-Dalton Transfer sensitivity (the transfer of inequality value from high values to low values reduces measured inequality)
5) Decomposability (inequality may be broken down by population sub-groups)
6) Statistical testability (test for the significance of changes in the index over time).

(The World Bank Group 2000, URL: http://www.worldbank.org/poverty/inequal/).

The Mean log deviation is the final result for the above equation. For each run (100 replicates) under the given parametric condition, mean log deviation, GE(λ=0; w_i^k=1), is calculated. The formula of GE(0) is follows:

$$GE(0) = \frac{1}{n}\sum_i \log\left(\frac{\bar{y}}{y_i}\right)$$

Then the mean of GE(0) (and the standard error of GE(0)) is calculated for each parametric condition. The values of GE(0) measures vary between zero and infinity, with zero representing no inequality and higher value representing a higher level of inequality.

5 Chapter V: Results and Discussion

This study graphically shows the emergence of a "stable hierarchy of cliques" that Eder and colleagues found by presenting some concrete simulation runs. The movie of a given simulation shows how the actual structure of the network evolves, showing the emergence and dissolution of ties as (virtual) time progresses. The movies shown will have a low number of actors for simplicity, though the actual analyzed simulations will have much larger numbers of actors. The initial goal here is to examine some simulated outcomes relating to the development and stabilization of network realizations. Then my paper will present the more abstract statistical analysis by showing the results of the measures of reciprocity, hierarchy, and inequality among actors, respectively for simulations with many more actors.

5.1 Movie of the Simulation

A movie of how the network structures change during simulation is provided for each model, and videos of sample simulation are presented for each model. In the following few paragraphs, I will explain how to read the movie format.

Parameter Space:

I specified parameter space in the following way:

Number of actors: 8

Cheerleading density: 0.25

Weight factor (α): 0.2

Weight factor (β) for CP3: 0.5

Networks

There are 9 networks shown in the sample run (8 actors + 1 analyst's). The network inside light-blued box in the middle is an analyst's representation of the whole network (global map) that is a collection of each actor's personal image of her own outgoing relationships at each point in virtual time. Virtual time point is shown at left top of global map. This is the network used for calculation of the final statistics at the end of each simulation run. In addition to a global map, 8 actors' cognitive maps of the network that represent individuals' knowledge about relationships at the given point in time surround the central analyst's map. When a specific actor wakes up to process messages, a pink-colored @ mark will appear on the left bottom of her cognitive map, which may or may not signal a change of ties. In addition, the @ mark on the left bottom of the global map is shown all the times when any actors remain in the active stage of their life cycle. When a global map converges, @ mark will disappear, though for small numbers of actors this usually coincides with the end of the simulation run. Additionally, a "wall clock" of virtual time is located in the upper left-hand corner of the analyst's map, which will turn pink every time it changes to a new point in time. It will revert back to black to indicate that the changes to the network for that frame of the movie technically are occurring "simultaneously" with the previous frame that had a pink time change. This time dilation is purely for illustrative purposes, and the actual simulations do not in fact run this slow and the actors do in fact perceive events according to the "wall clock" virtual time.

Actors

There are 6 non-cheerleaders (A, B, C, D, E, F) and 2 cheerleaders (G, H). Cheerleaders are marked by double-circled symbols, and non-cheerleaders are marked by single-circled symbols. The actor for which the cognitive map corresponds to is marked by orange-colored symbols. Each actor has her status value on the upper left of her cognitive map following the semicolon. When a non-cheerleader in fact makes a friend with a cheerleader, her status will increase and her updated status value turns into pink color momentarily.

Ties

Thin arrows represent asymmetric ties, and thick arrows represent symmetric ties. My video uses both color and line patterns to represent the type of ties in the following way:

Green, Solid: Friend ties

Blue, Broken (Short): formation of Dislike ties due to a reason other than direct Rejection

Blue, Broken (Long): formation of Dislike ties as a response to a Rejection Message

Red, Broken: formation of Enemy ties (only for CP3).

5.1.1 Sample Video of CP1

In CP1, an actor stochastically chooses a target based on the target's status value (S_{1i}). When an actor tries to form a reciprocated friendship and hence share the same p-group membership, CP1 uses actor-based comparison criterion. In the following, I provide examples of (1) formation of an asymmetric "friend" tie, (2) a formation of a "dislike" tie, (3) formation of a symmetric "friend" tie, (4) formation of automatic reciprocation, and (5) change of p-group membership. The simulation starts from pure null ties, and status values were stochastically determined for each actor (and resulted in a half-IQR value of 0.22).

(1) Formation of an asymmetric "friend" tie

At Time 54 (see E's cognitive map), E received a friendship offer from D, and E accepted D's offer because D's status value was within the half-IQR range. Consequently, E notes a "friend" tie from D to E, and sends a "response" message of acceptance to D. At Time 121 (see D's cognitive map), D received this "response" message, and notes a "friend" tie from D to E in her cognitive map.

(2) Formation of a "dislike" tie

At Time 68 (see B's cognitive map), B received a "response" message from H about the rejection of B's friendship offer to H (made earlier in time), because B's status value is outside of the half-IQR range of H. As a result, B sends her "dislike" tie to H and notes it in her cognitive map. At Time 159 (see H's cognitive map), H received a direct "notification" message about "dislike" tie from B to H, and H reciprocates the "dislike" tie to B.

(3) Formation of a symmetric "friend" tie

At Time 143 (see C's cognitive map), C got a friendship offer from E, and C accepted it, which resulted in the formation of a symmetric tie between C and E, and thus C and E are now sharing

the same p-group membership. At the same time point (see E's cognitive map), E is notified by C about the acceptance and E notes C as a friend and updated her p-group to be composed of the set of actors {C D E} in her cognitive map.

(4) Formation of automatic reciprocation

At Time 45 (see D's cognitive map), D received an offer from F who is higher than D in status, and so D accepts and then reciprocate her friendship with F. At the same time point in F's cognitive map, F notes her friendship tie to D and then notes a reciprocated tie between F and D, sharing the same p-group membership with D.

(4) Change of p-group membership

At Time 307 (see E's cognitive map), E received an offer from F who is higher than E in status, and so E accepts it, forming sharing p-group membership with F. Here, E (a lower status actor) changed her p-group membership with C to join F's p-group membership and temporarily canceling her shared p-group membership with C (but it is expected that eventually C will join E and F's p-group eventually by re-forming mutual tie with E). This process is shown at Time 404 (see E's cognitive map) where E forms a mutual tie with C, which results in C's (the lower status actor in this dyad) changing her p-group membership.

This simulation run converged at Time 524 (the @ mark at left bottom of global map disappears at this point in time), and the final results for the run was the formation of two clusters: a high status {H, G} and a middle-low status {A, B, C, D, E, F}, whose average status values were 0.89 and 0.37 respectively. This is only one particular realization, but variations in outcomes under identical parametric conditions would come from the stochastic initialization of assigning status values to actors in network**.** It is important to note that processes of stochastically choosing a target of friendship offer rarely affects the outcome since actors do not rely on gossip when they choose a target of friendship offer (this will be discussed more in the section of CP2).

With respect to each actor's cognitive image of network structure, actors who share the p-group membership tend to recognize other member's tie states, but not to recognize other p-group members'

states of positive ties. Closer observation shows that, among medium-low p-group members, for those whose status values are low (such as A and B), their images of in-group are less complete than those of the actors with higher status in the same p-group (such as D and E). The reason for this would be that low status actors tend to form friendship ties with their current p-group members. Since my simulation allows only newly formed ties to propagate, the states of ties that were formed previously before joining membership would not be gossiped to the new friends.

With regards to the statistics for the final network, the number of positive reciprocated dyads was 11 (proportion is 0.39), and the number of negative reciprocated dyads was 17 (proportion is 0.61). The length of the longest upward path of negative ties was 2 at the actor level and was 1 at the cluster level. The mean-log deviation is 0.16. It is interesting to note that the resulting structure is consistent with Heider's (1946) structural balance theory.

5.1.2 Sample Video of CP2

In CP2, an actor stochastically chooses a target based on the target's modified status value (S_{2i}). When an actor tries to form a reciprocated friendship (and hence share the same p-group membership), CP2 uses an actor-based comparison criterion. In the following, I provide an example of a non-cheerleader becoming a friend of cheerleader and some associated side-effects effect. This demo was also intended to show an instance of the effect of evaluative gossip on choosing a target for friendship offer. However, since the number of actors is small, by the time gossip of friendship rejection is propagated, most actors in network have already offered those rejecting actors. In this particular demo, an instance of an actor receiving the penalty for a prior rejection does not occur. It is expected that this event is more likely to occur when there are large number of actors in the network. The simulation starts from null ties and status values are stochastically determined for each actor, and resulted in a half-IQR of 0.26.

Non-cheerleader becomes a friend of cheerleader

At Time 102 (see F's cognitive map), non-cheerleader F was accepted her friendship offer by a cheerleader H, and now F makes (reciprocated) friend with H. Consequently, F's status increased from 0.72 to 0.82, and her updated status value turns into pink momentarily. At Time 178, F

reciprocates her friendship with G and shares the same p-group membership with G, canceling her former p-group membership with E. In this demo, F does not form mutual tie with E because after increasing her status value, the difference between F and E in their status values is more than half-IQR (0.26<0.35), which ended up with separating p-group membership between F and E.

This simulation converged at Time 601, and ended up with forming two clusters of {F, G, H} and {A, B, C, D, E} whose average status values are 0.91 and 0.32 respectively. Again, this is only one particular realization of CP2, but variations in outcomes would arise depending on when non-cheerleaders attempt to make friendship offer to cheerleaders. For instance, if a non-cheerleader B stochastically selects, and then subsequently forms a tie with another non-cheerleader C at the earlier point in time, B is more likely to have heard about C's experience of being rejected by cheerleader A, which would decrease the probability of choosing A as a target. This new, decreased value may then be beyond the half-IQR range in B's mind (due the violation of norm of egalitarianism). Conversely, when cheerleader A makes friendship offer to B who has already heard about her friend C's experience of being rejected by A, her offer may be rejected by B if her modified status value fails to exceed B's and furthermore falls outside of the half-IQR range (in B's mind only). This means that the variation in outcome under identical parametric conditions is mainly due to the timing of cheerleaders' friendship offer to non-cheerleaders within half-IQR range (as well as to the stochastic initialization). It is important to note that information propagation plays an important role in an actors' decision making here.

With respect to each actor's cognitive image of network structure, as in CP1, actors who share the p-group membership tend to recognize other member's tie states, but this depends on when they formed positive ties (and thus began receiving gossip information from the actor in question). With regards to the statistics calculation of this final network, the number of positive reciprocated dyads was 9 (proportion is 0.32), and the number of negative reciprocated dyads was 18 (proportion is 0.64). The length of the longest upward path of negative ties was 2 at the actor level and 1 at the cluster level. The mean log deviation of status values was 0.39. Again, the resulting network is consistent with structural balance.

5.1.3 Sample Video of CP3

As in CP2, an actor with a high, modified status value (S_2) is more likely to be selected as the target of a friendship offer, but is not guaranteed to be a target. With regards to forming reciprocated friendship ties, in CP3 an actor makes decisions by balancing an individual success in increasing status and the value of group commitment to her current group members. More specifically, if the average value of the weighted status score for her current p-group is less than the average value of weighted status score of her potential new p-group (with her alone included), she accepts the offer, and hence betrays her former friend(s). This simulation video specifies the weight of the comparison of these two averages as 0.5 for simplicity (disloyalty parameter β=0.5). In the following, I will provide the example of the formation of an "enemy" tie.

The simulation starts from null ties and status values are stochastically determined for each actor, resulting in half-IQR as 0.255. At Time 71, F got a friendship offer from E and accepts it based on the half-IQR criterion, resulting in an asymmetric friendship tie formation from E to F. At Time 85, E received a friendship offer from F and accepts it, resulting in a symmetric positive tie formation between E and F, and hence sharing same p-group membership. Here, E made her decision about acceptance by calculating the average value of status score of her potential new p-group {E F}, that is (0.383+0.595)/2, which is compared with E's status score (S_{1E}=0.382). Normally, β would have an influence here, but it drops out from both sides of the comparison when β=0.5. At Time 101, G received a friendship offer from F and accepted it, resulting in an asymmetric friendship formation from F to G. At Time 111, F received a "response" message about G's acceptance and F updated her status score to S_{1F}=0.665 since F succeeded in making friend with cheerleader G. At the same time, F received a friendship offer from G and accepted it, resulting in a symmetric friendship formation between G and F and the sharing the same p-group membership. Here, F made her decision about acceptance by comparing the average value of status score of her potential new p-group {F, G}, that is (0.665+0.795)/2, with the average value of status score of her current p-group {F, E}, that is (0.665+0.383)/2. Since {F,G} is the winner, F formed new p-group with G, F canceling her previous positive tie to E and sending a "notification" message of her p-group membership change to E. At Time 139, E received the message of F's p-group membership change,

and E then sent an enemy tie to F. It is important to note that F never received any gossip about E's enemy feeling to herself, since F does not have any friends who are connected to E.

This simulation converged at Time 774, and ended up with forming two clusters of {F, G, H} and {A, B, C, D, E} whose average status values are 0.781 and 0.203 respectively. Again, this is only one particular realization of CP3, but variations in outcomes would arise depending on how often the penalty of violating group solidarity (in the form of enemy tie formation) occurs in a particular run. The frequency of betrayal behavior depends on when p-group membership of current p-group is formed at the time of friendship offer or decision-making.

With respect to each actor's cognitive image of network structure, as in CP1, actors who share the p-group membership tend to recognize other member's tie states, but this depends on when they formed positive ties. With regards to the statistics calculation of the final network, the number of positive reciprocated dyads is 12 (proportion is 0.43), and the number of negative reciprocated dyads is 16 (proportion is 0.57). The length of the longest upward path of negative ties is 1. The Mean log deviation of status values is 0.32.

All videos illustrate when (or how early) there are any shifts in networks structure for each model. In the CP1 demo, we can see the ranked cluster between a high status p-group {G, H} and a middle status p-group {C, D, E, F} was formed at earlier stage during simulation (at Time 231), with generating more upward negative ties between these p-groups. At Time 307, members of a middle status p-group changed temporarily to {D, E, F}, and at Time 338, another p-group {B, C} appeared with {A} being a singleton. However, eventually at Time 442, all actors except cheerleaders {G, H} form the same p-group membership. It seems that structural shift occurs mainly due to changes in memberships of a medium and a low status p-groups in CP1 (but they eventually merge into a single low-medium status p-group).

In the CP2 demo, the ranked cluster between a high status p-group {F, G, H} and a middle status p-group {C, D, E} was formed at relatively later stage during simulation (at Time 419), with {B} joining the latter group at Time 442, and {A} joining at Time 601.

In the CP3 demo, one can observe that negative ties were generated fairly quickly, with all possible negative ties being formed by Time 493. Then, the membership of a low-medium status p-group became more crystallized. A ranked cluster evolves between a high status p-group {F, G, H} and a medium status group {C, D, F}, which actually started to form at earlier stage during simulation (Time 193). In summary, CP3 starts to form ranked clusters at earlier stage in time, with negative ties being formed quickly. CP1 also starts to form ranked clusters at relatively earlier stage, and cluster formation (of a low-medium p-group) starts to be formed at relatively later stage in time. On the other hand, CP2 started to form ranked clusters at a relatively later stage in time. Since my simulation a stochastic process in choosing of friendship offer, these differences among models in terms of their structural shift may occur randomly.

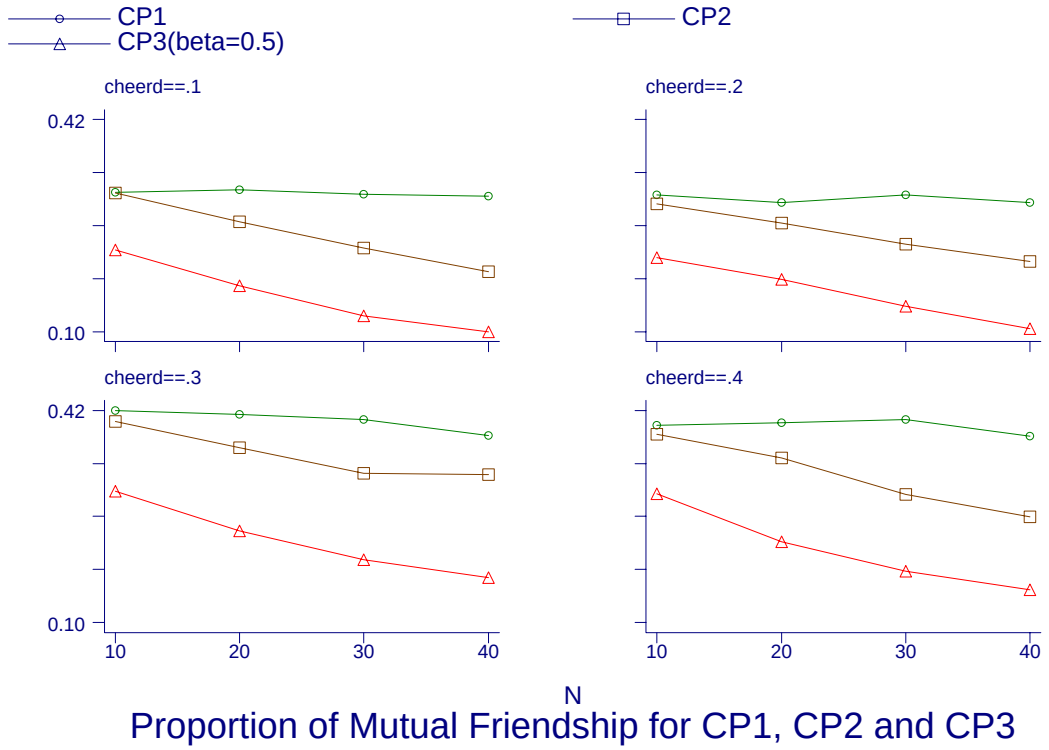
5.2 Measure of Reciprocity

This section presents the results of the mean proportion of both mutual friendships and mutual dislikes of 100 resulting networks for each model under each specific condition (number of actors, *n* and cheerleading density, *cheerd*). The x-axis shows the number of actors (*n*=10, 20, 30, 40), and y-axis shows mean proportion of mutual relation for four levels of cheerleading density (*cheerd*=0.1, 0.2, 0.3, 0.4).

5.2.1 Proportion of Mutual Friendship

The following graphs in Figure 7 show the mean proportion of mutual friendships (positive reciprocity).

Figure 7: Graph of Proportion of Mutual Friendships by Cheerleading Density for CP1, CP2, and CP3



There are 8 major findings observed from the above graphs.

With regards to CP1:

1. Under the condition of high cheerleading density (*cheerd*=0.3, 0.4), the proportion of mutual friendships is also high.
2. For each level of cheerleading density, the proportion of mutual friendships does not change for each level of number of actors.

With regards to CP2:

3. Under the condition of high cheerleading density (*cheerd*=0.3, 0.4), the proportion of mutual friendships is also high.
4. As number of actors increase, there seems to be a trend that mutual friendships decrease.

With regard to CP3:

5. Under the condition of high cheerleading density (*cheerd*=0.3, 0.4), the proportion of mutual friendships is also high.

6. As number of actors increase, there seems to be a trend that mutual friendships decrease.

With regard to the difference between CP1 and CP2:

7. Under the condition of n=40, the difference in the proportion of mutual friendships between CP1 and CP2 becomes large.

With regard to the difference between CP2 and CP3:

8. Overall, CP2 and CP3 tend to behave similarly, but CP3 is much lower than CP2 in its value of the proportion of mutual friendships.

A possible explanation of the findings 1, 3, and 5 is that at high ratio of cheerleaders to non-cheerleaders, it is more likely that actors with moderately high attractiveness level can be selected as cheerleaders as initial conditions. Since the weight factor for cheerleader is specified as α=0.2, the difference of these cheerleaders and non-cheerleaders in their status values would not differ so much. Thus, it is more likely that non-cheerleaders can make friends with cheerleaders, which result in more mutual friendships.

A possible explanation of finding 2 is that the evaluation of status values at the time of selecting a friendship target or making decision about acceptance is not affected by gossip, and that reciprocity is forced (in the case of friendship offers to lower-status).

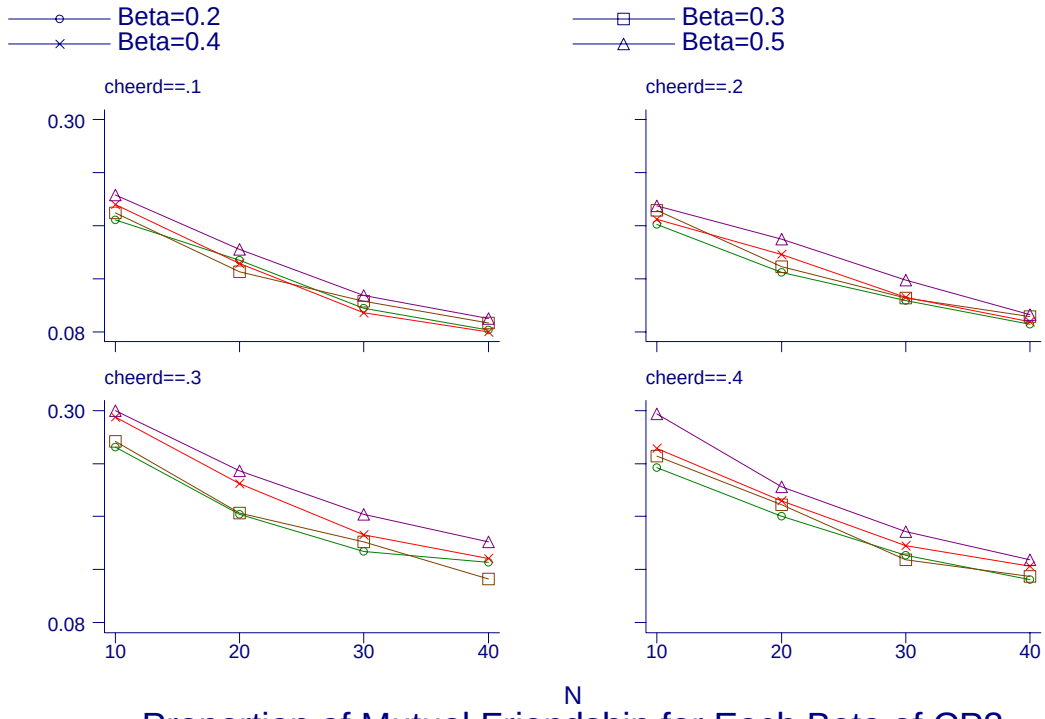
Concerning the findings 4 and 6, both CP2 and CP3 use modified status scores (S_{2i}) when an actor chooses a target of friendship offer. The results show that as the number of actors increase, the proportion of mutual friendships decreases, which imply that the more actors there are, the lower the frequency of making friendship offers. One of the possible causes of this lower frequency would be from the influence of gossip. In other words, as the number of actors increases, the likelihood of having one or more friends who have been rejected by a given target increases, and thus it is more likely that the S_{2i} value for a given target has dropped, making it less likely to receive an offer. This behavior can be interpreted in that the other girls, after hearing gossip, are no longer interested in making friendship offers to the higher status girls (see Appendix A for further discussion).

Concerning a possible explanation of 7, this may be related to the combination of explanation of findings 2 and 4. With regards to the explanation of finding 8, the difference between CP3 and CP2 is

that CP3 uses the concept of betrayal behavior. Therefore, a possible reason why CP3 tends to have less mutual friendships than CP2 would be the effect of introducing the penalty of violating group commitment in CP3. Since betrayed actors react to betrayers by sending "enemy" ties, the former friendship relations are severed and can never again become a mutual friendship, which result in additional decrease in proportion of mutual friendships compared with CP2.

The following graphs in Figure 8 examine only CP3 in terms of different value of disloyalty parameter β. Smaller values of β means that an actor values more group commitment rather than seeking status. The graphs of β=0.5 is identical to those in Figure 7.

Figure 8: Proportion of Mutual Friendships (Positive Reciprocity) by Cheerleading Density for β=0.2, 0.3, 0.4, and 0.5



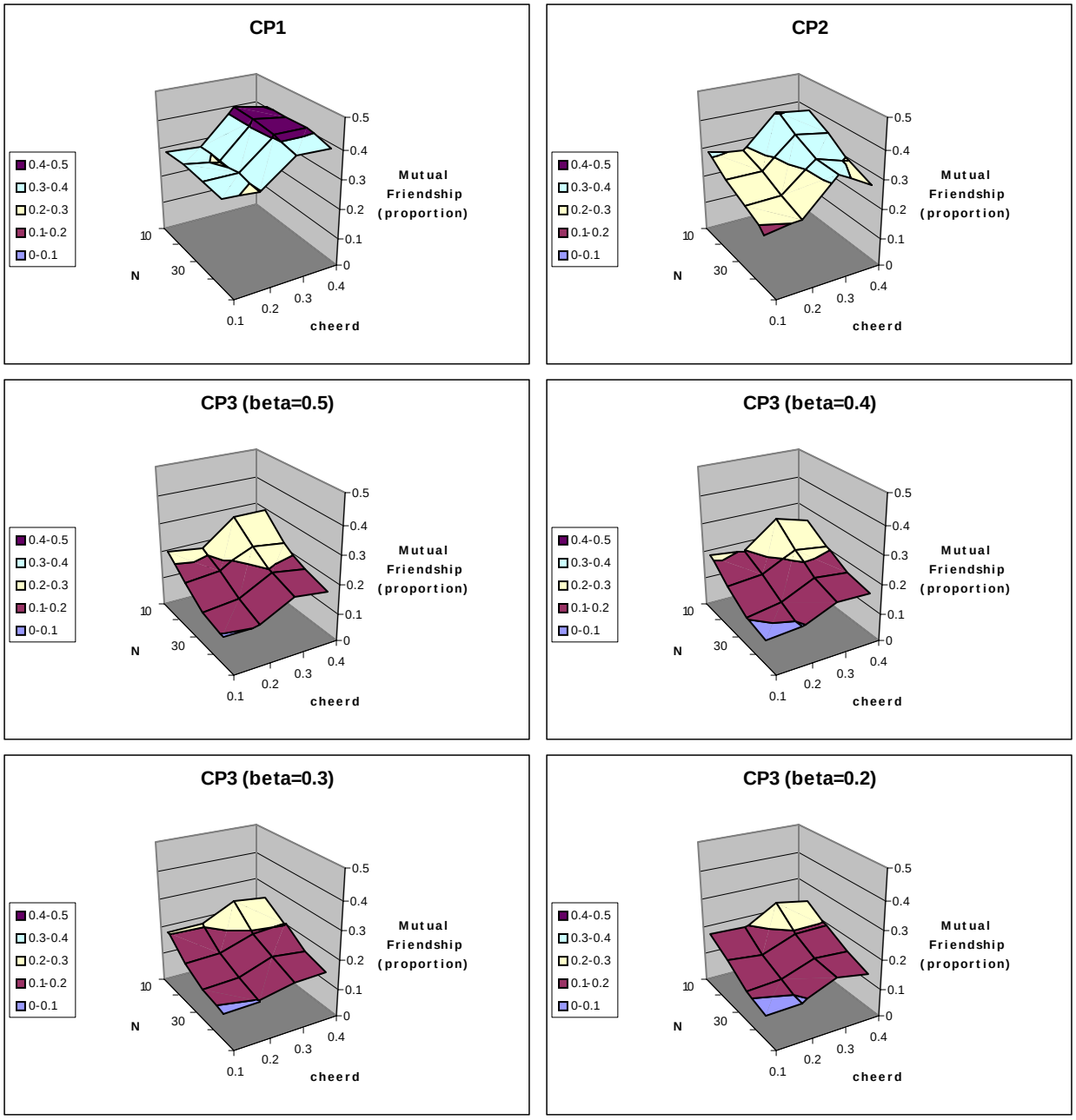
According to the above graph, there are two major finding as follows:

1. The smaller values in β tend to have a smaller proportion of mutual friendships.
2. As the number of actors increase, the proportion of mutual friendships decreases for all levels of cheerleading density.

The finding 1 might be explained by the tendency for actor to reject a friendship offer from foreign p-group members in favor of staying in current p-group membership as β value decreases. The reason for finding 2 might simply be the effect of the size (*n*) of a given network.

The following surface plots in Figure 9 show how the mean proportion of mutual friendships is affected by number of actors and cheerleading density for all models.

Figure 9: Surface Plots of Mean Proportion of Mutual Friendship for Each Model



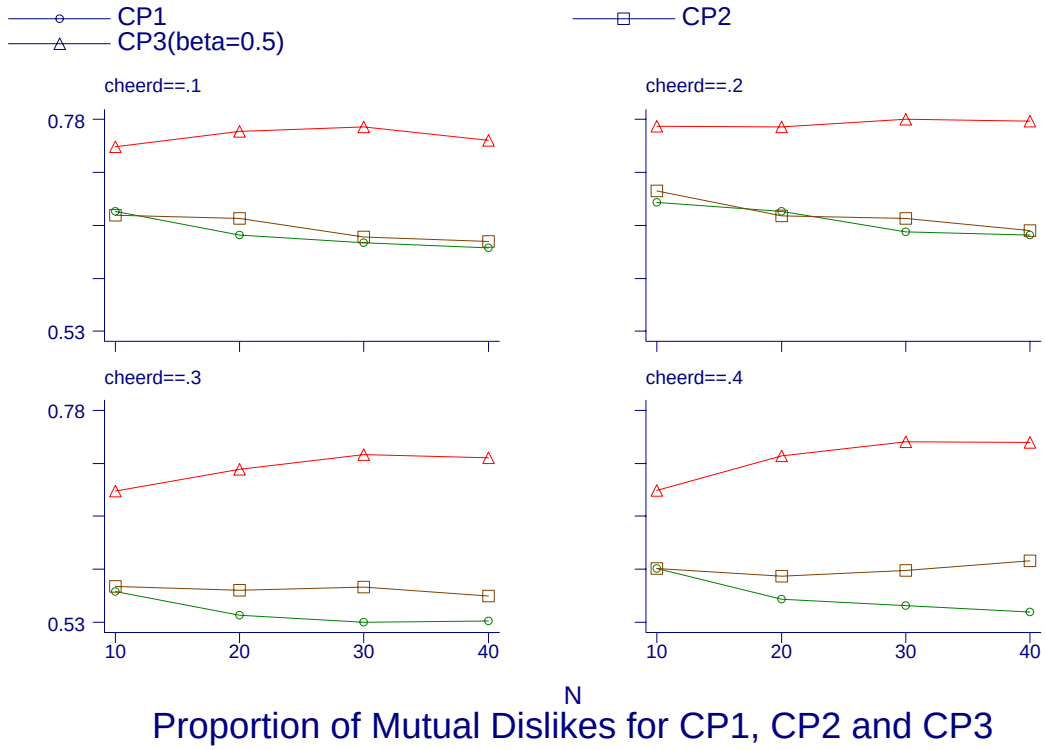
The above surface plots show that CP1 has the highest flat surface under the conditions of high cheerleading density, which is denoted by the dark purple area (range from 0.4 to 0.5). We can see the pattern that in both CP1 and CP2, as the values of cheerleading density drop from 0.3 to 0.2, the proportion of mutual friendship drops drastically. In addition to this trend, in CP2, we can observe that as the number of actors increase, the proportion of mutual friendship decreases (towards the lavender and blue range of 0.0 to 0.1).

In CP3 with different values in beta, we can see that as the value of beta decreases (more in the direction of group commitment), the area of the surface with a high proportion of mutual friendship (which ranges from 0.2 to 0.3) tends to become small, and lies under the condition of small number of actors with high cheerleading density. We can also observe that as the level of cheerleading density decreases (especially from 0.3 to 0.1), the proportion of mutual friendship tends to decrease across all values of beta. In addition to this, as the number of actors increase, the proportion of mutual friendship tends to decrease as well across all values of beta (this may be a trivial size effect).

5.2.2 Proportion of Mutual Dislikes

The following in Figure 10 graphs show the proportion of mutual dislikes (or stronger, as enemy ties are included in this) relation for CP1, CP2, and CP3. These graphs are almost mirror images of corresponding graphs for the proportion of mutual friendships.

Figure 10: Proportion of Dislike or Enemy Relations by Cheerleading Density for CP1, CP2, and CP3



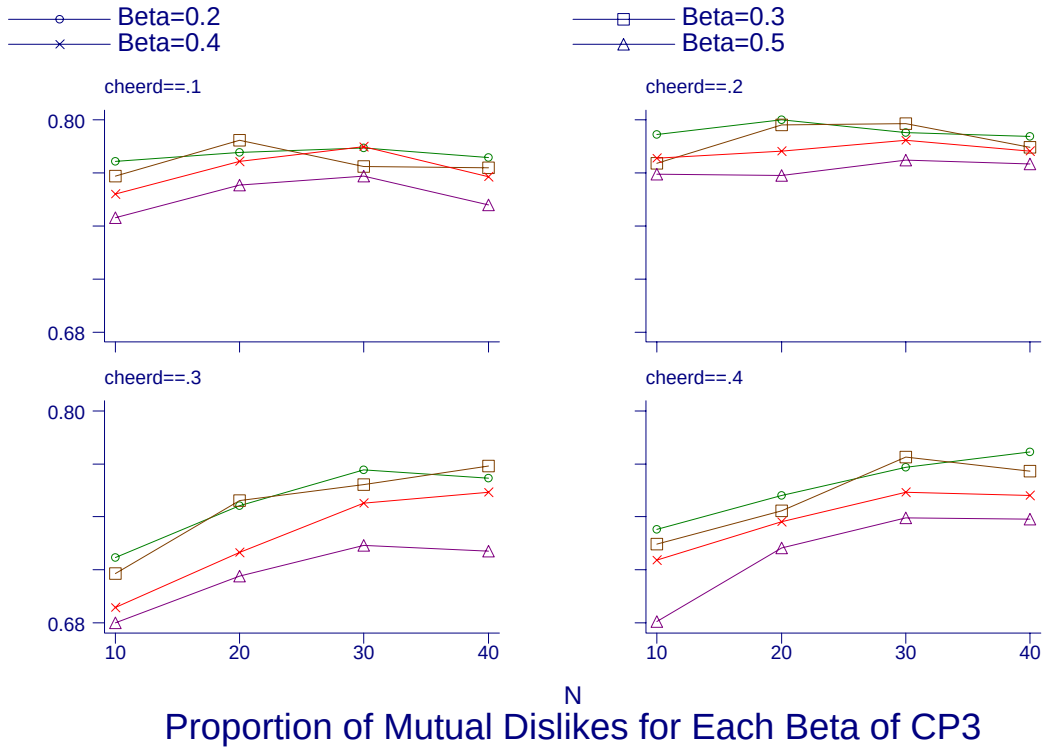
According to the above graphs, there are 2 major findings as follows:

1. A proportion of mutual dislikes does not seem to differ much between CP1 and CP2.
2. The high proportion of mutual dislikes for CP3 compared to other models.

One of the possible explanations of 1 might be that an actor's hesitance to make a friendship offer to cheerleaders due to the influence of gossip in CP2 works as a hindrance more to the generation of friendship relation than to the formation of dislike relation. With regard to the possible explanation of 2, it may be due to the effect of the generation of "enemy" ties.

The following graphs in Figure 11 show the proportion of negative reciprocity for each value of β for CP3. Again, these graphs are approximately mirror images of corresponding graphs for the proportion of friendship relation.

Figure 11: Proportion of Mutual Dislikes (Negative Reciprocity) by Cheerleading Density for β=0.2, 0.3, 0.4, and 0.5



As expected, the proportion of mutual dislike is high for small values in beta, due possibly in part to the rejection of friendship offers from other p-group members.

5.3 Measure of Hierarchy

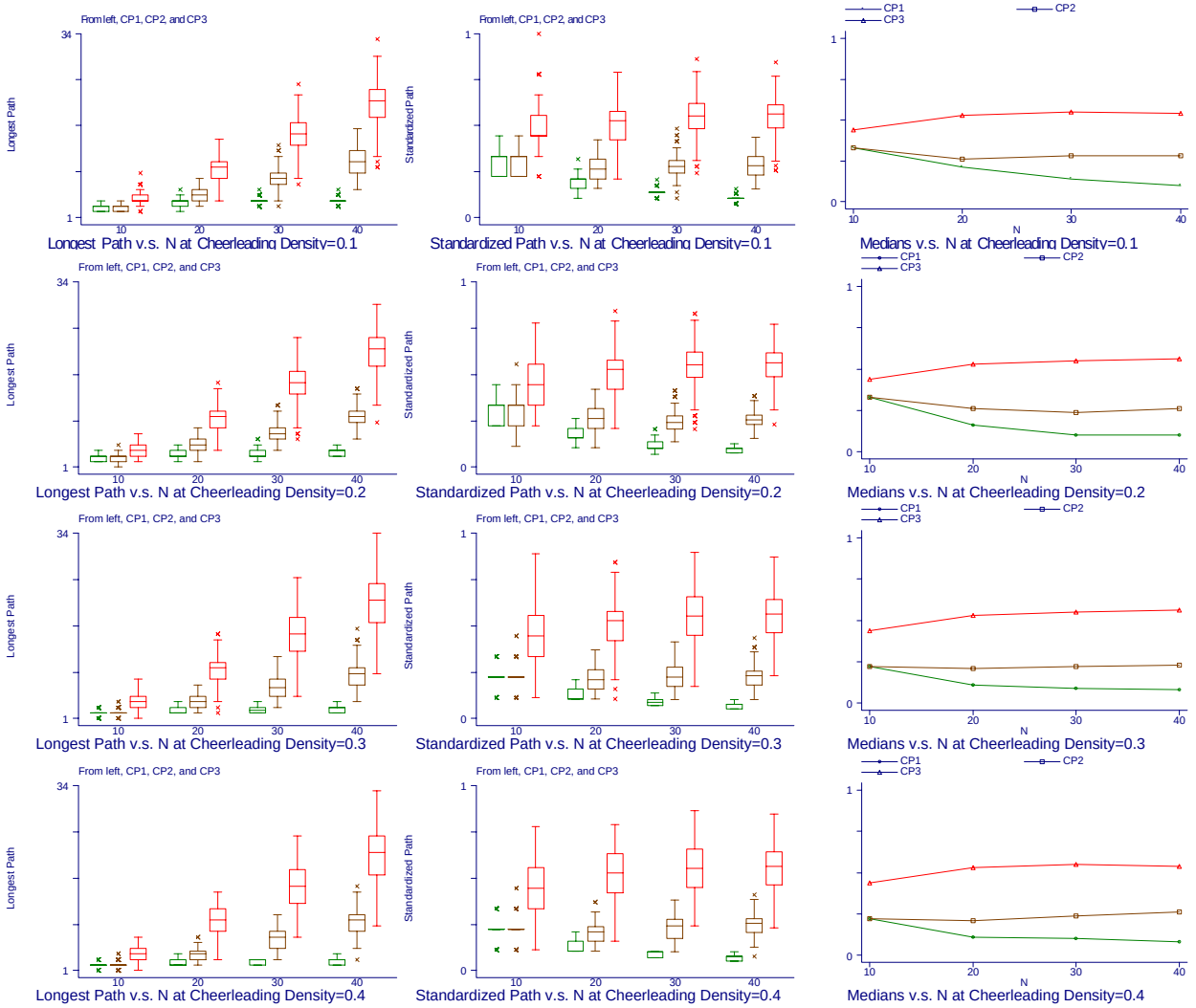
This section presents the results of the measure of hierarchy (for 100 resulting networks) for each model under each specific condition. First, I will show the graphical presentations of both summary statistics (using box-and whisker plot) and distribution (using scatterplots) of the longest upward negative path at the individual level for each model. Then I will present both summary statistics and distribution of longest path at the cluster level to show the levels of ranked clusters under each parametric condition. As an additional analysis, I also present the scatterplots of number of clusters of the resulting networks to get a sense of how many clusters arise under each parametric condition. Lastly, I explore the possible mechanism of rivalry among cheerleaders by analyzing the mutual dislikes only between cheerleaders. In

so doing, my study calculated both rivalries among individual cheerleaders as well as cluster-level rivalries among clusters of cheerleaders.

5.3.1 Individual-Level Hierarchy

The Figure 12 shows the box-and-whisker plots of the maximum length of a negative upward path versus number of actors for each level of cheerleading density for CP1, CP2, and CP3 (using β=0.5), as well as the corresponding standardized version and plots of only medians of this standardized version. Standardized graphs are shown on the right side of the non-standardized version, and corresponding median plots are shown on the right side of the standardized version for each level of cheerleading density.

Figure 12: Maximum Length of Negative Upward Paths for CP1, CP2, and CP3 (on the left is longest path, on the middle is standardized path, and on the right is median of standardized path)



There are three major findings from the above box-plots.

1. Overall, CP3 has the longest negative upward paths (i.e. more levels), with CP2 following.
2. For each level of cheerleading density, the non-standardized box-plots show an increasing trend as number of actors increase for CP2 and CP3, while it does not appear so for CP1.
3. However, standardized box-plots show that there is virtually no tendency for CP2 and CP3 to increase negative upward path as the number of actor increases.
4. Standardized box-plots show that CP1 has a decreasing trend of negative path as the number of actors increase.
5. Overall, CP1 seems to have smaller variation compared with other models.

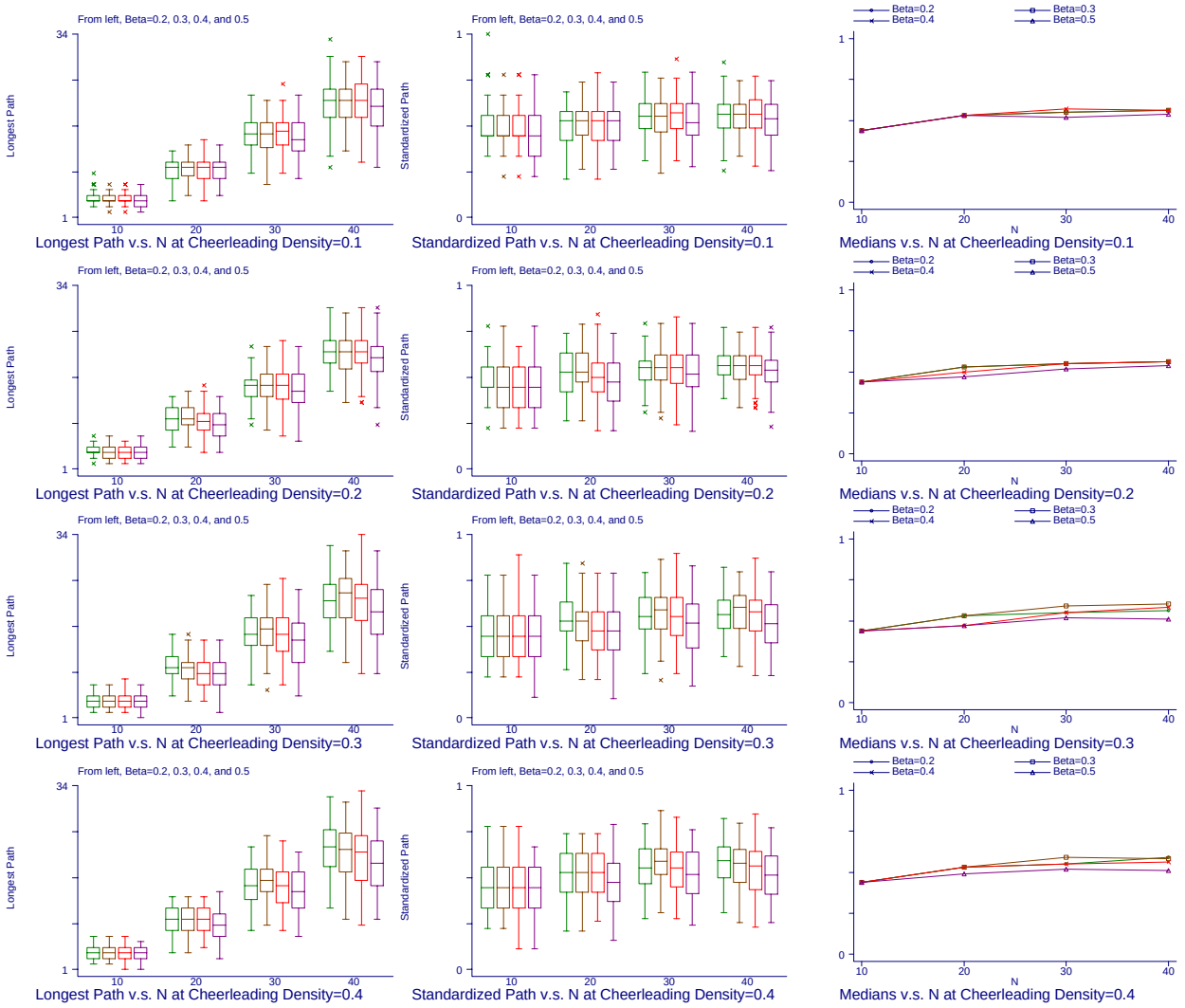
A possible accounting for 1 might be that since CP3 introduces the penalty of violating group commitment, enemy ties are also included in the count of upward negative ties, which necessarily increases the count compared other models. In addition, since actors in CP3 use a decision logic based on the p-group level, a friendship offer from an actor within the half-IQR is not guaranteed, depending on how her p-group was formed at the time of the decision. Considering that the CP2 has the second highest path lengths in general, I would imagine that the generation of dislike ties (as the penalty of violating egalitarian relationship) would be relevant.

With regard to finding 2, the increasing trend of the count of path for CP2 and CP3 as the number of actor increase may simply be because the maximum possible path length also increases as a function of the number of actors in a network. Consequently, as the finding 3 shows, once we standardize negative upward paths by the maximum possible upward path for each level of the number of actor, the value of the standardized path in CP2 and CP3 do not differ that much at each level of the number of actors.

Concerning finding 4, recall that CP1 is not influenced by any evaluative gossip at the time of making friendship offer or decision-making. Since CP1 specifies that as long as actors are within the half-IQR each other, the formation of positive reciprocation is to be expected and which will result directly in the expansion of memberships of the existing p-groups as the number of actors increase. With regard to finding 5, since CP1 is the simplest model that represents only the core idea of "cycle of popularity," a smaller variation is expected compared with other models that incorporate additional mechanisms.

The Figure 13 shows the box-and-whisker plots of the length of negative upward paths versus number of actors for each level of cheerleading density for each value of β in CP3, as well as the corresponding standardized version and a plot of just the medians of the standardized version (for clarity).

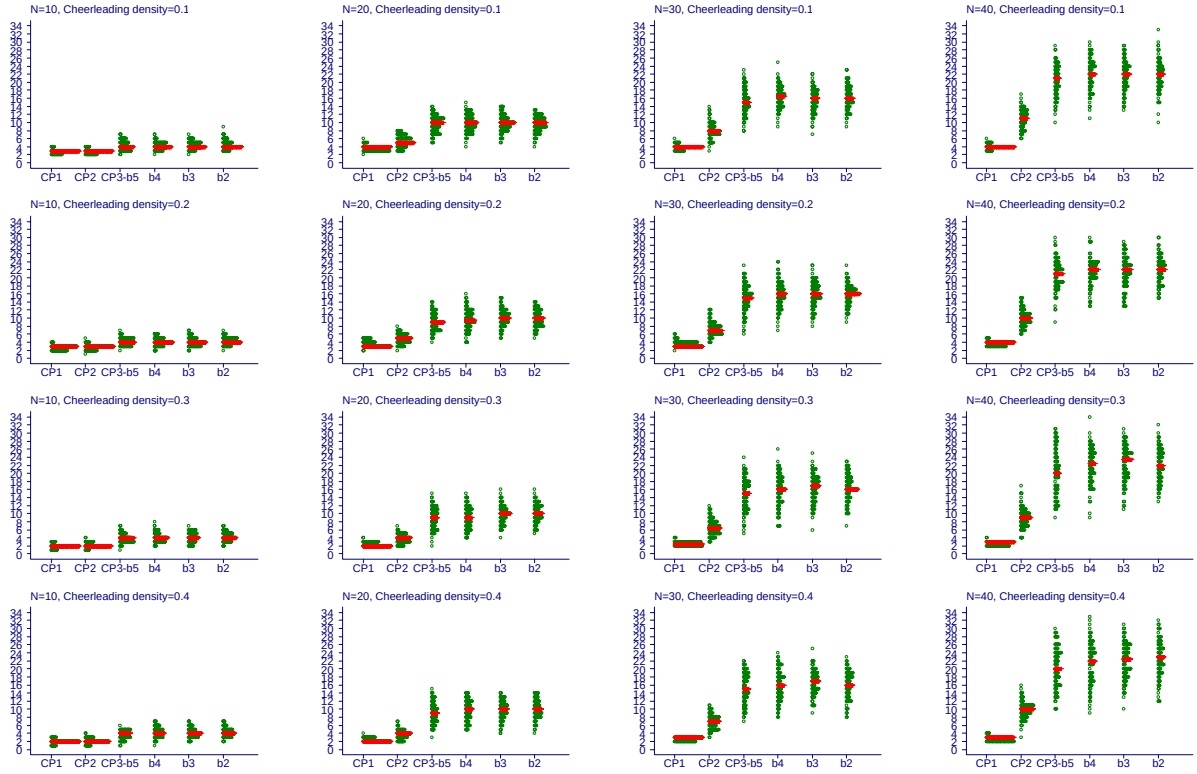
Figure 13: Maximum Length of Negative Upward Path Length for each Beta of CP3 (on the left is longest path, on the middle is standardized path, and on the right is median of standardized path)



In general, β=0.2 and β=0.3 tend to have similar values of standardized negative upward path, which may be explained that a β of 0.3 is small enough to influence actors' decision in favor of group commitment, and thus would cause more negative upward ties. Continuing on then, decreasing β to 0.2, won't change the result very much. β=0.5 seems to have lower values of the standardized path, which may be due to the lower frequency of forming negative ties compared with the other beta values.

The following matrix of 16 graphs in Figure 14 show the scatter-plots of outcomes of the longest path to display all the data for all models in a single, compact way. The column of the matrix represents the number of actors (*n*=10, 20, 30, 40), and the row indicates the cheerleading density (*cheerd*=0.1, 0.2, 0.3, 0.4). For each scatter-plot, the x-axis represents 6 models (CP1, CP2, CP3-beta=0.2, beta=0.3, beta=0.4, beta=0.5), and y-axis represents the possible outcomes of the longest path. The red lines show median outcome under each parametric condition.

Figure 14: Scatterplots of the Longest Path with Red Lines Representing Median Value

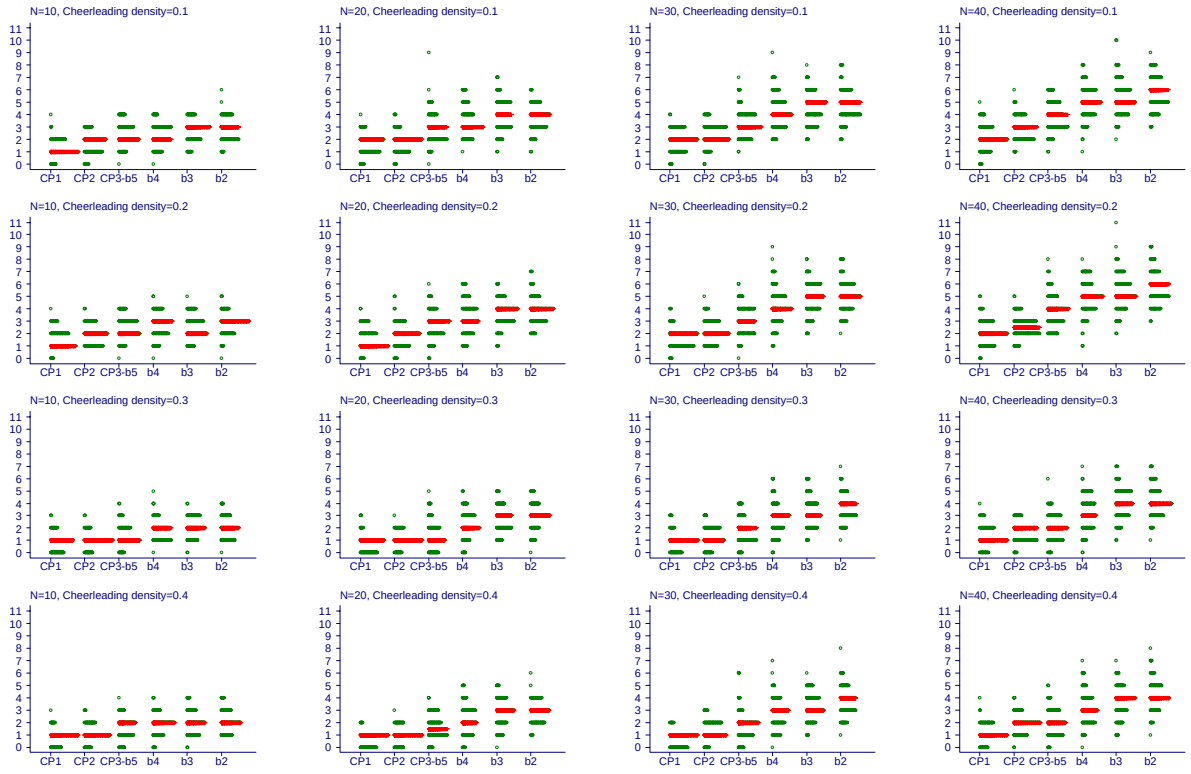


These scatterplots show the distribution of outcomes for each model. As the number of actors increase, the variation of outcomes becomes larger for each level of cheerleading density, especially for CP3, which implies that various through-time trajectories of outcomes may occur. CP2 also tends to have more variation as the number of actors increase. However, this is not the case for CP1 since decision logic is simple and therefore the through-time trajectories of outcomes are also expected to be simple.

5.3.2 Cluster-Level Hierarchy

The following matrix of 16 graphs in Figure 15 shows the scatter-plots of possible outcomes of the longest path at the cluster level for each model with red lines represent medians of outcomes.

Figure 15: Scatterplots of the Longest Path at Clustered Level with Red Lines Represent Median Value

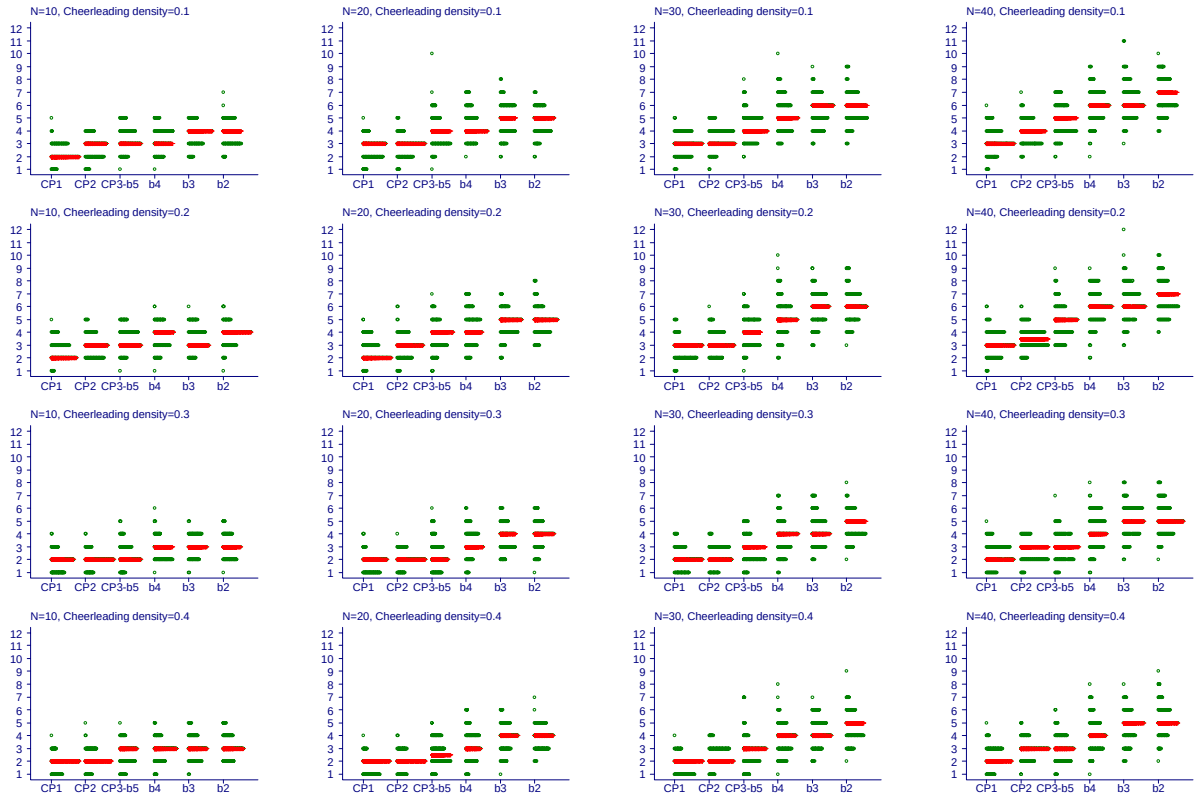


There are mainly three observations from these plots. First, under the condition of large number of actors, the medians of ranked cluster outcomes tend to increase as the model becomes more complicated (from CP1 to CP3) and the values in beta decrease (more loyal an actor behave) for CP3. One of the possible explanations of this result would be that more complicated models generate more negative ties that partition a given network into more clusters and levels, which leads to more levels of hierarchy in a network. Second, the median of ranked cluster outcome for CP1 hardly increases as the number of actors increase. This result also indicates that in CP1, actors tend to extend the same group members, which result in fewer numbers of clusters and fewer levels of hierarchy in a network. Lastly, the outcomes of ranked clusters in CP3 tend to decrease with high cheerleading density for a given number of actors.

5.3.3 Number of Clusters

As supplemental analyses of ranked clusters, the following matrix of 16 graphs in Figure 16 shows the scatterplots of resulting number of clusters for CP1, CP2, and CP3 (for β=0.2, 0.3, 0.4, 0.5). Again, the column of the matrix indicates the number of actors (*n*=10, 20, 30, 40), and the row indicates the cheerleading density (*cheerd*=0.1, 0.2, 0.3, 0.4). For each scatterplot, x-axis represents 6 models (CP1, CP2, CP3-beta=0.2, beta=0.3, beta=0.4, beta=0.5), and y-axis represents the resulting possible number of clusters (ranging from 1 to 12). The red lines show median number of clusters for each parametric condition.

Figure 16: Scatterplots of Number of Clusters with Red Line Represents Median Value



Overall, the results show that the median numbers of clusters for CP3 with small values in beta (more in the direction of group commitment) tend to increase as the number of actors increase for each level of cheerleading density. One of the possible explanations of this result would be that as the number of actors increase, the likelihood of generating more clusters increases because actors are more likely to

reject friendship offers from foreign group members under the assumption of more commitment to their current group, which results in a greater likelihood of negative ties and a cleaving of the network. However, the observation of this mechanism is less apparent for less complicated models such as CP1 and CP2.

Similar to the last finding of the ranked cluster outcome, the median numbers of clusters for a given number of actors tend to be small with high cheerleading density in CP3. This result also implies that as the number of cheerleaders increase in a given network, the fewer the number of clusters in a given network is to be expected. The results of both ranked clusters and the number of clusters imply that cheerleading density seems to have an important effect on the outcomes. Therefore, I conducted some additional analyses of relationships among cheerleaders in the following section.

5.3.4 Rivalry Among Cheerleaders

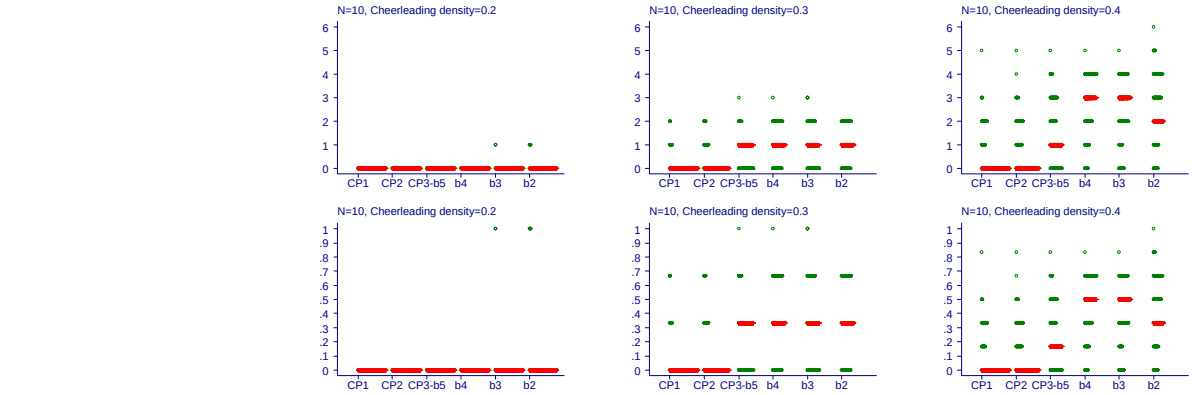
For any given cheerleader, if there exist a symmetric negative tie between cheerleaders, I count it as one conflict to reflect the occurrence of infighting between cheerleaders, and I call this intra-cheerleader rivalry. I also obtained a similar count of infighting between cheerleaders at the cluster level. The infighting between individual cheerleaders is necessarily greater than or equal to the infighting between cheerleaders at cluster level.

5.3.4.1 Intra-Cheerleader Rivalry

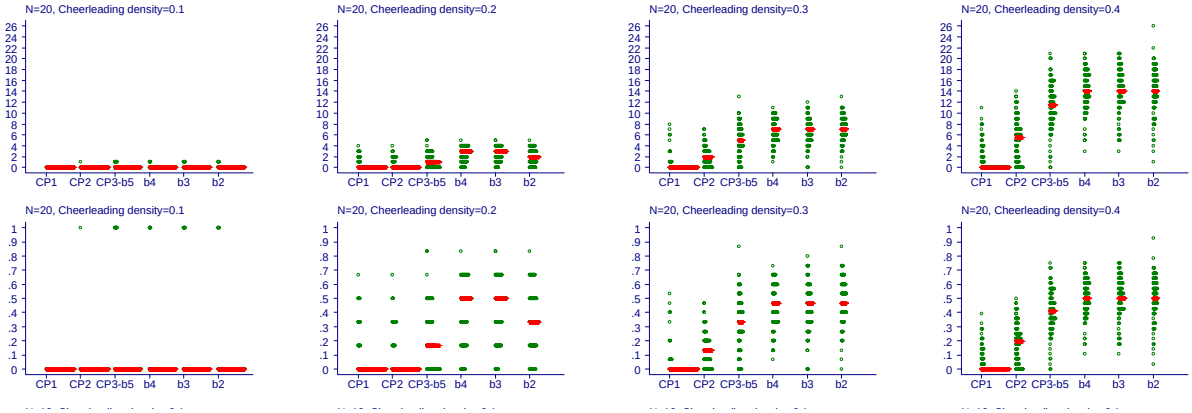
The following scatter-plots in Figure 17 show counts of conflict between cheerleaders. For each level of the number of actors (n=10, 20, 30, 40), the scatter-plots represent the frequencies of intra-cheerleader rivalry obtained for each level of cheerleading density as well as the corresponding standardized version (which are shown below the original scatter-plots). The standardized intra-cheerleader rivalry is calculated by dividing the count of negative mutual ties between cheerleaders by maximum possible negative mutual ties among cheerleaders for a given number of cheerleaders. The number of cheerleaders is obtained by multiplying the number of actors by cheerleading density.

Figure 17: Count of Mutual Dislikes Between Cheerleaders for Each Level of Number of Actors

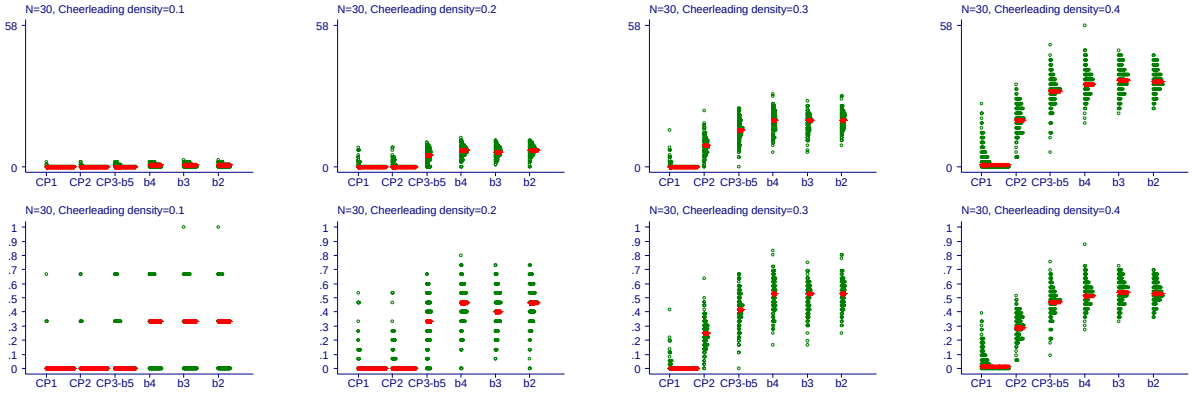
N=10



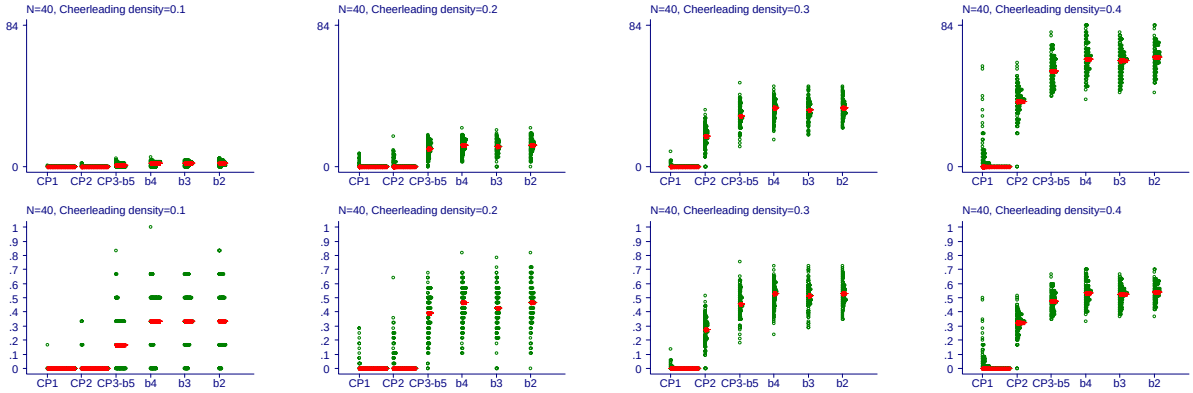
N=20



N=30



N=40



There are three main findings based on the above-standardized version of scatter-plots for each parametric condition. First, for each level of number of actors (except *n*=10), CP3 tends to have the high level of intra-cheerleader rivalry where at high cheerleading density (*cheerd*=0.3 and *cheerd*=0.4), the medians of standardized value of infighting between cheerleaders are approximately 0.5, indicating almost a half of mutual relationships between cheerleaders reflects rivalry in CP3. On the contrary, under the condition of low cheerleading density (*cheerd*=0.1), the medians of standardized values of infighting between cheerleaders decrease, indicating fewer proportions of cheerleaders in a given network tend to get along with each other in CP3.

Second, median values of intra-rivalry in CP2 start to increase at the cheerleading density of 0.3 for each level of the number of actors except *n*=10 (where increase in intra-cheerleader rivalry is found at the cheerleading density of 0.4). One of the possible accounts of this result would be that in CP2, the effect of evaluative gossip on making decision of rejecting an offer from other cheerleaders could occur under the condition that at least 30 percent of the actors in a network are cheerleaders.

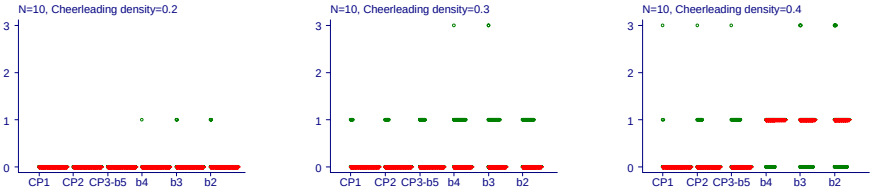
Lastly, under low cheerleading density (*cheerd*=0.1), CP1 has virtually no intra-cheerleader rivalry. What little there is tends to increase with increasing cheerleading density. One of the possible explanations of this result would be due to the lack of influence of evaluative gossip on making decision in CP1.

5.3.4.2 Inter-Cheerleader Rivalry

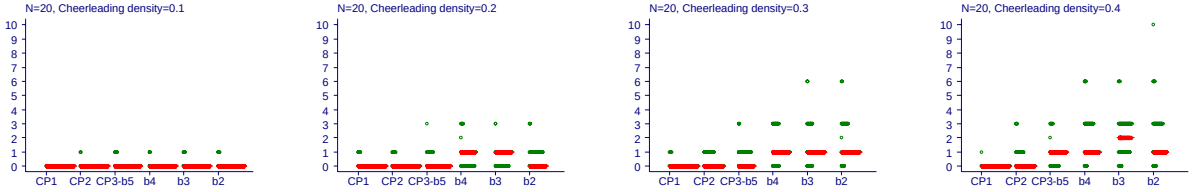
The following scatter-plots in Figure 18 show the count of mutual dislikes between "cheerleader" clusters, which reflect infighting between cheerleaders at the cluster level. Here, if any members of the cluster are cheerleaders, then that cluster is considered to be a "cheerleader." I call this inter-cheerleader rivalry. Here, any rivalries that exist only among cheerleaders within a cluster are suppressed.

Figure 18: Count of Mutual Dislikes Between "Cheerleader" Clusters for Each Level of Number of Actors

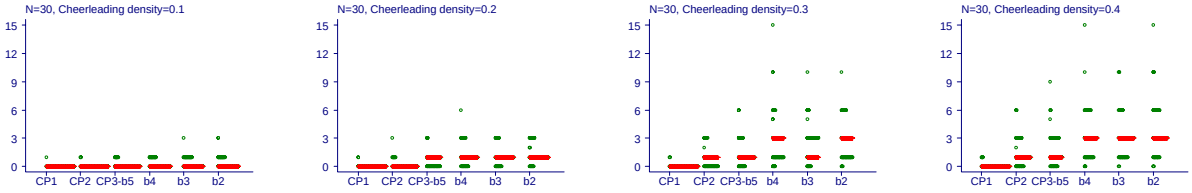
N=10



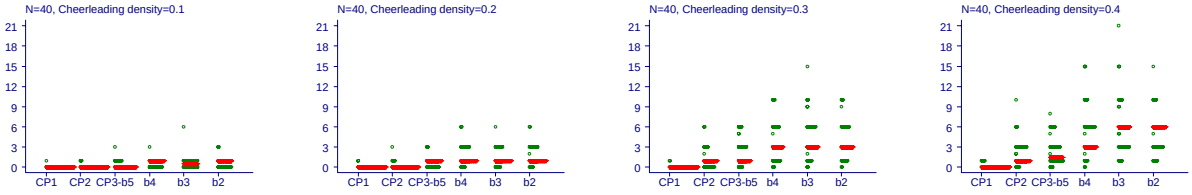
N=20



N=30



N=40



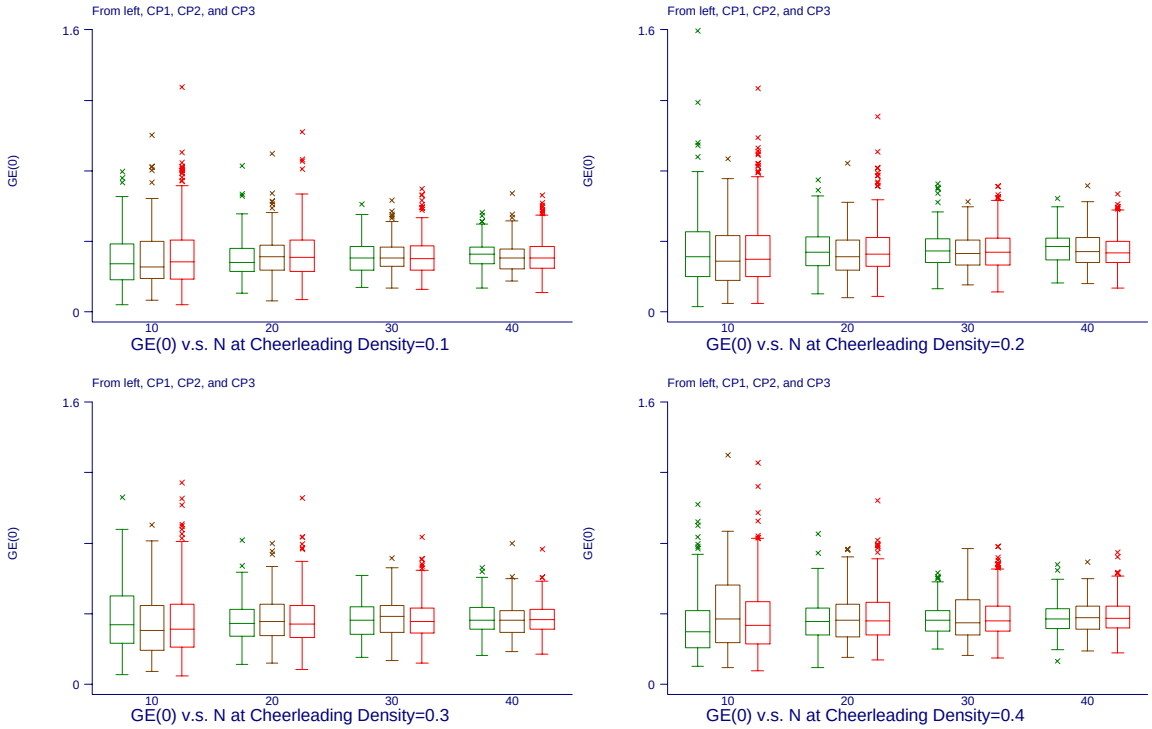
One of major findings with these scatter-plots is that with high cheerleading density, CP3 (with smaller values in beta) tends to have increased frequency of infighting among cheerleaders at the cluster level,

especially under the condition of a large number of actors[79]. One of the possible explanations of this result would be that with more cheerleaders in a given network, it is more likely for these cheerleaders to be split into other clusters, considering more variation in status values among cheerleaders. It follows that these "cheerleader" clusters generate mutual dislike relations, which lead to more occurrence of infighting among cheerleaders at the cluster level.

5.4 Measure of Inequality

The Figure 19 shows the box-and-whisker plots of GE(0) versus number of actors for each level of cheerleading density for CP1, CP2, and CP3 (using β=0.5).

Figure 19: Box-plot of GE(0) for CP1, CP2, and CP3



According to the above box-plots, it is hard to see any particular pattern as a function of the number of actors for each level of or across cheerleading densities for all models. The results imply that three models do not differ so much as to affect the levels of inequality among actors. Also, because it uses a

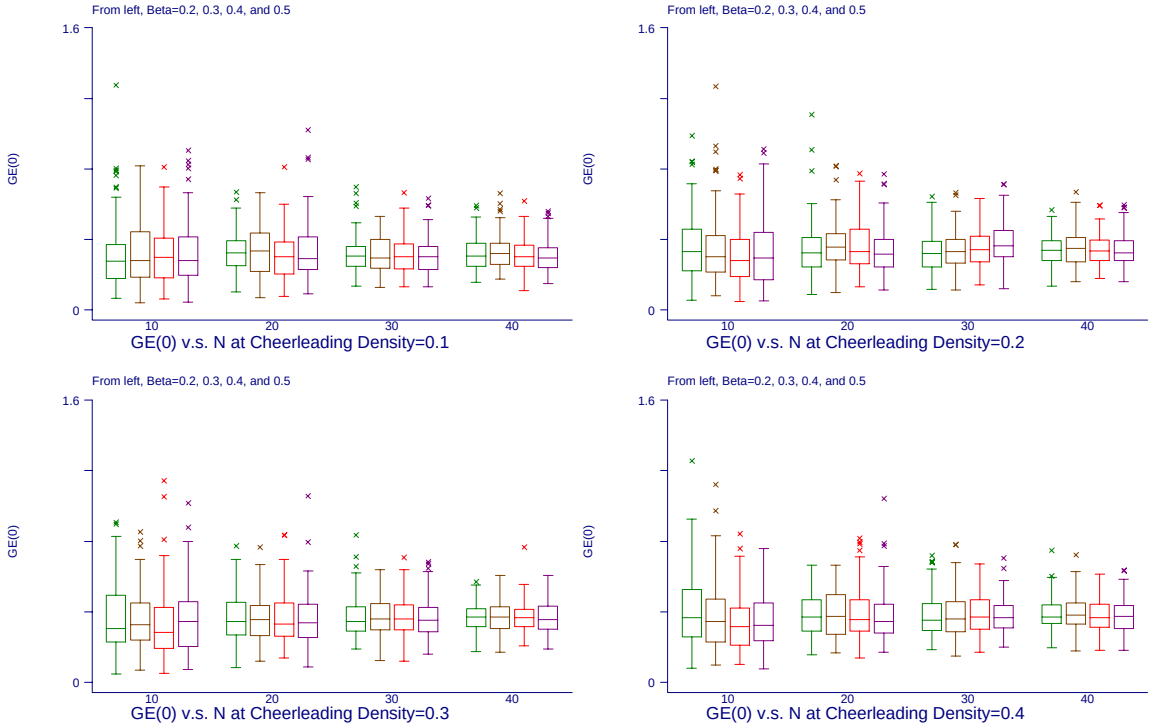
[79] Median frequency of infighting between cheerleaders under the condition of *n*=30, *cheerd*=0.3 for CP3-b3 would be very close to be the next level of the outcome 3.

logarithmic scale, it might be possible that GE(0) does not capture inequality of individual status scores (S_{1i}) sufficiently enough to detect any differences in GE(0) among models.

I regressed GE(0) on number of actors (3 dummy variables with n=10 as a baseline category) and cheerleading density (2 dummy variables with *cheerd*=0.1 as a baseline category) for each model to get a sense of model fitting by using adjusted R^2 (adjusted by the number of parameters in a model). As a second model, I entered interaction the effect among these variables. For CP1, adjusted R^2 was 0.024 for main-effect model and 0.021 for the model with interaction effect. For CP2, adjusted R^2 was 0.029 for main-effect model and 0.028 for the model with interaction effect. For CP3, adjusted R^2 was 0.025 for the main-effect model and 0.024 for the model with interaction effect. These results imply that interaction effect hardly matters, and even the main effect model hardly explains the variance of GE(0) for each CP model.

The Figure 20 shows the box-and-whisker plots of GE(0) versus number of actors for each level of cheerleading density for each level of β for CP3.

Figure 20: GE(0) for Each Beta of CP3



Again, it is difficult to see differences among three models, and my models do not seem to differ so much in affecting inequality among actors. For CP3 with β=0.2, adjusted R^2 was 0.025 for main-effect model and 0.022 for the model with interaction effect. For CP3 with β=0.3, adjusted R^2 was 0.019 for main-effect model and 0.015 for the model with interaction effect. For CP3 with β=0.4, adjusted R^2 was 0.039 for main-effect model and 0.038 for the model with interaction effect. For CP3 with β=0.5, adjusted R^2 was 0.018 for main-effect model and 0.019 for the model with interaction effect. These results also imply that interaction effect hardly matters, and even main effect model little explain the variance of GE(0) for each beta value of CP3.

In summary, my simulation results show that under the condition of high cheerleading density, the proportion of mutual friendships is higher than the case of low cheerleading density for all models. In addition, the proportion of mutual friendships is negatively related to the number of actors for only CP2 and CP3, but not CP1. CP3 has lower proportion of mutual friendships than other models, and as the value of the disloyalty parameter decreases (more in the direction of group commitment), the proportion

of mutual friendships decreases. Concerning the results of negative relations, the proportion of mutual dislikes (including enemy) is higher for CP3 than for CP1 and CP2, and also both CP1 and CP2 do not differ much in their values. In CP3, smaller values of the disloyalty parameter (more in the direction of group commitment) tend to have a larger proportion of mutual dislikes.

With regards to the level of hierarchy of simulated networks, I found that CP3 has more levels (measured by the longest path). In addition, CP3 has more ranked clusters generated in a network compared with other models with small values of disloyal parameter having more rankings. Furthermore, under the condition of high cheerleading density, CP3 tend to have fewer ranked clusters. Similar results were obtained in the number of clusters generated in a network. Concerning the result of CP1, I found a decreasing trend of longest path as the number of actors increase. My study also suggested a possible mechanism of rivalry between cheerleaders in CP3 by demonstrating a higher frequency of infighting between cheerleaders both at the individual level (intra-cheerleader rivalry) and at the cluster level (inter-cheerleader rivalry) under the conditions of high cheerleading density. On the other hand, virtually no rivalry between cheerleaders was found in CP1, especially under the condition of low cheerleading density.

Finally, the result of measure of inequality among actors in the resulting networks shows that there is no particular pattern across models. Additionally, the number of actors and cheerleading densities do not seem to affect the inequality level as well. The similar results were obtained for different values in the disloyalty parameter in CP3.

5.5 Concluding Remarks

My study suggests the possibility of multiple mechanisms that are responsible for the evolution of social network structures. My simulation study focused on the core mechanism of "cycle of popularity," with some additional mechanisms included in more complex models. When my study adds the mechanism of evaluative gossip to the core mechanism of "cycle of popularity," we observed different through-time trajectories of network outcome features. Similarly, when my study adds the mechanism of

conviction formation to explain social actions that are reflected on substantive rationality, still other through-time trajectories of network outcomes were observed. Furthermore, my study also implies a possible mechanism of rivalry among cheerleaders, which may be applicable only under a certain mechanism.

As transitivity can be explained by various mechanisms such as an individual's tendency toward friendliness (expansiveness), a structural tendency toward mutuality (reciprocity), a tendency toward hierarchy measured by the number of in-degrees (differential popularity), a tendency toward density (clusterability), and a cognitive tendency toward balance (Hallinan 1982), so too can mutual friendship be also explained by various mechanisms. My simulation movies of CP1 and CP2 showed consistency with Heider's structural balance theory. This result implies that structural balance might also be explained by other mechanisms, such as "cycle of popularity."

One of the major implications in my study is that people's unwillingness to make friendship offers would serve as a hindrance in the generation of mutual friendships, and hence the expansion of positive relational structures. One of the possible sources of constraints of people's willingness to initiate tie formation would be the personal values that person holds, such as egalitarianism, group commitment, etc, and which are reflected in substantive rationality. Other researchers have pointed out this possible effect of personal values on friendship initiation before. For instance, Lockheed (1986) explains strong tendency of girls' preference for gender segregation by their normative values that involve negative statements about cross-sex classmates. My study suggests that the effect of values on friendship formation could occur within same gender peer relations as well.

My study also demonstated that the proportion of mutual dislikes (including enemy) is more noticeable than that of mutual friendships, especially in the model that adds the group-level decision logic and the penalty of violating the value of group solidarity. In addition, as actors favor more the value of group commitment, the proportion of mutual dislikes (including enemy) increases. These results suggest the importance of examining the formation of negative relations. However, this empirical research has been a difficult, as Davis and Leinhardt's (1972) theorem of ranked clusterability has not really been

empirically investigated. One of the main reasons for this is that most network analysts usually measure affective relations based on the existence of positive ties and don't collect negative relational data, and therefore most empirical relational data rarely contains negative ties.

The limited availability of signed relations leads network analysts to define "signed" graphs by deriving them from only the positive tie networks. For example, negative ties were defined in terms of the directionality of positive ties (Davis & Leinhardt 1972), by discarding the arcs with negative signs under the assumption of positive side of signed relations (Holland & Leinhardt 1971), or by treating the presence of negative feelings by creating the category of 'everyone else' (Hallinan 1974). In this way, many network analysts have developed formulations of structural balance theories by paying special attention to positive ties. Consequently, they found that transitivity is a key structural property in relational data without signs, which has contributed to the considerable development of social network methods. It is possible that this is instead a consequence of the derivation process, and so although this methodological development provides us with descriptive nature of structural balance in social networks, studies on the negative side of signed relations has been insufficient. However, obtaining longitudinal data about dislike or enemy feelings toward others would be impractical considering the ethical issues regarding psychological effect on the part of subjects. Generating simulated data would be practical way to go. Nonetheless, it must be noted that in the study of the evolution of network structure, network analysts should be "much more conscious of the limitation of data" (Marsden 1990, p. 456).

I must acknowledge that there are four main limitations in my simulation study. First, my simulation did not keep track of the types of dislike ties. More specifically, my simulation specifies that a dislike tie is generated as a result of being rejected, it is generated as a result of being directly notified an incoming dislike tie, and it is generated as a result of indirectly hearing from a third party that someone is sending an enemy tie to them. It would be necessary to use specific type of dislike ties as a consequence of specific event in calculating the level of hierarchy in resulting networks especially under the assumption that actors make decisions at the group level.

Second, my simulation does not propagate other's history of tie states, dealing only with new-formed ties. This limitation would constraint actors from obtaining accurate cognitive image of networks. Usually, girls would talk about their past experience with someone to their new friends to express their expected behavior as Eder's study showed. However, it was not clear from the study how often and how much prior histories were discussed with new group members, and if there was any preference given to recent versus distant events, etc.

Third, my study does not have a way to reconcile my simulated data with reality, primarily because of lack of availability of longitudinal, negative tie information among American adolescent girls. However, redress seems to be difficult considering the impracticability of collecting such data.

Lastly, my study has emphasized the importance of affective factors in people's decision making, assuming that most normative values contain affects that serve as the motivational force. However, the instantiation of this idea is limited to only negative part of relational structures, and this study did not treat the effect of affects on the formation of positive relational structures.

Some additional items that I learned while completing this simulation study are:

1. Exceptions in behavior can easily violate causality in the algorithmic sequencing of events. For instance, CP1 specified an exceptional rule of "forced reciprocation" (reciprocation follows acceptance) in the case that a higher status actor makes a friendship offer to a lower status. This behavioral logic is reasonable since actors in CP1 are assumed to be status-seekers. However, algorithmically, forced reciprocation skips the event sequence by means of message exchanges. Since my simulation uses message exchanges as events that cause changes in network structures, generating "automatic" reciprocation as if the message exchanges had already occurred can influence other decision logics indirectly. Finding these byproducts is hard to catch. The lesson I learned from this is that the danger of using effect of events as behavioral rules. Furthermore, social processes (such as those derived from empirical studies) are not easily expressed by algorithmic processes.

2. Computer simulation, as opposed to mathematical models, provides a vehicle by which ideal behavioral assumptions can be explored, and this can be used to address attacks on RC assumptions. I found difficulty in determining where to draw the line between model sophistication and the addition of ad-hoc rules in an effort to model "human beings". As I tried to more realistically represent WM adolescents, additional rules seem necessary but which then complicate the interpretation of the results. A simple, easy to interpret model is at one end of the spectrum, and the other end is a true model of human behavior that is nigh impossible to interpret reliably. Even though a simple model is better with which to observe some pattern of behavior, if such a model does not accurately represent human behavior, I still have to wonder if this lessens its veracity.
3. There are so many different ways of doing a simulation concerning how to define objects, variables, as well as assumption of distribution of variables. Therefore, there is a danger that any one simulation is embedded in the choice paths not taken. When there are no empirical findings about the distribution of variables, my choice of distributions would come from subjective observation. The lesson I learned is that if these choices are discussed openly, then researchers' natural scientific sense of caution about over-interpreting the results will come to the fore, thus we can try to avoid grossly misrepresenting the substantive significance.
4. Simulations produce a flood of data that easily exceeds one's ability to comprehend them in their raw form, and it becomes essential to find ways to extract the information that one needs without biasing it overly or (worse) missing something entirely. The simple answer is to just focus on fewer parameters, but a more daunting (but likely more fruitful) answer would be to explore more concise and effective ways of summarizing the raw data, and thus avoid the information overload in the first place.

In conclusion, my study attempted to create an instantiation of Feminist Cognitivist Theory of Action. The component of "comparative rationality within multidimensional self" where feminist notion of multidimensional self is combined with the cognitivist view of relative strength of a system of reasons is

worth mentioning here. My simulated results imply that under the assumption of viewing individuals as having a multidimensional self, more complex behaviors were generated. The resulting through-time trajectories of outcomes were characterized by high levels of ranked clusters, high occurrence of mutual dislikes, etc, which is quite different from those under the assumption of individuals as one-dimensional self. These features were especially noticeable when women have strong reasons to endorse the value of group commitment (and reject competitive individualism), and thus maintain the viable networks of their current relationships through their loyalty. Therefore, my simulation study may provide a partial answer to the question raised by Friedman and Diem (1993) concerning a limitation of Rational Choice Theory: "within one individual- that is, among multiple selves- how much and what kind of variation is there in the use of "interpersonal comparisons? (We shall call these *intra*personal comparisons)" (p.96).

With regards to the issue of policy implementation, my study observed that more hierarchal network structures were generated when actors make group-based decisions that comply with the value of group commitment. Under this condition, the level of ranked clusters tends to decrease as more cheerleaders are in the given network. This observation implies that implementing policies that increase the status-conferring positions would possibly reduce the extent of social ranking within middle school. However, my study also suggests that implementing such a policy would also generate more rivalry among those who had already secured status-conferring positions.

With respect to feedback using the literature, my computational model generated results consistent with Eder's observation of the emergence of hierarchical cliques in networks of adolescent girls as a result of their negative feelings in their peer relations. If negative the ties are removed from my simulated network, my results would be consistent with the quantitative findings that describe girls' networks as horizontally fragmented small groups with high density. However, my simulation does not examine the density within groups. On the other hand, qualitative ethnographic findings that emphasize hierarchically dimensional network structures among girls would be more consistent with my simulated results, especially under the assumption that girls obey trustful relationship with others.

The current study only looked at homogenous network with respect to gender. A future study could aim at examining the effect of one gender's network on the other, as well as considering other categories in terms of race/class/ethnicity. This kind of analysis would help deepen the understanding of evolution of social networks arisen from heterogeneous component. Additionally, as computer processing power doubles roughly every 18 months, larger and larger groups could be simulated to see if my current observations hold true as the number of actors increase – especially with regards to the influence of gossip propagating through the network.

APPENDIX A

Further Discussion on the Effect of the Number of Actors and Modified Status Scores

Let us denote the number of actors rejected by a cheerleader as Fr, cheerleading density as cd, and total number of actors as N. For simplicity, let assume that the number of friends are all non-cheerleaders N(1-cd). Assuming that a popular girl has a perfect status value (S_1=1) and any offer to this perfect cheerleader is refused, the probability of having made offer to a cheerleader and been rejected by her is:

Π = P(making offer to a cheerleader $\cap$ being rejected)

= P(making offer to a cheerleader)P(being rejected | offer to a cheerleader)

= P(making offer)*1

= (cd*N)/N

= cd

assuming the events of making offer and being rejected are conditionally independent for simplicity. Since Fr is binomial, the expected value of Fr is written as:

$E\{Fr\}$= [N(1-cd)] Π

= [N(1-cd)] cd

This expected value is converted to the next larger integer value (ceiling) for the next part of the analysis. Now the S_2 of a cheerleader is calculated. Small values of S_2 mean a greater likelihood of being beyond the half-IQR, and thus less likely to be made offer. For instance, when N=10, and cd=0.1,

$\Pi_{10, 0.1}$= cd = 0.1

$E_{10, 0.1}\{Fr\}$= [10(1-0.1)] 0.1 = 0.9

ceiling $E_{10, 0.1}\{Fr\}$=1

therefore, S_2=1/2

Table 3 shows these statistics by using other combinations of number of actors and cheerleading density.

Table 3: Calculation of Expected Number of Friends Rejected and Cheerleader S_2

N	cd	Π	N(1-cd)	E{Fr}	Ceiling E{Fr}	S_2
10	0.1	0.1	9	0.9	1	1/2
20	0.1	0.1	18	1.8	2	1/3
30	0.1	0.1	27	2.7	3	1/4
40	0.1	0.1	36	3.6	4	1/5
10	0.2	0.2	8	1.6	2	1/3
20	0.2	0.2	16	3.2	4	1/5
30	0.2	0.2	24	4.8	5	1/6
40	0.2	0.2	32	6.4	7	1/8
10	0.3	0.3	7	2.1	3	1/4
20	0.3	0.3	14	4.2	5	1/6
30	0.3	0.3	21	6.3	7	1/8
40	0.3	0.3	28	8.4	9	1/10
10	0.4	0.4	6	2.4	3	1/4
20	0.4	0.4	12	4.8	5	1/6
30	0.4	0.4	18	7.2	8	1/9
40	0.4	0.4	24	9.6	10	1/11

This table shows that for each level of cheerleading density, as the number of actor increases, the expected value of friends being rejected also increases, and hence modified status value of rejecting cheerleader decreases. The following graph plots modified status values (S_2) as a function of the number of actors, but before that let me calculate the expected status value for non-cheerleaders. Since status value of non-cheerleaders comes only from attractiveness level (weight factor for cheerleader is zero for non-cheerleader) and my study assumed it was uniformly distributed from 0 to 1 earlier, then the expected status value for non-cheerleaders is expressed by:

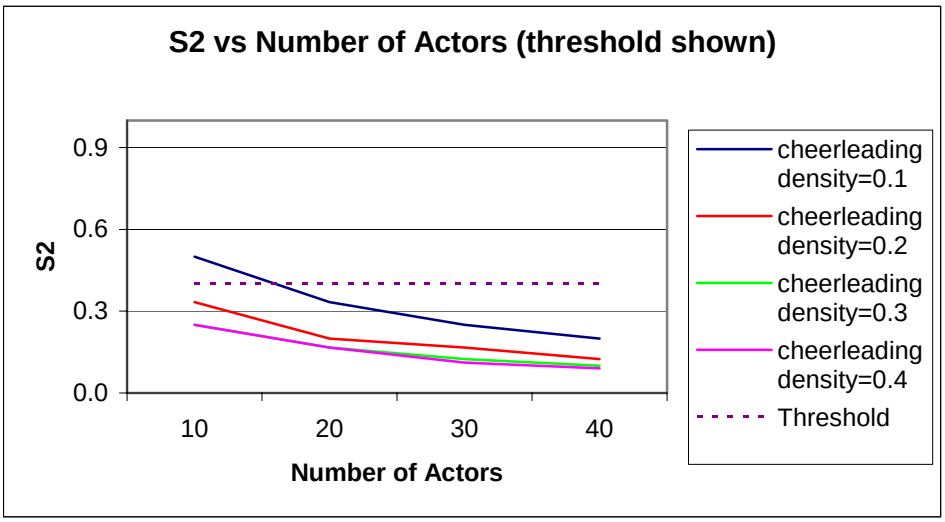
$$E\{S_1\} = (0 + 1) /2 = 1/2$$

Since I split actors into two groups of cheerleaders and non-cheerleaders based on attractiveness level, this expected value is multiplied by (1-α) for non-cheerleaders in the following:

$$E\{S_1\} = 0.5 * 0.8 = 0.4$$

since this simulation specifies α=0.2. The following graph plots how different S_2 values for cheerleaders as reference of this expected value of S_1 for non-cheerleaders as a threshold.

Figure 21: Graph of Modified Status Value of Cheerleaders vs. Number of Actors



The above graph in Figure 21 shows that as the number of actors increase, the difference between S_2 for cheerleaders and threshold becomes wide, which imply that non-cheerleaders are less likely to make a friendship offer to cheerleaders. The limitation in this analysis is to assume that all non-cheerleaders are friends, but it is quite hard to estimate exactly how many friends an actor can be expected to have at a given point in time. Additionally, while the assumptions are perhaps overly simple to make this argument, one can still get the feeling of why, as the number of actors increases, the expected number of actors rejected increases.

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